Application, Appendix, DEQ Supplement, Routing Study, Direct Testimony and Exhibits of Virginia Electric and Power Company

Before the State Corporation Commission of Virginia

500 kV and 230 kV Golden-Mars Lines, Lockridge 230 kV Loop, Sojourner 230 kV Loop, and Related Projects

Application No. 350

Case No. PUR-2025-00056

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Volume 4 of 5

Application of Virginia Electric and Power Company
for approval and certification of electric transmission facilities:
500 kV and 230 kV Golden-Mars Lines, Lockridge 230 kV Loop, Sojourner 230 kV Loop, and Related Projects
Case No. PUR-2025-00056

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Dominion Golden to Mars – 230-kV and 500-kV
Underground Feasibility Study

Dominion Energy

Golden to Mars 230-kV and 500-kV
Underground Feasibility Study
Project No. 170234

Revision 7
03/27/2025

Dominion Golden to Mars – 230-kV and 500-kV Underground Feasibility Study

Prepared for

Dominion Energy
Golden to Mars 230-kV and 500-kV
Underground Feasibility Study
Loudoun County, Virginia

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Prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

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RECORD OF REVISION

Revision No.	Date	By	Section Revised	Description
0	07/22/2024	AKM - BMcD	N/A	Initial Draft Deliverable
1	07/26/2024	AKM - BMcD	5.0 Transition Station 6.0 Cost Estimate Analysis	1. Updated transition station design details 2. Included Transition station layouts 3. Updated Transition station assumptions 4. Included transition station cost estimates
2	07/31/2024	AKM - BMcD	5.0 Transition Station 6.0 Cost Estimate Analysis Appendices	1. Included Mars Substation layout 2. Included Mars Substation cost estimate 3. Included Appendix D Preliminary Station Layouts
3	08/30/2024	AKM - BMcD	4.0 UG Feasibility Review 5.0 Transition Station 6.0 Cost Estimate Analysis 7.0 Preliminary Construction Schedule 9.0 Feasibility Summary Appendices	1. Included transition stations (TS3 & TS4) 2. Included UG Routes 6 and 7 3. Included survey analysis of routes 4. Included OH/Engineering Cost estimates 5. Included Section 7.0 and Appendix E for preliminary schedule 6. Updated feasibility summary with new preferred route
4	9/10/2024	AKM-BMcD	7.0 Preliminary Construction Schedule	1. Updated schedule description to remove mention of goal in service date
5	12/06/2024	JMR BMcD	All Sections	1. Added feasibility analysis for 4 new UG Routes. 2. Removed abandoned routes section and moved the routes into the feasibility analysis section. 3. Included class 5 cost estimates for all routes. 4. Removed preliminary schedules. 5. Included Appendices E and F with new routes trenchless crossings feasibility analysis and ampacity memo. 6. Updated feasibility summary with new routes.
6	01/24/2025	JMR BMcD	Section 4 and Section 5	1. Incorporated ERM edits to sections 4 and 5.
7	03/27/2025	JMR BMcD	Executive Summary	1. Included Executive Summary.

EXECUTIVE SUMMARY

As part of the Golden to Mars transmission project, Dominion Energy Virginia (DEV or Dominion) considered the installation of two (2) underground (UG) transmission circuits, one 230-kV circuit rated at 1,572 MVA and another 500-kV circuit rated at 4,357 MVA, connecting two (2) new stations in Loudoun County, Virginia, near Dulles International Airport (IAD). To support this initiative, DEV has contracted Burns & McDonnell Engineering Company, Inc. (BMcD) to conduct a feasibility study for the proposed UG transmission routes. The feasibility analysis included the study of eleven (11) proposed UG routes provided by DEV which focused on routing, technical feasibility for each proposed route, installation methods such as open-cut trenching and trenchless technology, the required cable load ratings, the restrictions of Virginia Department of Transportation (VDOT), existing utility congestion, environmental considerations, permitting requirements, UG transmission cable system and station costs, and other relevant factors. This feasibility analysis only focuses on the UG transmission scope of the project.

Through the feasibility analysis several challenges for the proposed routes were identified, including:

- Construction difficulties through floodplains, wetlands, and existing infrastructure such as concrete culverts.
- Issues obtaining permits and easements, especially on sensitive facilities or federal lands.
- Traffic impacts and spacing constraints for duct bank and splice vault placements.
- The need for significant land acquisition outside of public rights-of-way (ROW) and potential extensive relocation of existing utilities.
- The need for larger ROW on trenchless crossings.
- Complexities with trenchless crossings due to the probable presence of Diabase rock and the requirement for larger equipment.
- Potential for delays due to the drilling process and complex construction conditions in private infrastructure areas.

Due to these significant constructability challenges, none of the proposed eleven (11) UG routes are considered constructable options for the Golden to Mars transmission project.

1.0 PURPOSE

DEV contracted BMcD to conduct a feasibility study based on routing options provided by DEV for installing two (2) UG transmission circuits in Loudoun County, Virginia located northwest of IAD. Additional route alternatives were also included by BMcD based on additional transition station locations provided by DEV and under the assumption that open-cut duct bank installation would be allowed in all roadways, yielding to seven (7) probable routes: UG Route 1 through UG Route 7. DEV also requested to perform a feasibility study on four (4) additional new routes proposed by DEV: UG Route R1 through UG Route R4, considering the constraint imposed by VDOT of not allowing open-cut duct bank installation in some specific roadways and the existing utility congestion found per provided survey that limits the proposed UG transmission line in several of these proposed UG routes. The proposed UG circuits are to be installed between the new Mars Substation and a proposed new transition station where the circuits will transition from UG to overhead (OH) and continue to Golden Substation, except for new routes R3 and R4 where the circuits are proposed to be installed between two (2) proposed new transition stations. For the UG portion of the Golden to Mars Project, DEV is proposing to install one (1) 230-kV circuit rated at 1,572 MVA and one (1) 500-kV circuit rated at 4,357 MVA. This report focuses on the feasibility of the underground transmission solution and routes being evaluated. Based on the desired rating requirements and the proposed installation corridors provided by DEV planning, BMcD has performed a technical feasibility, routing, and construction cost estimate analysis for all proposed UG routes.

The following considerations were taken when performing the feasibility analysis:

- Civil Installation Type
    - Open-cut trench
        - 230-kV and 500-kV duct bank systems installed within the same Right-of-Way (ROW)
        - 230-kV and 500-kV duct bank systems installed in separate ROWs
    - Trenchless

        - 230-kV and 500-kV trenchless crossing systems installed within the same ROW

- Ampacity
    - Required cable ratings
    - Cable size/number of cables required
    - Evaluate both 85% and 100% Daily load factor (DLF) cases for open-cut trench installation
    - Evaluate 100% DLF case for trenchless installation
    - Installation method
- Routing
    - Open-cut trench routing options
    - Trenchless crossing options
    - Proposed transition station location
- Cost Estimates
    - Civil installation costs
    - Electrical systems costs
    - Transition station costs

2.0 SYSTEM CONSIDERATIONS

The design scope is to provide a feasibility analysis and provide recommendations for the design of the proposed Golden to Mars UG transmission lines. Seven (7) transition stations were evaluated in total for the different UG lines route options, Transition Station 1 (TS1) through Transition Station 7 (TS7). The length of the UG cable systems between proposed terminals is in the range of 1.6 miles to 4.6 miles depending on UG route selection.

The anticipated installation method for most of these routes consists entirely of open-cut trenching (concrete encased duct bank). Open-cut trenching is the preference and priority in selecting an UG route. However, for some of these proposed routes there are segments where trenchless technology (Jack & Bore, Microtunneling, Horizontal Directional Drilling) is anticipated to be required

The majority of the proposed UG routes in the project include the utilization of some properties outside of the public Right of Way (ROW). In contrast, the power corridors of Route R1, Route R2, Route R3 and Route R4 travel mainly through private lands. The UG routes take two approaches, a combined construction where both the 230-kV system and the 500-kV systems co-exist within the same ROW and a separated construction where the 230-kV system and the 500-kV duct bank are considered to occupy their own ROW. The separated routes, UG Routes 1, 3, 6 and 7, maximize the use of public ROW and each circuit occupies a separate side of their shared corridors, using separate alignments. Likewise, the portions of these routes that travel through private lands, have a separate alignment and each duct bank requires a separate ROW. The combined routes, UG Routes 2, 4, 5, R1, R2, R3 and R4, travel through mainly private lands so a shared alignment and single ROW for both circuits is utilized. For these routes, the spacing between each duct bank is minimized and both the 230-kV circuit and 500-kV circuit are considered to coexist within the same ROW.

Placement, frequency, and design of splice vaults were considered based on the following:

- A splice vault location placed approximately every 2,400 feet for the proposed 230-kV UG Cable System.
    - Two (2) splice vaults at each location, housing six (6) splices each.

- A splice vault location is placed approximately every 1,700 feet for the proposed 500-kV system.
    - Three (3) splice vaults at each location.
    - Two (2) splice vaults will house six (6) splices each while the third splice vault will house three (3) splices each.
- Splice vault dimensions and layout is dependent upon the cable system voltage class (As discussed below in Section 2.4).
- Splice vaults to be located based on prudent engineering design to avoid geometric issues with:
    - Existing infrastructure
    - Environmentally sensitive areas
    - Traffic interruptions
    - Existing geography
- A maximum of six (6) cable splices are proposed to be installed in a single vault.

Termination structures are assumed to be typical substation UG single circuit H-frame termination structures at transition station locations.

2.1 Underground Installation Requirements for Open-Cut Installation

The following section outlines the duct bank installation method for open-cut trench construction that is being considered for the proposed Golden to Mars UG project.

2.1.1 Concrete Encased Duct Bank

Concrete-encased duct banks are a form of open-cut trench installation. A typical duct bank system consists of conduits cast in concrete in a trench. This construction method is highly favored in urban areas of major cities or within road ROW. With this type of construction, a trench will be dug at a required depth and width. A layer of bedding material will be placed to provide a stable and level ground. PVC or HDPE conduits with a specified diameter and thickness will be

assembled and placed in a trench at a predetermined depth and configuration. Conduit spacers will be utilized to meet the designed configuration and maintain spacing between conduits. The trench is then filled with an approved thermal concrete to facilitate the heat dissipation from the cable and protect the conduit system. Thermal concrete is high density, low air content concrete with a low thermal resistivity. Thermal concrete will extend from the bottom of the trench to cover the conduits, conduit fittings, and reinforcement (if required). After the concrete has cured, it is then backfilled with engineering fill, fluidized thermal backfill (FTB), which is a concrete-like material that has been commonly used historically for underground transmission backfills. It is a mixture of natural mineral aggregate, sand, cement, water, and a fluidizer that is formulated to meet specific thermal and strength requirements. Fly ash is a commonly used fluidizer. However, if fly ash is not readily available, a water-soluble resin or slag can be used. FTB is delivered in fluid state and can be poured or pumped into trenches very easily.

The main benefits of duct bank systems are the physical protection of the conduits and the ability to maintain conduit separation which can help with mutual heating concerns. Additionally, the duct bank system creates a raceway of conduits to pull cable into without the need for additional civil operations. Figure 2-1 shows a typical open trench construction of a duct bank system before being backfilled with concrete.

Figure 2-1: Duct Bank System Example

2.1.1.1 Duct Bank Considerations

Table 2-1 lists some typical considerations associated with open trench installation and details them specifically within the context of a concrete-encase duct bank installation.

Table 2-1: Duct Bank Installation Considerations

Considerations	Duct Bank Installation
Cable Protection	Concrete encasement provides high level of protection for traditional open-cut methods.
Routing Flexibility	Duct banks allow flexibility to route around existing utilities while maintaining appropriate clearances and bending radii.

Considerations	Duct Bank Installation
Private Easements	Any required deviations from the existing route (outside of public ROW) will require private easements in this area.

2.2 Underground Installation Requirements for Trenchless Installations

Trenchless alternatives for the installation of new cables provide advantages such as minimizing disruption to traffic, environmentally sensitive areas, existing utilities, and the general public. Given the project's proximity to main traffic roads, highways and the routes crossings through different waterbodies and future utilities, trenchless installation methods are expected to be necessary for some of these UG route options on this project.

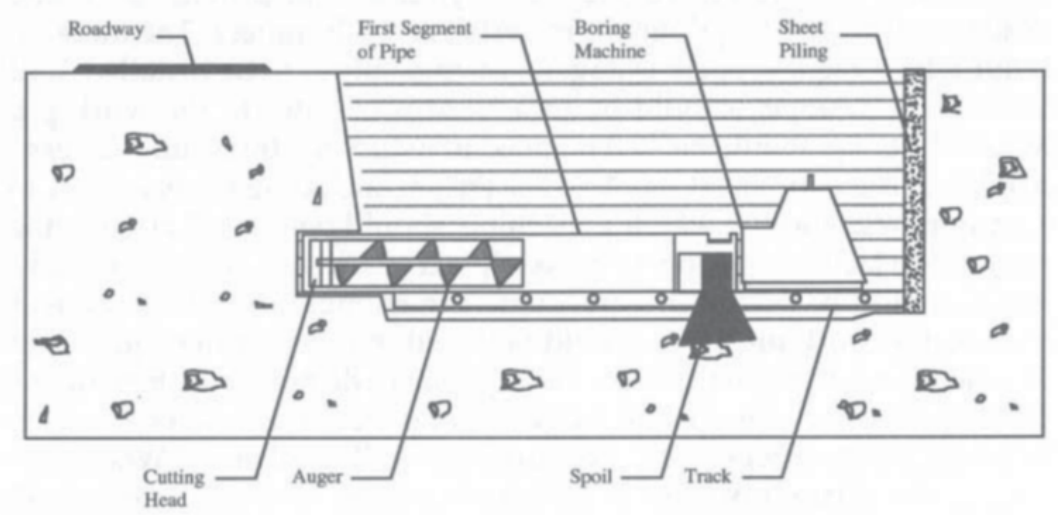
The purpose of this section is to discuss the details of technically feasible trenchless conduit installation options for this project.

2.2.1 Jack & Bore

The Jack and Bore (J&B) installation method (a type of horizontal auger boring) has been developed for pipe diameters ranging from 8" to 60", straight, and short length (<400 feet) trenchless installations. A J&B installation method is preferred for short crossings over other trenchless technologies that have greater minimum recommended installation lengths.

J&B is a multi-stage process that involves jacking a steel casing from a launching pit to a receiving pit (or launching shaft to receiving shaft). The materials encountered at the face of the bore are removed by augers contained within the casing. The spoils removed by the augers are transported to the launching pit, where they are collected for disposal. Typical accuracy of J&B can vary significantly with changing soil conditions; however, this accuracy can be greatly improved by using a pilot tube guidance system to establish the centerline of the alignment. Once the steel casing reaches the receiving pit, it is extruded by a non-metallic casing (e.g., HOBAS pipe) suitable for containment of electrical cables, although at a significantly higher cost. Figure 2-2 details a typical J&B installation taken from ASCE Manuals and Reports on Engineering Practice No. 106: "Horizontal Auger Boring Projects".

Figure 2-2: J&B Typical Installation



Shallow groundwater may present ground stability problems with J&B, particularly if loose, clean sands are present. Where applicable, the groundwater table may need to be lowered by dewatering. In addition, the trenchless contractor may reduce risk of ground instability by maintaining a plug of soil between the head to the augers, and the edge of the lead casing. The effectiveness of these methods will vary depending on soil conditions, site access (for dewatering) and depth of groundwater. J&B may be used in bedrock, depending on the compressive strength of the materials present. This may require use of a cutting head equipped with discs.

2.2.1.1 Jack & Bore Risks

Potential sources of risk associated with J&B construction for the Project are summarized in Table 2-2 below.

Table 2-2: J&B Installation Risks

Risk Source	Potential Outcome	Comments
Encountering obstructions – cobbles or boulders, debris	May require clearance through excavation from ground surface, or from within the jack and bore casing.	Oversized materials need to be characterized, and contingency plans for handling should be developed. The jack and bore alignment would need to be located below the fill, within the underlying native soils.

Risk Source	Potential Outcome	Comments
Unanticipated subsurface conditions	Project delays, additional contractor costs.	The subsurface conditions should be characterized by test borings prior to trenchless design. If shallow (<30 feet), the depth of bedrock should be determined. The depth of groundwater shall be determined.
Encountering underground utilities	Encountering utilities could result in utility damage, failure of installation.	Location of all utilities within 20 feet of the jack and bore installations should be determined prior to construction. Crossing shall be designed to maintain clearance from existing utilities. Utility owners should be notified in advance of construction.
Elevated jacking pressures	Jacking pressures can exceed ability of jacks to maintain forward progress, causing reduced penetration rate, pipe damage.	Estimated jacking loads need to be calculated. Casing pipe needs to be designed to withstand estimated installation pressures. Site-specific lubrication needs to be considered.
Surface settlement adjacent to pits	Surface settlement could occur adjacent to pits, impacting pavements, building foundations.	Pit excavation support would need to be designed to minimize ground movements. Equipment excavation rates need to be monitored carefully to avoid over-excavation. Surface monitoring points shall be used to detect settlement during construction.

Risk Source	Potential Outcome	Comments
		Pit design would need to include site-specific dewatering plan sufficient to provide a stable, dry work surface (both pits).
Surface settlement or heave along jack and bore alignment(s)	Surface settlement or heave could occur during jack and bore, impacting pavements.	Equipment excavation rates need to be monitored carefully to avoid over-excavation. Dewatering may be necessary to reduce potential for uncontrolled inflow of saturated granular soils if present. Surface monitoring points should be used to detect settlement during construction. An appropriate installation depth should be selected based on the site-specific subsurface conditions present.
Groundwater Seepage	If bore is below the groundwater table, groundwater may present stability problems with the J&B, particularly if loose, clean sands are present.	Groundwater table may be lowered by dewatering. A soil plug can be utilized between the head to the augers, and the edge of the lead casing.

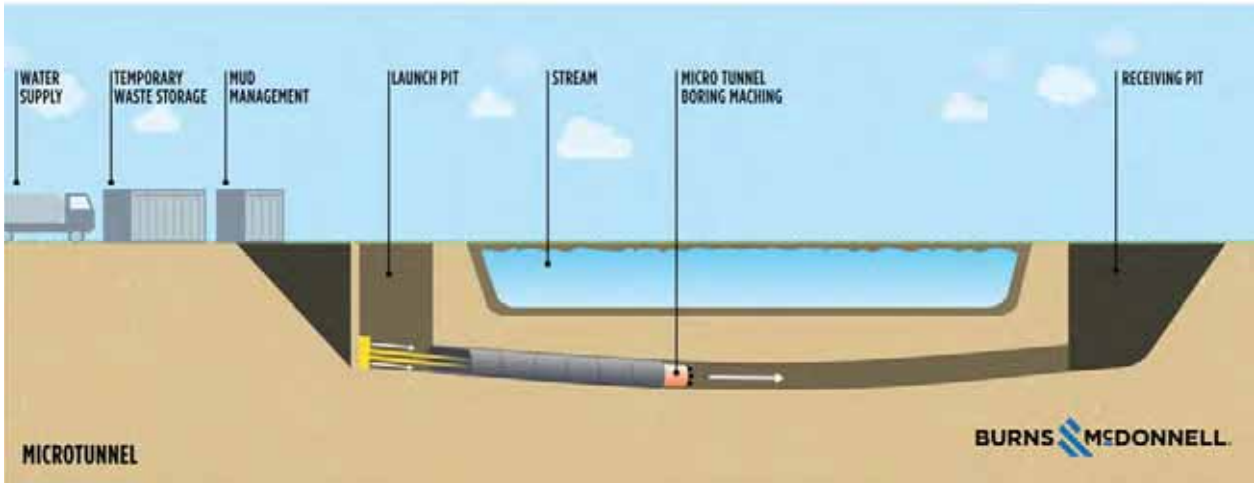
2.2.2 Microtunneling

Microtunneling is a remotely controlled pressurized face operation where the pipe is hydraulically pushed or jacked from a launch shaft to a retrieval shaft. The pressurized face characteristic refers to the ability of this trenchless method to apply positive face stabilization at all times in all types of

soil and under groundwater head pressure up to approximately 80 to 100 ft. Face support is applied through the use of pressurized slurry which is pumped in a circulating loop from holding tanks at the ground surface to the slurry chamber located at the front of the microtunnel boring machine (MTBM) through slurry lines. A bulkhead at the front of the MTBM isolates the groundwater and earth pressure at the face of the MTBM from the atmospheric pressure within the installed pipe.

As the MTBM advances, the cutter wheel excavates material in front of the machine. The excavated material passes through the crushing chamber and falls into a collection/slurry chamber where the spoil mixes with the clean slurry water pumped down from the holding tanks. The heavier slurry is then pumped back through the installed pipe sections and up the jacking shaft to a separation plant. The separation plant is used to process the slurry by removing the soil constituents to allow the fluid component to be recycled for re-use. The recycled water falls into holding tanks until pumped down to the MTBM slurry chamber in the closed slurry loop. By controlling the amount of material entering the machine with the advance rate of the MTBM and controlling the fluid pressures within the slurry chamber, the MTBM is capable of independently balancing earth and groundwater pressures simultaneously. This characteristic allows excavation of very soft material and materials under high ground water pressures without the need for dewatering. A laser/theodolite system is typically used to monitor line and grade as the MTBM is advanced through the subsurface. Steering jacks coupled with an articulation joint within the MTBM are used to steer the machine to line and grade tolerances of plus or minus 1” over the length of the installation. A schematic of a typical microtunnel installation is provided in Figure 2-3 below.

Figure 2-3: Typical Microtunneling Schematic



Microtunneling installations typically involve installing pipelines ranging in 30-inch up to 10 ft in diameter. For installations greater in length, intermediate jacking stations (IJS) are required. An IJS consists of a series of hydraulic rams installed within shaft located along the microtunnel alignment at the tunnel depth that, when activated, moves a telescoping steel shell that clamps to and advances the pipe string in front of the IJS. IJS's are placed along the microtunnel alignment and travel with the pipe string as it is pushed through the formation by the main hydraulic jacks in the launch shaft. When needed, the hydraulic rams in the IJS can be activated to provide additional jacking force within the pipe string to overcome frictional forces or face pressure. For risk mitigation purposes of long-drive microtunnels, it is common to require placement of an initial IJS within 100 ft of the front of the launch shaft and at a regular spacing of approximately 500 ft along the remainder of the microtunnel alignment, depending upon the anticipated jacking force requirements.

2.2.2.1 Microtunneling Risks

Potential sources of risk associated with microtunneling construction for the Project are summarized in Table 2-3 below.

Table 2-3: Microtunnel Installation Risks

Risk Source	Potential Outcome	Comments
Encountering obstructions – cobbles or boulders, debris	May slow down drilling or require clearance through the microtunnel casing.	Oversized materials need to be characterized, and contingency plans for handling should be developed. Appropriate drill heads shall be selected for the environment
Unanticipated subsurface conditions	Project delays, additional contractor costs.	The subsurface conditions should be characterized by test borings prior to trenchless design. If shallow (<30 feet), the depth of bedrock should be determined. The depth of groundwater shall be determined.

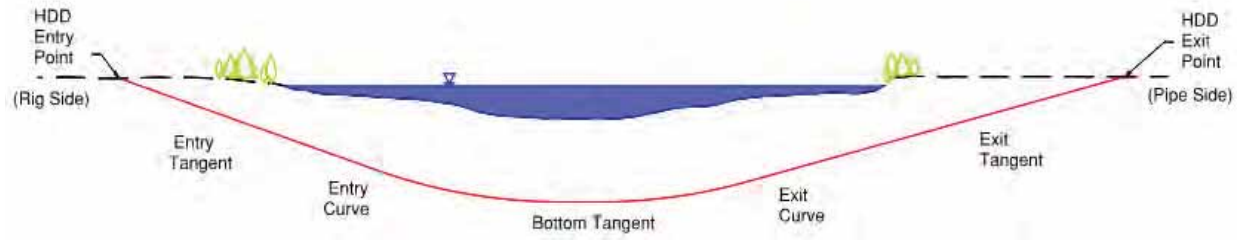
Risk Source	Potential Outcome	Comments
Encountering underground utilities	Encountering utilities could result in utility damage, failure of installation. Most likely location to encounter them will be near the excavation pits	Location of all utilities within 20 feet of the jack and bore installations should be determined prior to construction. Crossing shall be designed to maintain clearance from existing utilities. Utility owners should be notified in advance of construction.
Surface settlement adjacent to pits	Surface settlement could occur adjacent to pits, impacting pavements, building foundations.	Pit excavation support would need to be designed to minimize ground movements. Equipment excavation rates need to be monitored carefully to avoid over-excavation. Surface monitoring points shall be used to detect settlement during construction. Pit design would need to include site-specific dewatering plan sufficient to provide a stable, dry work surface (both pits).
Surface settlement or heave along microtunnel alignment(s)	Surface settlement or heave could occur during microtunneling, affecting the surface	Equipment excavation rates need to be monitored carefully to avoid over-excavation. Surface monitoring points should be used to detect settlement during construction. An appropriate installation depth should be selected based on the site-specific subsurface conditions present.

2.2.3 Horizontal Directional Drill

A Horizontal Directional Drill (HDD) is a form of trenchless technology utilized to minimize surface impacts. The typical installation length of an HDD ranges from a few hundred feet up to a few thousand feet, depending on installation geometry, ground conditions, and capabilities of the drill rig. Installation of conduits by an HDD is generally accomplished in three stages: pilot hole drilling, reaming, and conduit pulling. The pilot hole drilling stage involves drilling a small pilot hole along the designed HDD path. The reaming stage involves enlarging the pilot hole to a diameter which will accommodate the conduit bundle. The conduit pulling stage involves pulling the conduit bundle back through the enlarged hole.

A typical HDD profile consists of five (5) parts: the entry tangent, entry curve, bottom tangent, exit curve, and exit tangent. The entry tangent is typically between 10 and 12 degrees below grade; however, they can range anywhere from 8 to 20 degrees below grade. The exit tangent can be angled between 5 and 12 degrees below grade, but is frequently oriented at 8 to 10 degrees. Increased exit angles will require the pull section to undergo more stress and potentially require suspension at an elevated position as the cable bundle in HDD installations is pulled towards the HDD rig. Exit angles that are too small can increase the likelihood of inadvertent returns near the exit point. The bottom tangent depth can be determined by several factors, including soil/ground materials, borehole diameter, existing obstacles (such as utilities and structures), environmental concerns, and permitting requirements. The bottom tangent depth is designed to reduce the risk of inadvertent return, reduce the risk of surface settlement or heaving, provide allowance for error in existing grade survey or account for future grade changes, and account for the cable derating factor for electrical installations. The typical industry standard for entry and exit curve radius is 100 times the conduit bundle where the minimum entry and exit curve radius is defined by 1,200 times the diameter of the drill rod. See Figure 2-4 for the typical HDD geometry.

Figure 2-4: Typical HDD Geometry



Inadvertent return can occur when the overburden soil's confinement strength is insufficient to withstand the downhole pressure exerted by drilling fluid. As a result, drilling fluid would escape the borehole and emerge to the ground through void and cracks of the soils and rocks fractures. Inadvertent returns could happen because of various reasons such as excess fluid flow, high fluid pressure, improper drilling mixture, improper rate of penetration, annular space obstruction, and unstable geological formations. Inadvertent return typically occurs in drilling through the weak cohesive soils with low shear strength like soft silts and clays. In soils such as these, a casing can be installed with the HDD as a way to support the borehole during drilling, which also helps to reduce settling of soil and facilities at grade. Additionally, casings can be installed with the conduits and filled with thermal grout to reduce the cable derating throughout the HDD in electrical installations.

2.2.3.1 Horizontal Directional Drill Risks

Potential sources of risk associated with HDD construction for the Project are summarized in Table 2-4 below.

Table 2-4: HDD Installation Risks

Risk Source	Potential Outcome	Comments
Encountering obstructions – cobbles or boulders, debris	May require clearance through excavation from ground surface or relocation of the drill rig and a new bore to be drilled depending on obstruction depth	Oversized materials need to be characterized, and contingency plans for handling should be developed.

Risk Source	Potential Outcome	Comments
Unanticipated subsurface conditions	Project delays, additional contractor costs.	The subsurface conditions should be characterized by test borings prior to trenchless design. If shallow (<30 feet), the depth of bedrock should be determined. The depth of groundwater shall be determined.
Encountering underground utilities	Encountering utilities could result in utility damage, failure of installation.	Location of all utilities within 20 feet of the HDD installation should be determined prior to construction. Crossing shall be designed to maintain clearance from existing utilities. Utility owners should be notified in advance of construction.
Insufficient Drill Rig Pulling Capabilities	Conduit bundle weights can exceed pulling capabilities of certain drill rigs, causing conduit bundles to be stuck within the bore	Estimated pulling loads required must be calculated prior to HDD operations and a rig of sufficient pulling capabilities shall be selected to complete the drill
Surface settlement or heave along HDD alignment(s)	Surface settlement or heave could occur during the HDD operations, impacting pavements.	Surface monitoring points should be used to detect settlement during construction. An appropriate installation depth should be selected based on the site-specific subsurface conditions present.

Risk Source	Potential Outcome	Comments
Inadvertent Return	Drilling fluid escapes the borehole, either underground or at the entry/exit points, and flows into the environment	A site-specific geotechnical study shall be completed prior to drilling operations. Annular pressure calculations shall also be performed to determine whether borehole integrity can remain intact during the drills. A drill fluid clean up kit shall also remain on site during drilling operations

2.3 Cross-Linked Polyethylene (XLPE) Cable

XLPE is a type of cable that consists of a metal conductor surrounded by XLPE as the insulating material, a metallic sheath and commonly a polyethylene jacket. XLPE cables have the benefit of being durable enough to be pulled long distances in a variety of environments while remaining flexible enough to be pulled through geometrically complex conduit raceways. XLPE cables can be constructed with both aluminum and copper conductors and at a variety of sizes while not requiring any sort of fluid system or rigid pipe design. Although the historical data on XLPE cables is not as extensive as some fluid filled pipe-type systems, modern installations are increasingly utilizing XLPE cable system. Figure 2-5 from the Southwire cable catalog shows an example of a typical high-voltage UG XLPE cable.

Figure 2-5: XLPE UG Power Cable

XLPE cables will be installed between vaults spaced approximately 2,400 feet apart for 230-kV and approximately 1,700 feet apart for 500-kV. The primary drivers for this spacing are the cable reel transportation logistics and the pulling tensions experienced by the cables. Detailed design would include of pulling calculations to determine the exact spacing of these splice vaults and a determination of which constraint controls for this alignment. The vaults for each UG cable system would be designed to house up to a total of 6 splices per vault. Based on the 230-kV system requirement detailed in Section 3.0 below, two (2) vaults are required for each vault location, to splice the four (4) cables-per-phase circuit. Based on the 500-kV system requirement detailed in Section 3.0 below, three (3) vaults are required for each vault location, to splice the five (5) cables-per-phase circuit.

2.4 Splice Vaults

Splice vault locations are anticipated along the underground route to facilitate cable installation and splicing as well as for operation and maintenance access over the lifespan of the installation. The vault size and layout are determined by the space required for cable size, cable pulling, splicing, and supporting the cable in the vault. Based on these factors, the anticipated interior dimensions of the vaults for the 230-kV system are 10 feet wide by 8 feet tall by 26 feet long (10’ x 8’ x 26’).[1] The anticipated interior dimensions of the vaults for the 500-kV system are 15 feet wide by 8 feet tall by 40 feet long (15’ x 8’ x 40’).[1] Almost all transmission cable splice vaults have two access manholes to facilitate cable installation. These splice vaults can be precast or cast-in-place depending on the area of installation and if other utility lines are nearby preventing the installation of a precast splice vault.

It is always recommended that splice vaults be the first item to be installed for an underground cable system. This helps prevent unknown utilities from necessitating moving the splice vaults. Relocating the splice vaults will affect the cable cut lengths that have been previously determined. See Figure 2-6 below for typical 230-kV splice vault details and see Figure 2-7 below for typical 500-kV splice vault details.

[1] Interior vault size is a function of minimum interior dimensions necessary for installation, racking, and splicing of high voltage cables. Final wall, ceiling and floor thicknesses, and thus final exterior dimensions, will be determined during the final design process based on depth of installation, anticipated soil and groundwater conditions, and traffic loading requirements.

Figure 2-6: Typical 230-kV UG Splice Vault

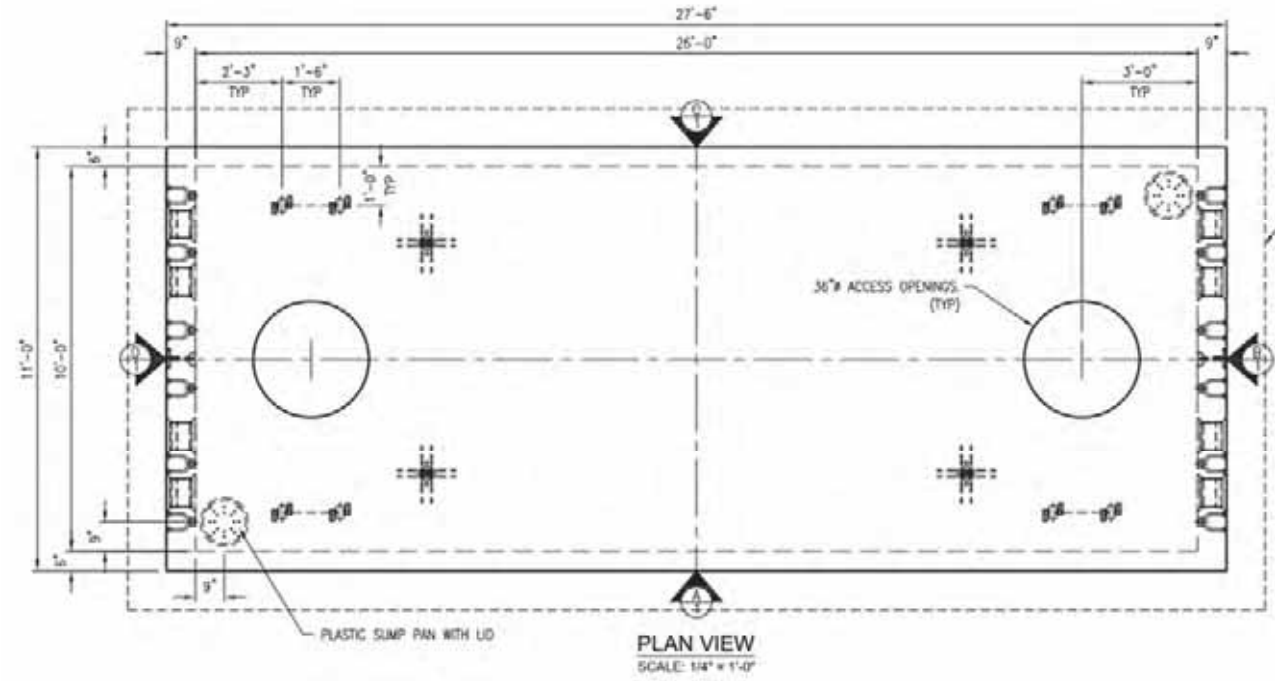
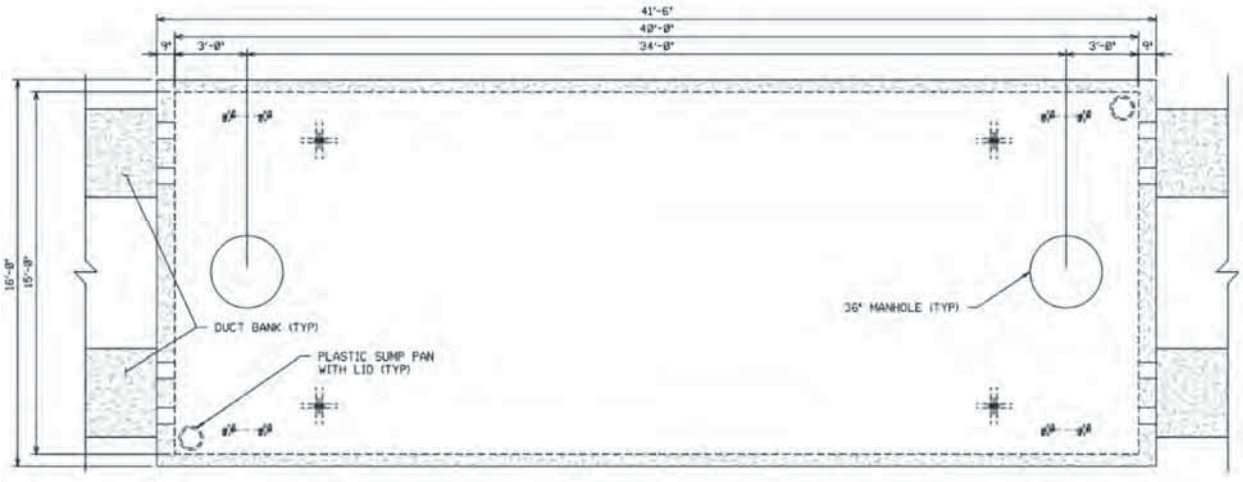


Figure 2-7: Proposed 500-kV Splice Vault



For the Golden to Mars project, two (2) splice vaults are anticipated to be required at each 230-kV splice location and three (3) splice vaults are anticipated to be required at each 500-kV splice location to accommodate the number of cables needed to reach the desired per circuit ratings. See Figure 2-6 and Figure 2-7 above for the assumed 230-kV and 500-kV splice vault details. For routes where, the 230-kV and 500-kV duct banks share the same ROW, the splice vaults may be

staggered to to minimize foot print impacts. See Figure 2-8 and Figure 2-9 below for an example of how these vaults may be arranged.

Figure 2-8: Golden-Mars Splice Vault Location, 85% DLF

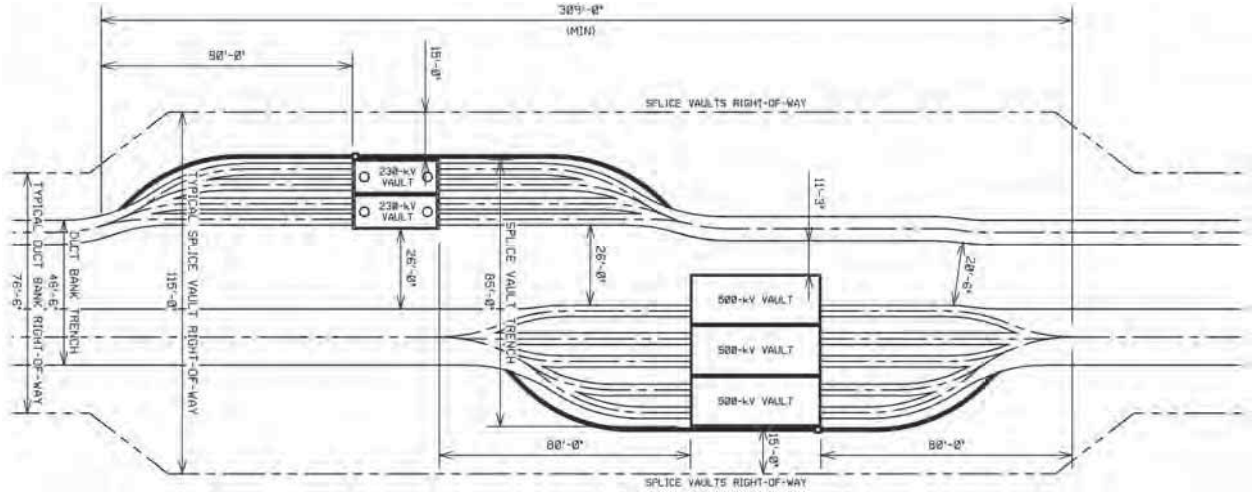
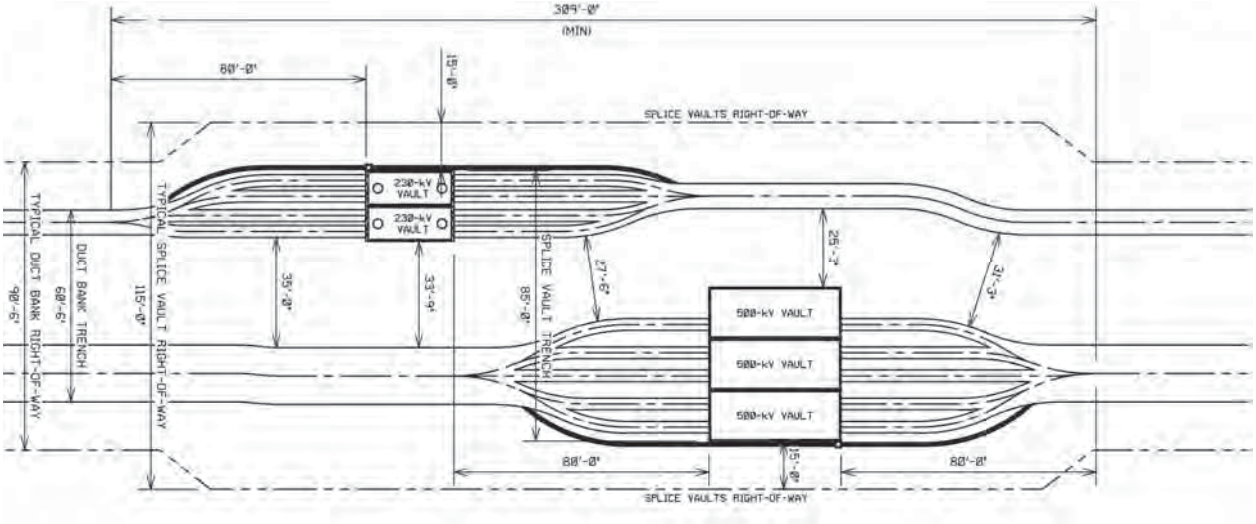


Figure 2-9: Golden-Mars Splice Vault Location, 100% DLF



3.0 DESIGN AND INSTALLATION CRITERIA

3.1 System Requirements & Environment

System ratings for the proposed underground Golden to Mars transmission circuits were provided by Dominion Engineering for the evaluation included in this report. The cables, splices, grounding system and other components shall meet the following requirements in Table 3-1 and Table 3-2 below:

Table 3-1: System Rating for Golden to Mars 230-kV Underground Transmission Circuit

Design Parameter	Parameter Value
Number of Circuits	One (1)
Nominal Voltage	230-kV
Nominal Frequency	60 Hertz
Normal Ampacities	3,950 Amps (1,572 MVA)
Continuous Conductor Temperature	90 ºC
Emergency Conductor Temperature	105 ºC
Daily Load Factor (DLF)*	85% and 100%
Maximum Short Circuit Conductor Temperature	250 ºC
Cable Sheath Bonding	Single point bonded

* For each open-cut duct bank configuration, both 85% DLF and 100% DLF will be evaluated. For trenchless configurations only 100% DLF will be evaluated.

Table 3-2: System Rating for Golden to Mars 500-kV Underground Transmission Circuit

Design Parameter	Parameter Value
Number of Circuits	One (1)
Nominal Voltage	500-kV
Nominal Frequency	60 Hertz
Normal Ampacities	5,031 Amps (4,357 MVA)
Continuous Conductor Temperature	90 ºC

Design Parameter	Parameter Value
Emergency Conductor Temperature	105 ºC
Daily Load Factor*	85% and 100%
Maximum Short Circuit Conductor Temperature	250 ºC
Cable Sheath Bonding	Single point bonded

* For each open-cut duct bank configuration, both 85% DLF and 100% DLF will be evaluated. For trenchless configurations only 100% DLF will be evaluated.

3.2 Operating Environment

The following describes the assumed operating environment in which the cables will be installed and operated within.

3.2.1 General

The proposed cable systems will be installed using primarily concrete-encased duct bank installation methods within a mixture of existing public ROW, private, and/or public property available in the project vicinity area in Dulles, Virginia. Some of the proposed routes will require trenchless installation methods at determined crossings.

- The duct bank will consist of polyvinyl chloride (PVC) conduits to carry the power cables. The duct bank design will include one (1) spare conduit per subcircuit for emergency repair scenarios. In addition to the power cable conduits, one (1) smaller PVC conduit will be included, per cable set, to carry the ground continuity conductors (GCC), in addition to one (1) smaller PVC conduit to carry a fiber communication cable per circuit.
- The trenchless installation will consist of:
- HOBAS casings (centrifugally cast, fiberglass reinforced, polymer mortar) to carry the conduit bundle for J&B and Microtunneling installations. These casings will be filled-in with thermal grout to aid the power cables load capacity. The conduit bundle will consist of PVC conduits to carry the power cables, including one (1) spare conduit per subcircuit for emergency repair scenarios. In addition to the power cable conduits, one (1) smaller PVC conduit will be included, per cable set, to carry the GCC, in addition to one (1) smaller PVC conduit to carry a fiber communication cable per circuit.

- High-Density Polyethylene (HDPE) casings to carry the conduit bundle for HDD installations. These casings will be filled-in with thermal grout to aid the power cables load capacity. The conduit bundle will consist of HDPE conduits to carry the power cables, including one (1) spare conduit per subcircuit for emergency repair scenarios. In addition to the power cable conduits, one (1) smaller HDPE conduit will be included, per cable set, to carry the GCC, in addition to one (1) smaller HDPE conduit to carry a fiber communication cable per circuit.

3.2.2 Assumed Operating Environment

At the time of publication of this report, no field investigation into existing soil conditions of the project site have been performed. Based on experience and engineering judgement, the operating environment parameters were therefore assumed for the purpose of this study as follows in Table 3-3 below.

Table 3-3: Golden-Mars UG Transmission Assumed Operating Environment

Parameter	Assumptions
Summer Ambient Earth Temperature	28 ºC for 3-7 feet of cover 20 ºC for 7-20 feet of cover 12 ºC for >20 feet of cover
Native Soil Thermal Resistivity*	150 ºC C-cm/watt for 85% DLF 115 ºC C-cm/watt for 100% DLF
Concrete Thermal Resistivity	65 ºC C-cm/watt
Flowable Fill Thermal Resistivity	70 ºC C-cm/watt
Grout Thermal Resistivity	80 ºC C-cm/watt
Minimum Burial Depth to Top of Duct Bank	3 feet

*Actual native soil thermal resistivity is unknown, and these values are assumed. It is lower for the 100% DLF, as this is the maximum allowable value to meet ampacity requirements using the same number of cables per phase as the 85% DLF option.

Note that the ambient temperature values are based on previous project data in a similar geographic location. The actual native soil thermal resistivity for the UG routes is unknown and a conservative number of 150 ºC C-cm/watt is assumed for the 85% DLF case. However, the native soil thermal resistivity value for the 100% DLF is lower (115 ºC C-cm/watt) as this is the maximum

allowable value to meet the ampacity requirements while keeping all other operating environment assumptions the same. Final soil thermal resistivity will be predicated on geotechnical investigations performed during the design phase of the Project.

3.2.3 Subsurface Conditions

The suitability of civil construction methods will depend on the site-specific subsurface conditions, including the following:

- Fill depth and gradation
- Native soil thickness, gradation. density/consistency, and permeability
- Bedrock depth, rock type, hardness, abrasiveness, compressive strength, and weathering
- Groundwater depth

A project-specific subsurface investigation has not been completed. For the purpose of discussion, we have assumed the following:

- Fill will be variable in gradation will range from about one to five feet in thickness.
- The native overburden will include residual soils, reflective of the underlying bedrock. Alluvial deposits may be present adjacent to streams and wetlands.
- Bedrock depths will range from about 10 to 30 feet below grade and will consist of sedimentary lithologies (shale, sandstone, siltstone).
- Groundwater may be present at depths ranging from 5 to 20 feet below existing ground surface.

3.3 Ampacity Analysis

Ampacity calculations were modeled for the proposed XLPE cable systems to verify that the system meets the load criteria for all installation scenarios. The ampacity calculations for the 230-kV cable were performed using a Southwire 230-kV 5,000 kcmil enameled segmented copper conductor XLPE cable cutsheet. The ampacity calculations for the 500-kV cable were performed using a Taihan 500-kV 5,000 kcmil enameled segmented copper conductor XLPE cable cutsheet.

The ampacity of the cables was then calculated as a function of the maximum conductor temperature to verify the cable could achieve the ratings provided by DEV. It was determined that a five (5) cables per phase (CPP) configuration was required to meet the ampacity ratings for the 500-kV circuit, within a single duct bank and that a four (4) CPP configuration was required for the 230-kV circuit, within a single duct bank. These results are outlined in Section 3.4 below and the ampacity executions are attached in Appendix B for duct banks, and are detailed in Appendix F for the different trenchless installations.

After the initial ampacity request, DEV has requested two (2) additional ampacity scenarios. For the first scenario, the 500-kV circuit is split into two (2) duct banks and the number of CPP is reduced to four (4) CPP. For the second scenario, both the 230-kV and 500-kV single circuit duct banks are reduced by one CPP to identify the maximum ampacity rating that can be achieved by running the cables to their maximum operating temperature of 90°C. An ampacity memorandum was created to analyze these scenarios. Please see Appendix B for the detailed ampacity memorandum of the additional scenarios and all ampacity executions.

Once the scenarios described above where completed, DEV requested to analyze three (3) additional ampacity scenarios for trenchless crossings installations considering five (5) CPP for the 500-kV circuit and four (4) CPP for the 230-kV circuit coexisting in the same power ROW. The first scenario consisted of J&B installations subdivided into two different settings: one considering a combination of bores with two (2) CPP in the same bore and one (1) CPP per bore, the other considering all bores each with one (1) CPP. The second scenario consisted of Microtunneling installations subdivided into the similar settings previously described for J&B. Finally, the third scenario corresponded to HDD installations considering all bores each with one (1) CPP. For each scenario, a parametric study was performed to reach at least the minimum ampacity requirements from Table 3-1 and Table 3-2. An additional ampacity memorandum was created to analyze these scenarios. Please see Appendix F for the detailed ampacity memorandum of the additional scenarios and all ampacity executions.

Ampacity calculations were completed utilizing the CYMCAP ampacity program to verify the conductor size(s) required and the duct bank design needed for the XLPE options. CYMCAP is the industry-accepted software (utilizing IEC and ICEA standards) used for underground cable ampacity calculations. It allows the user to model many different system parameters to give more

project specific results. These parameters include, but are not limited to, native soil thermal resistivity, different types of backfills (including the associated thermal resistivity), conduit types, customized conduit configurations, and customized cable construction.

For each ratings scenario, calculations were run based on an assumed worst-case scenario or "pinch point". The "pinch points" are typically the result of deeper duct bank installations, trenchless crossings, and adjacent heat sources (i.e., existing underground electrical circuits, steam lines, etc.). Since a detailed investigation of the subsurface conditions has not been performed at the time of this report, the thermal "pinch point" assumed for the open-cut installation was:

- Deep duct bank installation (8' to top of concrete)
- Parallel duct banks (Reference Figure 3-4 and Figure 3-5 below for minimum separation between duct banks)

The thermal "pinch points" assumed for trenchless installations are detailed in Appendix F.

These "pinch points" will be subject to change during future investigation of the actual site conditions that will be encountered. The sections below summarize ampacity results for the various installation scenarios and associated ampacity calculation results.

3.4 XLPE Ampacity Results

Table 3-4 through Table 3-7 below outline the ampacity calculations that were performed for the XLPE cable system. The required loading for the proposed 230-kV circuit is 3,950 Amps under normal loading conditions. The required loading for the proposed 500-kV circuit is 5,000 Amps under normal loading conditions. For open-cut installation scenarios, both 85% DLF and 100% DLF were evaluated. For trenchless installations scenarios only 100% DLF was evaluated. The following tables show the calculated ampacity for the open-cut trench concrete encased duct bank installations and trenchless installations.

Table 3-4: 230-kV Ampacity Results – Open-Cut Duct Bank Installations

Installation Type	DLF	Native Soil Thermal Resistivity ºC C-cm/watt	Horizontal Center-Center Conduit Separation (Feet)	Vertical Center-Center Conduit Separation (Feet)	Required Normal Ratings (Amps)	Calculated Normal rating (Amps)
Duct Bank	85%	150	2	2	3,950	4,444
Duct Bank	100%	115	2	2	3,950	4,296
Duct Bank	100%	150	2	2	3,950	4,196

Table 3-5: 500-kV Ampacity Results – Open-Cut Duct Bank Installations

Installation Type	DLF	Native Soil Thermal Resistivity ºC C-cm/watt	Horizontal Center-Center Conduit Separation (Feet)	Vertical Center-Center Conduit Separation (Feet)	Required Normal Ratings (Amps)	Calculated Normal rating (Amps)
Duct Bank	85%	150	4	1.5	5,000**	5,130
Duct Bank	100%	115	4	1.5	5,000**	5,025
Duct Bank	100%	150	4	2	5,000**	4,620*

*Ampacity results indicate that with a DLF of 100% an assumed native soil resistivity of 150 ºC C-cm/watt, the 500-kV circuit is unable to meet DEV ampacity requirements. Native soil thermal resistivity is lowered for the 100% DLF case, as this is the maximum allowable value to meet ampacity requirements.
** Further calculations are required to confirm that all executions meet ampacity requirements.

Table 3-6: 230-V and 500-kV Circuits in same ROW Ampacity Results – Open-Cut Duct Bank Installations

Installation Type	DLF	Native Soil Thermal Resistivity (ºC C-cm/watt)	Circuit Voltage (kV)	Horizontal Center-Center Conduit Separation (Feet)	Vertical Center-Center Conduit Separation (Feet)	Required Normal Ratings (Amps)	Calculated Normal rating (Amps)
Duct Bank	85%	150	230	2	2	3,950	4,202
			500	4	1.5	5,000*	5,008
Duct Bank	100%	115	230	2	2	3,950	4,183
			500	4	2	5,000*	5,005

* Further calculations are required to confirm that all executions meet ampacity requirements.

Table 3-7: 230-V and 500-kV Circuits in same ROW Ampacity Results – Trenchless Installations

Installation Type**	DLF	Native Soil Thermal Resistivity (ºC C-cm/watt)	Circuit Voltage (kV)	Horizontal Center-Center Casign Separation (Feet)	Maximum Depth of Cover Assumed (Feet)	Required Normal Ratings (Amps)	Calculated Normal rating (Amps)
J&B and Microtunneling	100%	115	230	15	30	3,950	4,047
			500	45		5,000***	5,043
J&B and Microtunneling	100%	115	230	15	40	3,950	3,972
			500	60		5,000***	5,140
HDD	100%	115	230	20*	45	3,950	4,061
			500	65		5,000***	5,006

*Center-to-center separation between 230-kV bore and 500-kV bore is 70 feet.
**All trenchless detailed executions can be found in Appendix F.
*** Further calculations are required to confirm that all executions meet ampacity requirements.

For the proposed 230-kV XLPE circuit, the ampacity ratings were met with a four (4) cables per phase system, without exceeding the 90 ºC operating temperature. For both the 85% DLF and 100% DLF case, the ampacity ratings were achievable with 115 ºC C-cm/watt or 150 ºC C-cm/watt native soil thermal resistivity, respectively.

For the proposed 500-kV XLPE circuit, the ampacity ratings were met with a five (5) cables per phase system, without exceeding the 90 ºC operating temperature. For the 85% DLF and case, the ampacity ratings were achievable with 115 ºC C-cm/watt or 150 ºC C-cm/watt active soil thermal resistivity.

However, for the 100% DLF case, the ampacity ratings were only achievable with a maximum of 115 ºC C-cm/watt native soil thermal resistivity.

3.4.1 230-kV Duct Bank

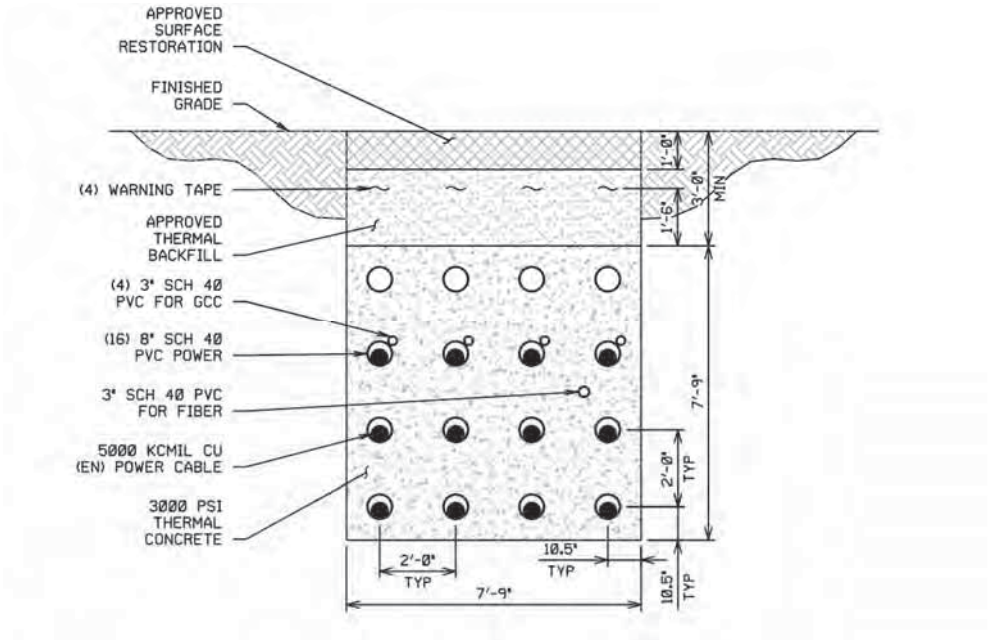
The cross section in Figure 3-1 below represents the anticipated open-cut duct bank configuration for the XLPE cable system, including 15 feet at each side for working space. For the 230-kV circuit, the vertical and horizontal spacing between the duct banks remains the same for the 85% DLF case and the 100% DLF case.

The 230-kV model was created with the following parameters:

- One (1) UG circuit (4x4) conduit arrangement
- Four (4) cables per phase
- 8’ depth of cover
- 24” center to center spacing on conduits

The ampacity calculations concluded that this configuration of cables could meet the project ampacity requirements for both 85% and 100% DLFs.

Figure 3-1: Golden-Mars UG Preliminary 230-kV XLPE Duct Bank Cross Section (37'-9" Total ROW)



A summary of the ampacity calculations can be seen in Appendix B of this document.

3.4.2 500-kV Duct Bank

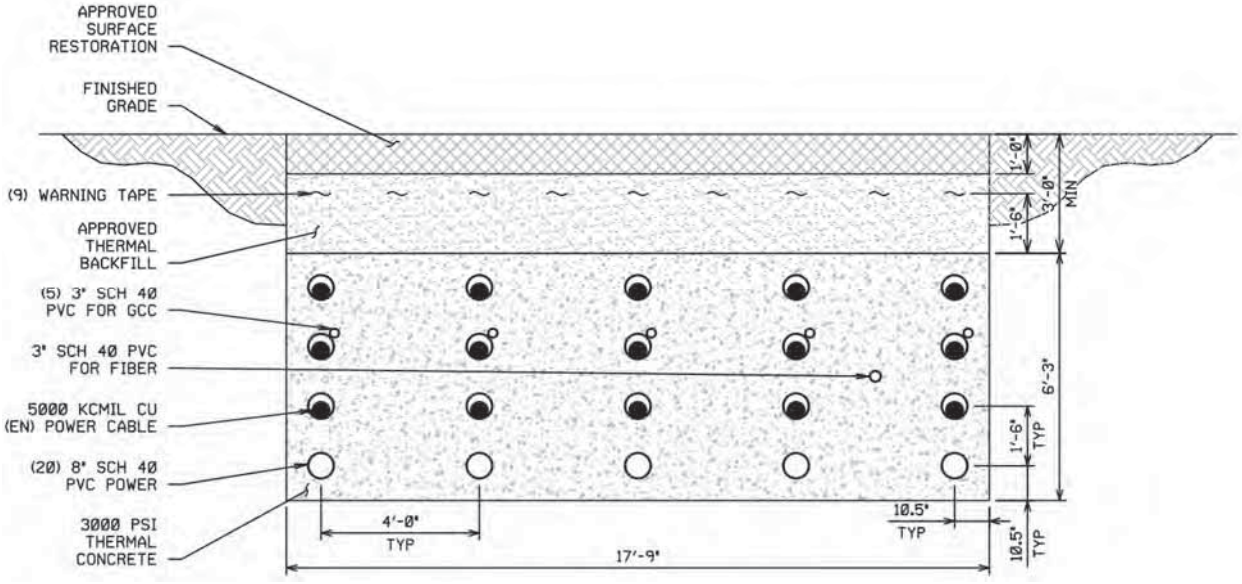
The cross section in Figure 3-2 below represents the anticipated open-cut duct bank configuration for the XLPE cable system, assuming an 85% DLF and including 15 feet at each side for working space. The cross section in Figure 3-3 below represents the anticipated open-cut duct bank configuration for the XLPE cable system, assuming a 100% DLF and including 15 feet at each side for working space. From the ampacity study, it was determined the 100% DLF case would require greater vertical spacing than the 85% DLF case.

The 85% DLF model for the 500-kV circuit was created with the following parameters:

- One (1) UG circuit with (4x5) conduit arrangement
- Five (5) cables per phase
- 8' depth of cover
- 48" center to center horizontal spacing on conduits

- 18” center to center vertical spacing on conduits

Figure 3-2: Golden-Mars UG Preliminary 500-kV XLPE Duct Bank Cross Section, 85% DLF (47’-9” Total ROW)

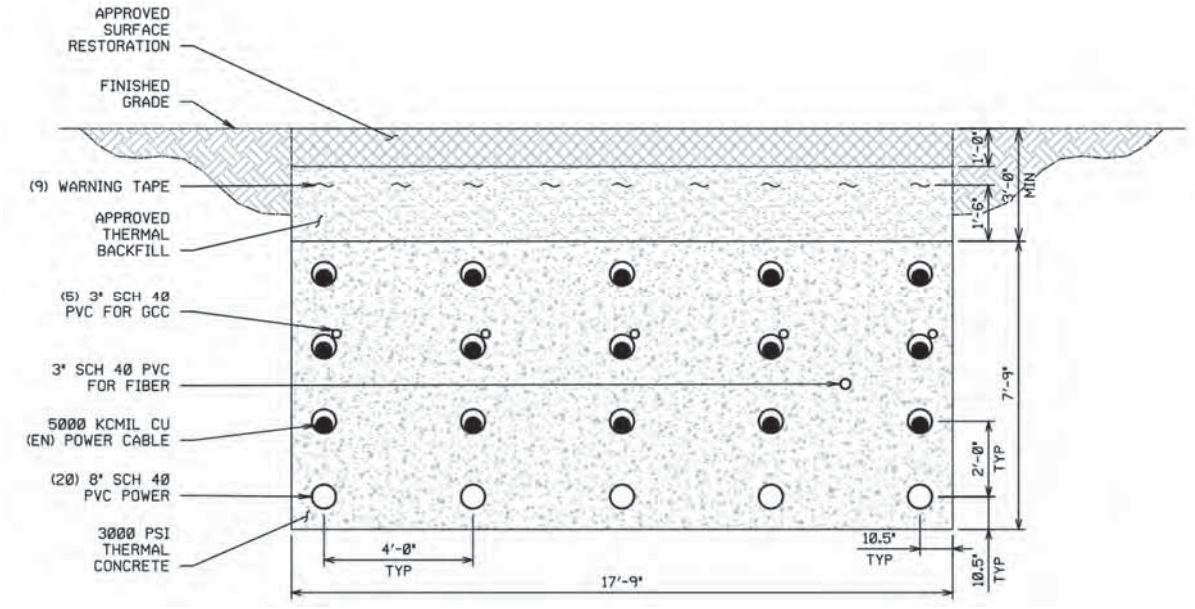


The 100% DLF model for the 500-kV was created with the following parameters:

- One (1) UG circuit with (4x5) conduit arrangement
- Five (5) cables per phase
- 8’ depth of cover
- 48” center to center horizontal spacing on conduits
- 24” center to center vertical spacing on conduits

The ampacity calculations concluded that this configuration of cables could meet the project ampacity requirements with a 100% DLF.

Figure 3-3: Golden-Mars UG Preliminary 500-kV XLPE Duct Bank Cross Section, 100% DLF (47'-9" Total ROW)

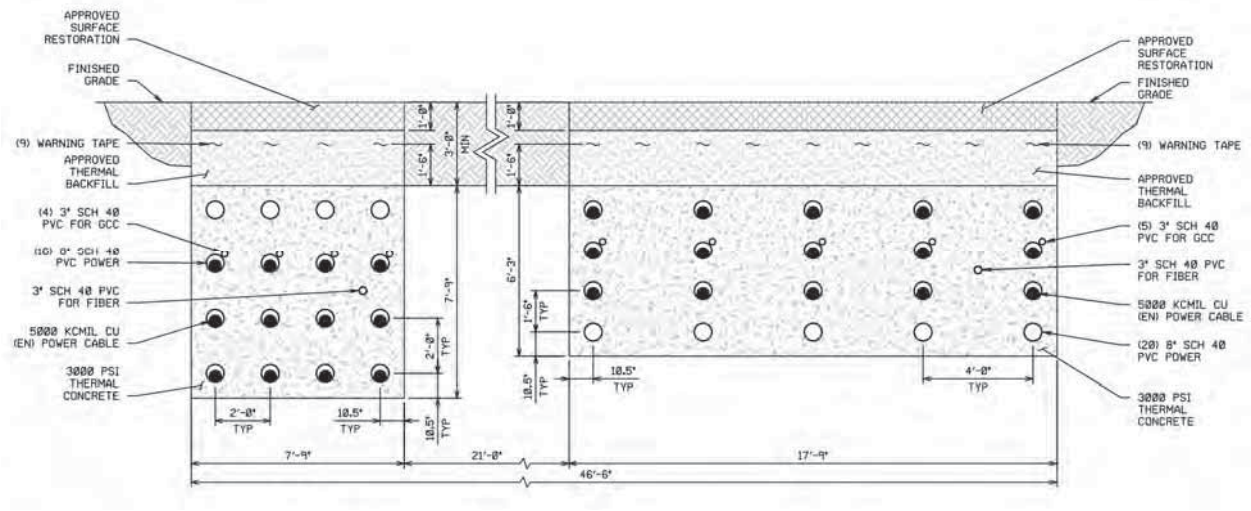


3.4.3 230-kV and 500-kV Duct Banks in Same ROW

The combined circuit route, UG Route 2, will require the 230-kV circuit and the 500-kV to co-exist within the same ROW. The cross section in Figure 3-4 below represents the anticipated open-cut duct bank configuration for the XLPE cable circuit with the 230-kV system and the 500-kV system within the same ROW, at 85% DLF and including 15 feet at each side for working space. The duct bank configuration for the 230-kV circuit is the same as detailed in Section 3.4.1 above. The duct bank configuration for the 500-kV circuit is the same as shown in Figure 3-2 above. The 85% DLF model for the 230-kV and 500-kV circuit within the same ROW was created with a 21-foot edge-to-edge separation between 230-kV and 500-kV duct banks.

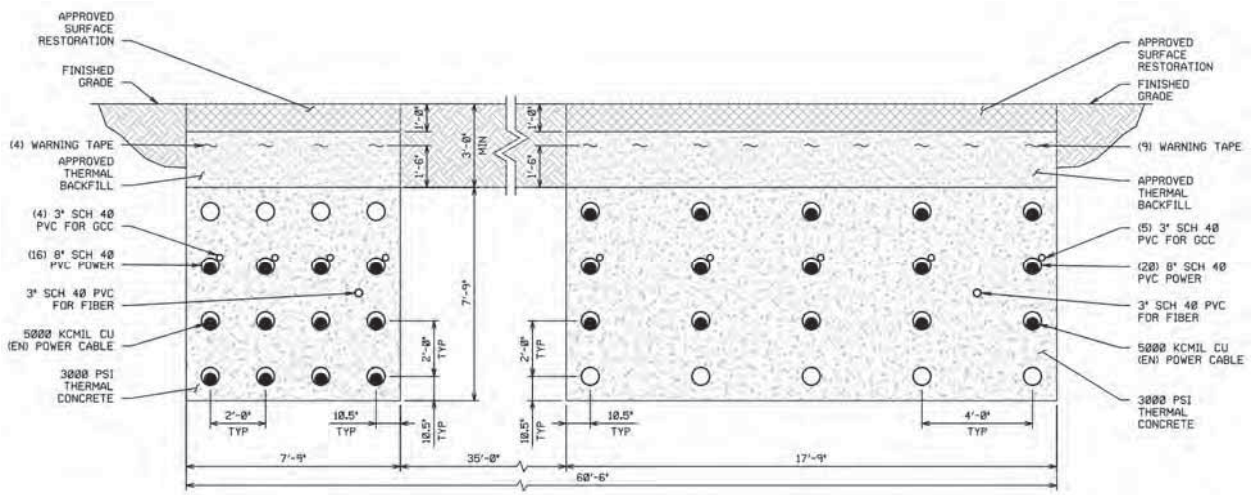
The ampacity calculations concluded that this configuration of cables could meet the project ampacity requirements with an 85% daily load factor.

Figure 3-4: Golden-Mars UG Preliminary 230-kV and 500-kV XLPE Duct Bank Cross Section, 85% DLF (76'-6" Total ROW)



The cross section in Figure 3-5 below represents the anticipated open-cut duct bank configuration for the XLPE cable circuit with the 230-kV system and the 500-kV system within the same ROW, at 100% DLF and including 15 feet at each side for working space. The duct bank configuration for the 230-kV circuit is the same as detailed in Section 3.4.1 above. The duct bank configuration for the 500-kV circuit is the same as detailed in Figure 3-3 above. The 100% DLF model for the 230-kV and 500-kV circuit within the same ROW was created with a 35-foot edge-to-edge separation between 230-kV and 500-kV duct banks. The ampacity calculations concluded that this configuration of cables could meet the project ampacity requirements with a 100% daily load factor. Note that all ampacity scenarios using 100% DLF, require a maximum native soil thermal resistivity of 115 ºC C-cm/watt to meet ampacity requirements.

Figure 3-5: Golden-Mars UG Preliminary 230-kV and 500-kV XLPE Duct Bank Cross Section, 100% DLF (90'-6" Total ROW)



A summary and the CYMCAP executions for all ampacity calculations can be seen in Appendix B of this document.

3.4.4 230-kV and 500-kV Trenchless Installations in Same ROW

The proposed new routes R1 through R4 will require at some specific locations the use of trenchless installations for both, the 230-kV circuit and the 500-kV circuit. Figure 3-6 below represents the anticipated J&B and Microtunneling configuration for the 230-kV XLPE cable system and the 500-kV XLPE cable system within the same ROW, at 100% DLF, assuming 30 feet maximum depth of cover and including 15 feet at each side for working space. Figure 3-7 below represents the anticipated HDD configuration for the 230-kV XLPE cable system and the 500-kV XLPE cable system within the same ROW, at 100% DLF, assuming 45 feet maximum depth of cover and including 15 feet at each side for working space. All the trenchless installations ampacity scenarios, parametric study, bore cross sections and ampacity executions are discussed in detail in Appendix F.

Figure 3-6: Golden-Mars UG Preliminary 230-kV and 500-kV XLPE J&B and Microtunneling Configuration, 100% DLF (270'-0" total ROW). See Appendix F

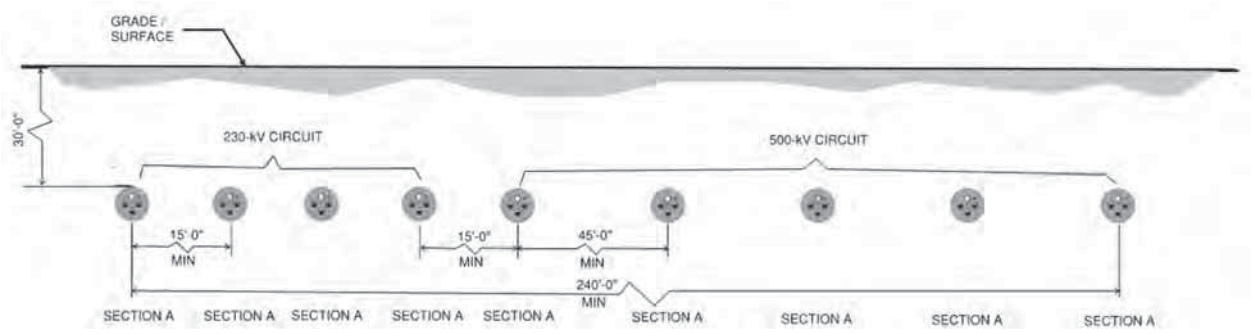
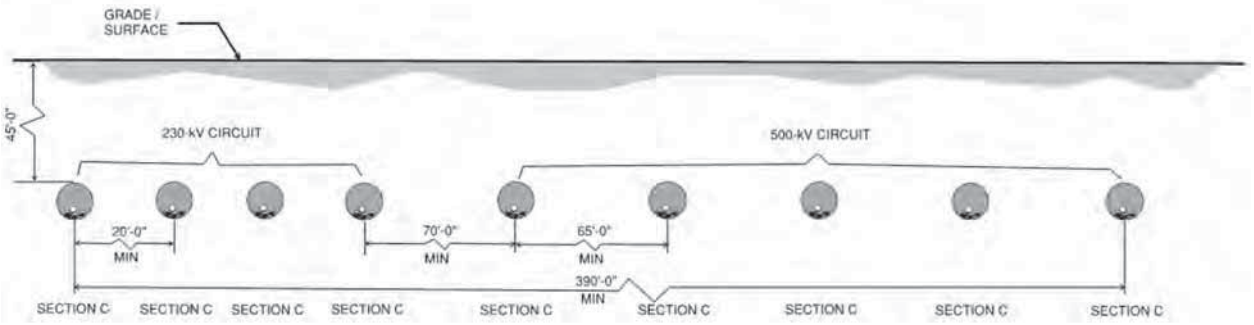


Figure 3-7: Golden-Mars UG Preliminary 230-kV and 500-kV XLPE HDD Configuration, 100% DLF (420'-0" total ROW). See Appendix F



4.0 UNDERGROUND FEASIBILITY REVIEW

BMcD initially evaluated seven (7) UG alignments provided by DEV and ERM (Environmental Resources Management, DEV's consultant) to review the feasibility of these UG routes. Following this initial analysis, ERM and DEV developed four (4) additional UG routes, R1 through R4, which were then submitted to BMcD for further feasibility review.

BMcD performed a desktop review of the routes for the proposed cable system using Google Earth and information provided by DEV and ERM. A site visit was also conducted for the proposed UG Routes 1 through 5. It is important to note that since the additional transition station locations (TS3 through TS8) were provided after the site visit was conducted, the additional routes (UG Routes 6, 7, R1, R2, R3 and R4) were not evaluated during the visit.

This analysis focused on the constructability of the routes based upon route congestion, road or right-of-way width, traffic impacts, and other factors readily available in a desktop level analysis. This report aims to identify any outstanding or unresolved issues that could potentially impact the selected route in the future, such as jurisdictional direction, unknown subsurface environmental conditions, real estate impacts, etc.

A Quality Level C (QL-C) and Quality Level D (QL-D) survey along the paths for the initially proposed routes (UG Routes 1,2 and 3) was provided to BMcD on August 1, 2024. The information on the survey was used to refine the feasibility of each proposed route and their alignments.

4.1 Underground Route Analysis

The objective of the Project routing development process was to identify UG route options from a proposed transition station location (TS1, TS2, TS3, or TS4) to the new Mars Substation (see Figure 4-1) or between proposed transition station locations (TS5 to TS6, or TS7 to TS2). The proposed transition station location and new Mars Substation are discussed in Section 5.0. The proposed underground route will consist of both a 230-kV and 500-kV cable systems. Based on the preliminary substation layout, the proposed 230-kV circuit will enter and terminate on the southeast corner of Mars Substation, while the proposed 500-kV circuit will enter and terminate at the southwest corner.

Figure 4-1: Mars Substation Location

To develop the route alternatives, the proposed UG routes were selected based on potential effects on social and environmental resources. By using multiple data layers within GIS and Google Earth, supplemented by field observations gathered during a site visit, the BMcD engineering team conducted an iterative review of the potential routes. The approach for this study consisted of several main tasks that helped guide the routing study analysis and generate the cost estimates associated with each proposed route.

Finding the preferred transition station location as described in Section 5.0 was the first major step in determining viable route options. In addition, the routing constraints listed in Table 4-1were considered.

Table 4-1 Routing Analysis Constraints

Constraint	Rationale
Existing Subsurface Utility Density & Location of Major Facilities	Pipes, cables, duct banks, manholes, tunnels, foundations, boulders, public utilities, and various other objects installed over time that occupy space under city streets. In urban areas especially, subsurface congestion has become a major obstacle to overcome. Underground duct banks must weave through these utilities while maintaining proper depth for protection and separation from other utilities for heat dissipation. In some cases, existing utilities may be relocated to mitigate conflicts.
Land Acquisition and Private Property Encroachment	The number of parcels crossed provides a general indication of the amount and density of development and potential impacts to landowners that would need to be contacted for temporary construction and/or permanent easements. Easement acquisition requires landowner coordination, which may impact the Project schedule. Generally, minimizing the number of easements required for a Project is preferred.
Road Details	While defining routing criteria, BMcD also considered the road widths. Though the proposed transmission circuit will be installed below grade, it is important to consider the above grade traffic conditions and available lanes during construction. While not determining the physical constructability within a particular corridor, road width can be an indicator of the ease of construction, the work hours allowed for construction, and impact to the traffic in the area.
Impact to Traffic	When trenching on a roadway, typically the traffic pattern will be impacted. Depending on the location of existing underground utilities, the trench could be located anywhere on the road ROW. In areas where the trench will be in the center of the road, additional construction techniques can be used to accommodate traffic patterns. The option to perform the work at night may be feasible and will need to be reviewed at the detailed design phase.

Constraint	Rationale
Sensitive Areas and Facilities	Public relations and public perception are also important characteristics to every project. It is important to maintain a good relationship with the public before, during, and after construction of a project. BMcD recommends evaluating the impact on public facilities such as schools, churches, and hospitals along proposed routes. In addition to public facilities, historically sensitive areas such as cemeteries, parks, wetlands, railroads, and landmarks are also considered when determining and evaluating routing. Open-cut trench activities can also prove challenging in wetlands and other environmentally protected areas both from a construction and a permitting standpoint. For this project a wetland area and highway have been identified.
Constructability	An underground power line ultimately needs to be constructible. Whether the route is in city streets or through a field, there needs to be a way to install the system. Some installation conditions and techniques are more difficult than others. Factors that affect constructability include depth to bedrock, soil conditions, construction work area availability and installation type (concrete encased duct bank system or trenchless). Constructability is also affected by utility density and traffic congestion.

4.1.1 UG Route 1

The proposed UG Route 1 starts from the proposed TS1 location and travels southwest along Route 606 towards Mars Substation. The 230-kV and 500-kV circuits remain in separate ROWs for the entirety of the route. The 500-kV circuit remains on the southern side of Route 606 (Old Ox Road), then diverts south on to Route 857 (Carters School Road) before turning east into the Mars Substation. The 230-kV circuit remains on the northern side of route 606, then diverts through the Amazon Integrated Access Device (IAD) data center parking lot for approximately 3,700 feet towards Mars Substation. The line will then head towards the Mars Substation where the UG circuits will be terminated. The proposed route is approximately 21,300 feet in length for the 230-kV

circuit and 19,400 in length for the 500-kV circuit; it is the longest route. An aerial image of the proposed UG Route 1 is shown in Figure 4-2 below.

As an alternate, the proposed UG Route 1 may be routed to the proposed TS3 location if the parcel for TS1 is not acquirable.

Figure 4-2: Golden-Mars UG Route 1

4.1.1.1 Existing Subsurface Utility Density and Location of Major Facilities

Overhead lines run along the majority of the route 606 corridor and a substation was also identified near the intersection of Route 606 and Ladbrook Drive. It is assumed that there will be underground utilities entering and leaving the identified substation. Figure 4-3 below shows the identified substation on Route 606. The UG duct bank will need to avoid foundations of existing overhead poles and any underground utilities along the route.

Based on the provided survey, a number of UG utilities exist along both sides of the Route 606 corridor. Leveraging the survey data, the route alignment has been adjusted to avoid as many subsurface utilities and structures as possible, while staying out of the Route 606 pavement

wherever possible. However, due to the high congestion of utilities, UG Route 1 is still expected to cross some existing utilities. The expected utility crossings include UG electrical lines, telecommunication lines, RCPs, and a foundation wall, amongst others as shown in Figure 4-4 through Figure 4-7 and Figure 4-36 through Figure 4-40 below. It is likely that with the footprint of the proposed duct bank, some level of utility relocation will be required to install the duct banks.

Figure 4-3: Substation Identified Along Route 606

Figure 4-4: UG Utility Density Along Route 606 - Near to Overland Drive

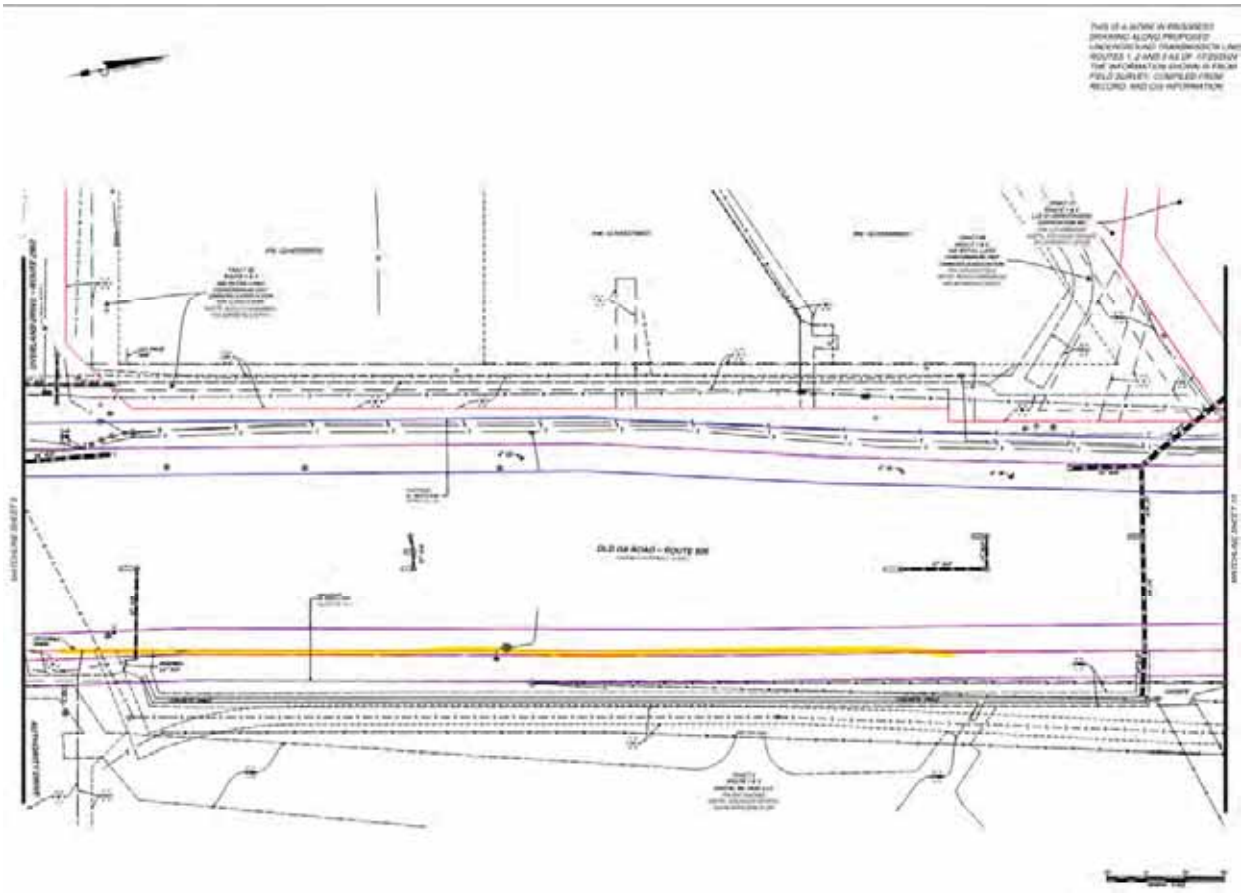


Figure 4-5: UG Utility Density Along Route 606 - Near to Beaver Meadow Road

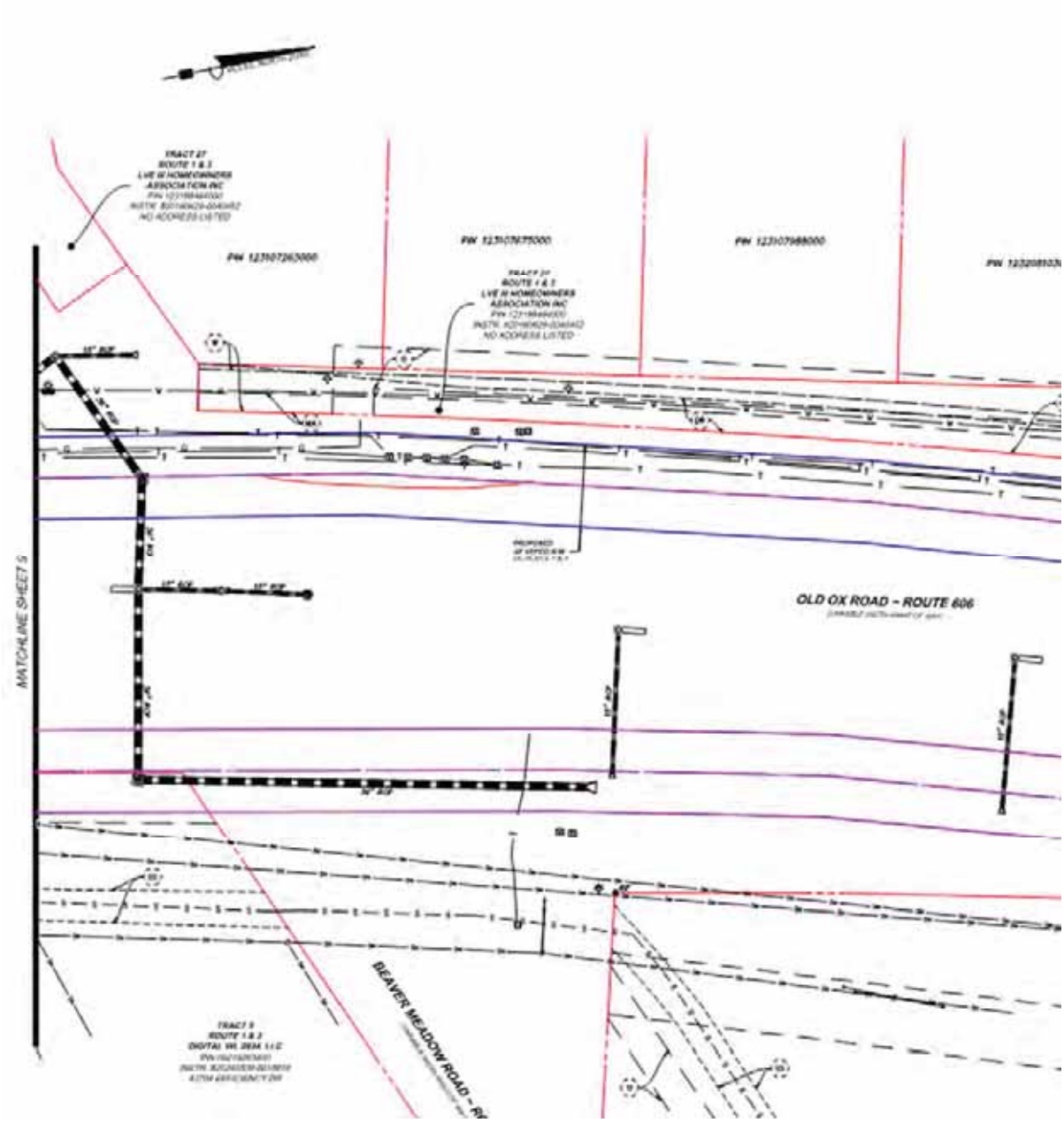


Figure 4-6: UG Utility Density Along Route 606 - Near to Stukely Drive

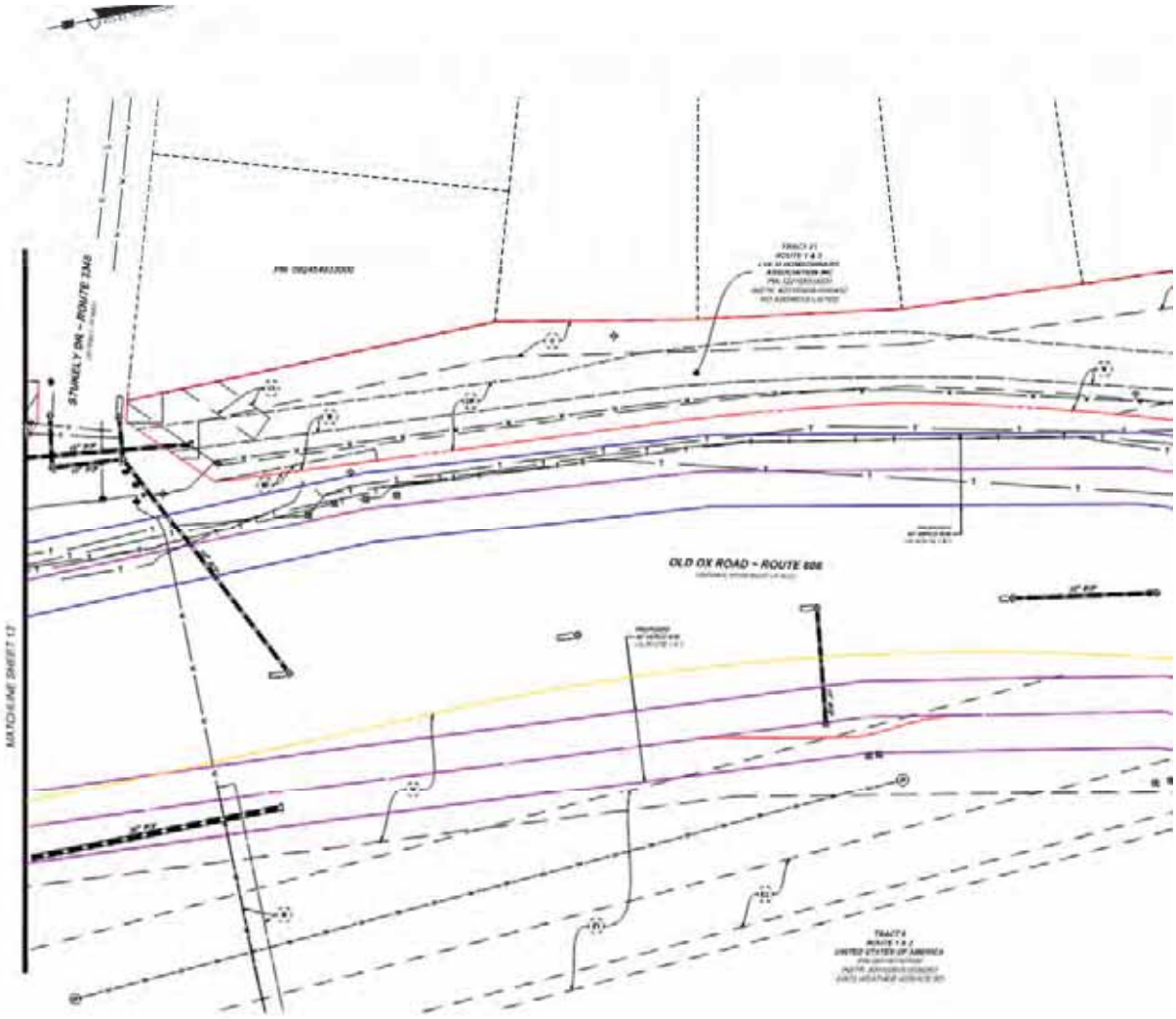
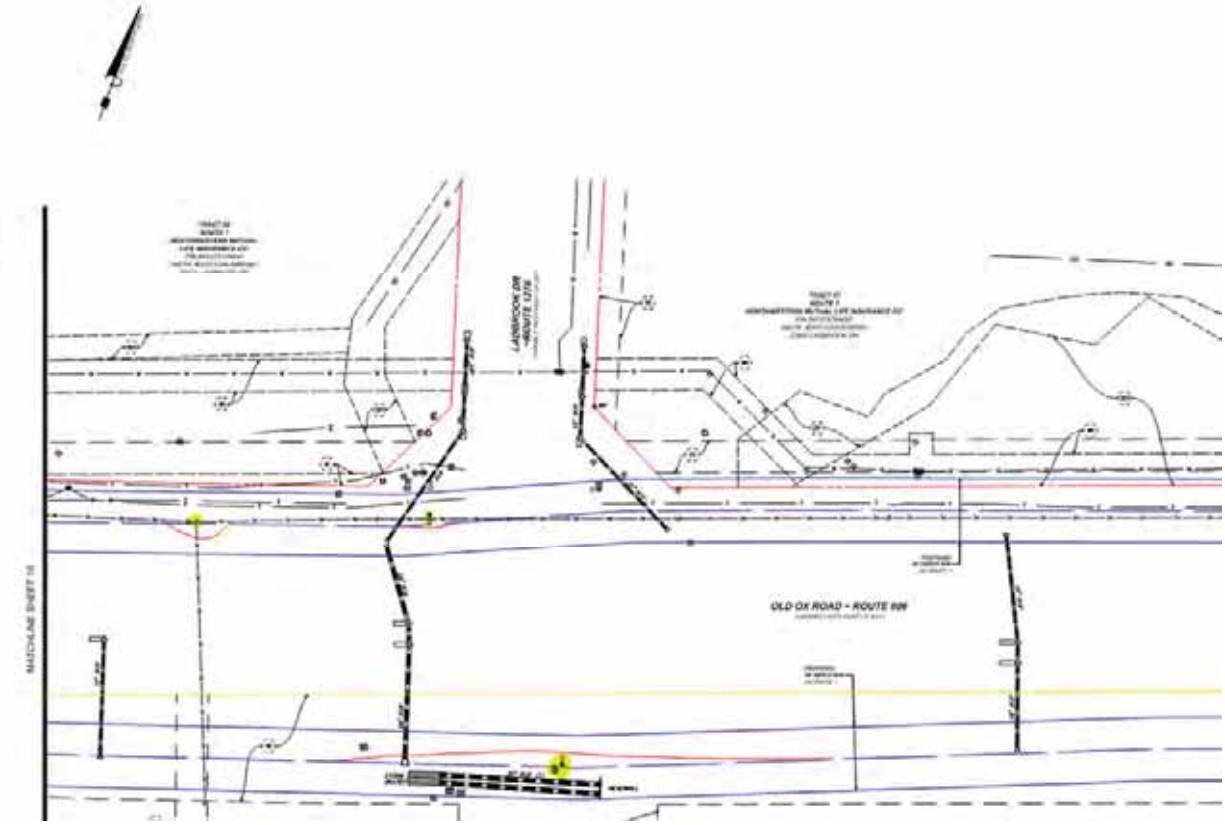


Figure 4-7: UG Utility Density Along Route 606 - Near to Ladbrook Drive



4.1.1.2 Land Acquisition and Private Property Encroachment

UG Route 1 remains in VDOT roads ROW for the majority of the route. However, there are some instances where the UG Route need to divert out of VDOT roads ROW to avoid an existing UG utility and to minimize impact to Route 606.

Per ERM analysis, the route would require new land rights where it deviates from public right-of-way onto a parcel owned by the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS). During a September 27, 2024 meeting, NOAA informed Dominion that they would not grant new land rights, citing the existence of viable alternative routes that avoid NWS lands.

Additionally, due to the location of the Mars Substation and TS1 outside of VDOT roads ROW, some private property encroachments are expected near the stations. The 230-kV circuit must route through private property, to avoid co-location with the 500-kV circuit on the Route 285 corridor. In

total, easements from three (3) unique parcel owners would need to be required for UG Route 1 (Prologis- Exchange (Location for the Amazon IAD), Digital Realty, and SDH Ashburn I, LLC). Figure 4-8 and Figure 4-9 below shows the location where easements will be needed for duct bank placement.

Figure 4-8: Route 1 Easements Near Mars Substation

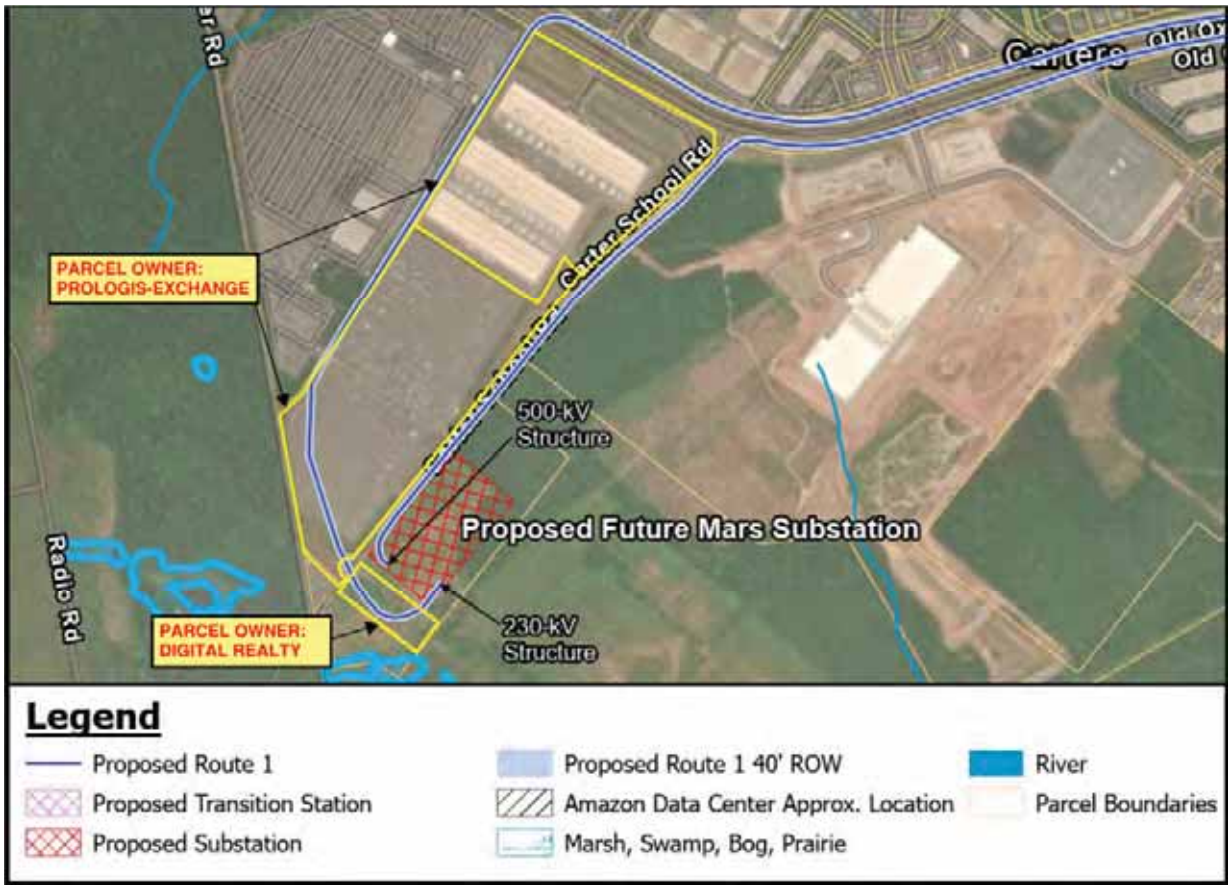
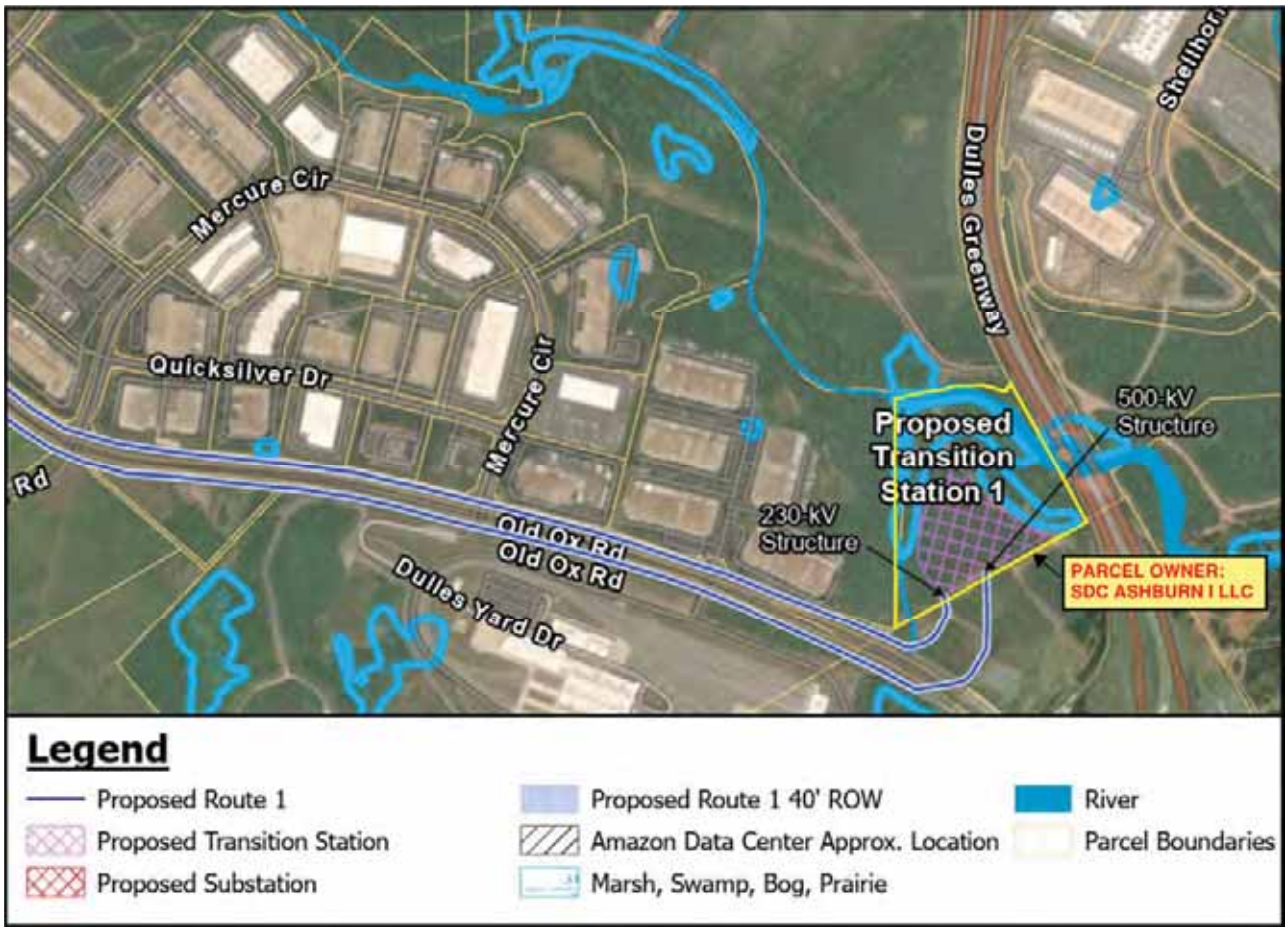


Figure 4-9: Route 1 Easements Near Transition Station 1



4.1.1.3 Road Details

The main corridor for this proposed route is Route 606 which is a four-lane road with a divided median. Route 606 is approximately 100 feet wide, and the duct bank installation can be completed in phases where a couple of lanes can remain open for traffic flow during construction. Figure 4-10 below shows an image of the Route 606 corridor. Since Route 606 is a secondary highway, the proposed UG must minimize impact by avoiding placing trenches on the asphalt where possible and limiting the traffic disturbance during construction to only one (1) lane of traffic. For the proposed UG Route 1, the alignment has been adjusted so the duct bank trench does not require digging into the asphalt on Route 606. At the crossing with Route 606 south of TS1 and at the crossing with Route 606 west of Pebble Run Place open-cut crossing through all traffic lanes is required.

Per ERM analysis, the Virginia Department of Transportation expressed opposition to open-cut installation along or across Route 606 during a September 16, 2024 meeting and in a follow-up email on September 26, 2024. Their concerns include construction-related traffic impacts, conflicts with existing utilities, and potential impacts to road integrity as a result of construction.

For some locations, if splice vaults are stacked adjacently, the vault trenches may need to occupy up to approximately 2 feet of the asphalt on the Route 606 shoulder. At these locations, excavation is only expected on the road shoulder, and no trenching is expected within the ongoing traffic lanes. However, a staggered configuration may be used to minimize impact to Route 606 and avoid excavating the asphalt.

The route crosses a total of eleven (11) other roads where they intersect with Route 606. When crossing these intersections, the duct bank installation will need to be performed in phases to avoid obstruction to the entire intersection. Night work may also be required to reduce obstruction.

For the proposed UG Route 1, 230-kV circuit and 500-kV circuit are installed in separate concrete-encased duct banks, each circuit having its own ROW. The minimum ROW required for the 230-kV circuit is approximately 38 feet in width. At vault locations, the minimum required ROW for the 230-kV circuit is approximately 52 feet. The minimum ROW required for the 500-kV is approximately 48 feet in width. At vault locations, the minimum required ROW is approximately 78 feet. This assumes that 15 feet of working space is required on both sides of the trench limits and outer vault edge.

Figure 4-10: Route 606 Overview

4.1.1.4 Impact to Traffic

Due to the road widths along the route, it appears that sufficient space should exist to allow for effective traffic management. However, the use of alternating lane closures and modified traffic patterns to allow for construction of the proposed duct banks. Only up to a single lane of traffic would be impacted on the Route 606 corridor. It is important to note that splice vaults should not be located in intersections and the preliminary locations have been carefully located using the information on existing utilities included in the survey. For the 230-kV circuit, a total of nine (9) vault locations are required. Since two (2) vaults are required for each 230-kV vault location, a total of eighteen (18) 230-kV splice vaults are required. For the 500-kV circuit, a total of eleven (11) vault locations are required. Since three (3) vaults are required for each 500-kV vault location, per-phase circuit. A total of thirty-three (33) 500-kV splice vaults are required. If needed, splice vaults can be placed in phases to minimize traffic disruptions and lane closures.

4.1.1.5 Sensitive Areas and Facilities

Two (2) water drainage ditch locations were identified along UG Route 1. One (1) at the intersection of Route 857 and Route 606, and one (1) on Route 606 between Ladbrook Drive and Stuckely Drive.

No trenchless crossings are anticipated near these drain ditches, as the circuit paths will avoid the ditches by routing around them. Near TS1, Route 606 is elevated creating a Dam for Horsepen Pond.

As reported by ERM, Dominion consulted with the Virginia Department of Conservation and Recreation (VDCR) about crossing Horsepen Dam. The dam, owned and maintained by the Metropolitan Washington Airports Authority (MWAA) and permitted by VDCR, is classified as 'high-risk' due to its large drainage basin and significant downstream development, including Route 606 and the Dulles Greenway bridge over Broad Run. VDCR highlighted several concerns: significant permitting and operational risks for construction near or within the dam, potential spillway inundation during construction and operation, and the requirement for MWAA's authorization and sponsorship of any dam alterations, which would necessitate hydrologic studies to reassess the inundation zone.

No trenchless crossings are anticipated to cross the pond, as the duct banks will be installed on Route 606, above the water body. Special consideration must be taken near ditches and Horsepen pond to minimize impact on the water bodies by the proposed route. See Figure 4-11 for an image of the drainage ditch on Route 857. Figure 4-12 and Figure 4-13 shows aerial maps views of the drainage ditch locations on UG Route 1.

Figure 4-14 and Figure 4-15 show Horsepen pond located on UG Route 1 near TS1.

Figure 4-11: Drainage Ditch Location on Route 857

Figure 4-12: Drainage Ditch on Route 857, Aerial View

Figure 4-13: Drainage Ditch on Route 606, Aerial View

Figure 4-14 Horsepen Pond near TS1

Figure 4-15: Horsepen Pond near TS1, Aerial View

4.1.1.6 Constructability

Factors that affect constructability include utility density and traffic congestion. The utility congestion along Route 606 will add complexity to the proposed UG Route. Constructability is also affected by depth to bedrock, soil conditions, construction work area availability and route installation type. Based off Geotechnical data from a nearby project site provided by DEV, diabase rock has been identified as the main rock formation at the nearby project site. Diabase rock is an igneous rock that is typically hard and abrasive. A detailed site-specific geotechnical investigation along the proposed route must be performed to further define the diabase rock depth variation along the route as well as other soil layer types, thicknesses and mechanical properties.

This analysis assumes that the parcel for transition station can be acquired. If the parcel cannot be obtained, the proposed route would not be feasible and TS3 would need to be considered as the alternate transition station location for UG Route 1. Reference Figure 4-16 below for an aerial overview of the TS3 location that UG Route 1 would need to reroute to.

Figure 4-16 UG Route 1 Alternate Transition Station Location TS3

UG Route 1 has been reviewed for constructability and feasibility for this project. Throughout this review different challenges have been identified in the previous Sections: UG utility congestion along Route 606 interfering with the proposed alignment, presence and depth of diabase rock formations, soil conditions, construction work area availability, VDOT limitations on Route 606 and traffic control along Route 606, the significant permitting and operational risk of crossing of Horsepen Dam, and the inability to obtain new land rights across the NOAA parcel. In addition, ERM reported that VDOT indicated to Dominion in writing that they are opposed to any open-cut crossing of Route 606 (which requires permission from VDOT). Based on these factors, the proposed UG Route 1 has been determined to not be constructable for this project.

4.1.2 UG Route 2

The proposed UG Route 2 starts from the proposed TS1 location and travels southwest mainly through private properties towards Mars Substation. The 230-kV and 500-kV UG circuits remain in the same ROW for the majority of the route except near the stations where the circuits separate to tie into the respective transition structures. The proposed route is approximately 18,400 feet in length. UG Route 2 leaves the proposed TS1, travelling southwest along Route 606 briefly before

diverting south through private lands (MWAA, Digital Reality). After crossing Route 606, the entire rest of the route remains outside of public ROW, all the way to Mars Substation where the UG circuits will be terminated. An aerial image of the proposed UG Route 2 is shown in Figure 4-17 below.

As an alternate, the proposed UG Route 2 may be routed to the proposed TS3 location if the parcel for TS1 is not acquirable.

Figure 4-17: Golden-Mars UG Route 2

4.1.2.1 Existing Subsurface Utility Density and Location of Major Facilities

Overhead lines run along the majority of the Route 606 corridor and a substation was also identified near the intersection of Route 606 and Ladbrook Drive. UG Route 2 only travels parallel Route 606 for approximately 3,800 feet and avoids the identified overhead lines and substation. UG Route 2 passes though mostly wooded areas and private lots. Future development in these areas

could introduce new utilities and infrastructure along the route, that may require future relocation of the proposed UG transmission circuits.

For UG Route 2, existing UG utilities are apparent on the section of the route which travels northeast parallel to Route 606, see Figure 4-36 through Figure 4-40. Based on the survey, several crossing points for different underground utilities (sanitary lines, storm water lines and manholes, water lines) were identified. Therefore, utility relocations are anticipated to be necessary for UG Route 2 in this section.

4.1.2.2 Land Acquisition and Private Property Encroachment

UG Route 2 is located outside of VDOT roads ROW for the majority of the route, so different property encroachments are expected. In total, easements from three (3) unique parcel owners will be required for UG Route 2 (MWAA, Digital Realty, SDH Ashburn I, LLC). Since it is federal land, permanent easements are not an option for the MWAA property and a special license would be required. Initially UG Route 2 travelled on a parcel owned by the United States of America (USA). The USA-owned parcel houses the National Weather Service (NWS) Forecast Office for Baltimore Washington, which is a government office. In general, easements for government property may be more difficult to obtain and duct bank construction must be careful to avoid disruption to the NWS and airport operations. ERM reported that during a September 27, 2024 meeting, NOAA informed Dominion that they would not grant any new land rights, citing the availability of viable alternatives that avoid National Weather Service (NWS) lands.

Figure 4-18 below shows the location where easements will be needed for duct bank placement along UG Route 2. UG Route 2 has been rerouted to avoid the USA property based on the provided survey information.

Figure 4-18: UG Route 2 Parcel Owners

4.1.2.3 Road Details

UG Route 2 travels briefly parallel to Route 606, which is a four-lane road with a separation median. Route 606 is approximately 100 feet wide, from road edge to road edge. The duct bank installation can be completed in phases where a couple of lanes can remain open for traffic flow during construction. At the crossing with Route 606 south of TS1, open-cut crossing through all traffic lanes is required.

ERM reported that during a September 16, 2024 meeting and in a follow-up email on September 26, 2024, VDOT expressed concerns about open-cut installation along Route 606, citing three key issues: traffic disruption, conflicts with existing utilities, and potential impacts to road integrity.

The route crosses a total of two (2) other roads where they intersect with Route 606. When crossing these intersections, the duct bank installation will need to be performed in phases to avoid obstruction to the entire intersection. The rest of the route travels through private lands consisting of private roadways, parking lots, and forestry. For UG Route 2, the 230-kV Circuit and 500-kV Circuit are collocated within the same ROW except near station locations where the circuits must divert to tie into their respective termination or transition structures. The minimum ROWs required for the collocated duct banks is 76.5 feet minimum ROW for the 85% DLF scenario and 90.5 feet at 100% DLF scenario. The spacing between the two circuits must increase to maintain ampacity at a high DLF; reference Section 3.4.3 above for duct bank design details.

At vault locations, the minimum required ROW for the dual circuit is approximately 115 feet in width. This number is determined based on request from DEV assumed design parameters. This assumes that a minimum 15 feet of working space is required on both sides of the trench limits and outer vault edge.

4.1.2.4 Impact to Traffic

UG Route 2 will briefly parallel Route 606 but will remain outside of the public ROW, except where the route crosses Route 606 towards the proposed transition station. Based on the road width for Route 606, it appears that sufficient space should exist to allow for effective traffic management during construction where the route parallels and crosses the roadway. However, is it anticipated that the use of alternating lane closures and modified traffic patterns will be required to allow for construction of the proposed duct banks. It is important to note that splice vaults should not be located in intersections and the preliminary locations have been carefully located using the information on existing utilities included in the survey. For the 230-kV circuit, seven (7) vault locations are required, for a total of fourteen (14) 230-kV splice vaults for UG Route 2. For the 500-kV circuit, eleven (11) vault locations are required, for a total of thirty-three (33) 500-kV splice vaults for UG Route 2. Because both circuits share the same ROW, it may be necessary to co-locate the splice vaults for each circuit within close proximity. This means that at those locations the route will require a larger ROW width for construction. Even though UG Route 2 is out of the public ROW, there are some private roads along the route. If needed, splice vaults can be placed in phases to minimize traffic disruptions and lane closures.

4.1.2.5 Sensitive Areas and Facilities

UG Route 2 avoids the water drainage ditch location within the study area as it diverts from Route 606 on to private property. However, UG Route 2 also crosses the Horsepen Pond as it exits TS1. Near TS1, Route 606 elevated creating a dam for Horsepen pond. No trenchless crossings are anticipated to cross the pond, as the duct banks will be installed on Route 606, above the water body. Special consideration must be taken near Horsepen pond to minimize impact on the water body by the proposed route. ERM stated that VDCR stated that construction along Horsepen Dam presents significant permitting and operational risks.

UG Route 2 will pass Fire station 304, located on MWAA property. This fire station is specially placed to protect IAD lands and provide services such as aircraft rescue, firefighting, and

emergency services. UG Route may impact unit deployment in and out of the fire station as it crosses the private roadway, Weather Service Road. This roadway provides a path from the fire station to the main road, Route 606. If this route is selected, coordination with the fire station will be required, to minimize impact to public safety. Note that there are also other roadways leaving the fire station that will not be impacted be UG Route 2, and they provide direct paths to IAD. See Figure 4-19 for an overhead view of the location of Fire Station 304 along the UG Route 2.

Figure 4-19: Fire Station 304 Along UG Route 2

4.1.2.6 Constructability

Factors that affect constructability include depth to bedrock, soil conditions, construction work area availability and route installation type. Constructability is also affected by utility density and traffic congestion. Similarly to UG Route 1, if parcel for TS1 is not able to be obtained, the proposed UG Route would need to be re-routed to the TS3 location. Reference Figure 4-20 below for an aerial overview of the TS3 location that UG Route 1 would need to reroute to. Additionally, a large portion of UG Route 2 the 230-kV and 500-kV circuits share a ROW. This may impact construction for future circuit repairs.

Figure 4-20 UG Route 2 Alternate Transition Station Location TS3

UG Route 2 has been reviewed for constructability and feasibility for this project. Throughout this review different challenges have been identified in the previous Sections: UG utility congestion along the segment paralleling Route 606, presence and depth of diabase rock formations, soil conditions, construction work area availability, VDOT limitations on Route 606 and traffic control along Route 606, encroachments into private property and federal lands, and circuits sharing the same ROW impacting construction for future circuit repairs. In addition, ERM stated that VDOT provided written confirmation of their opposition to any open-cut crossing of Route 606, for which their permission is required. Additionally, crossing Horsepen Dam presents significant permitting and operational risks as detailed by VDCR. Based on these factors, the UG Route 2 has been determined to not be constructable for this project.

4.1.3 UG Route 3

The proposed UG Route 3 starts from the proposed TS2 location and travels southwest along Route 606 towards Mars Substation. Directly leaving proposed TS2, the 230-kV and 500-kV circuits run parallel in close proximity to pass between an existing OH line on the west and private property to the east before entering Route 606. Note that even though the circuits come within close proximity,

they are still considered within separate ROWs and will maintain the minimum spacing required between the duct banks to meet the ampacity requirements. The two duct banks will be separated by 40 feet from duct bank edge to duct bank edge. The 500-kV circuit remains on the southern side of Route 606, then diverts south to Route 857 before turning east into the Mars Substation. The 230-kV circuit remains on the northern side of route 606, then diverts through the Amazon IAD data center parking lot for approximately 3700 feet towards Mars Substation. The line will then head towards the proposed transition station where the UG circuits will be terminated. The proposed route is approximately 15,500 feet in length for the 230-kV circuit and 13,400 in length for the 500-kV circuit; it is the shortest route. An aerial image of the proposed UG Route 3 is shown in Figure 4-21 below.

Figure 4-21: Golden-Mars UG Route 3

4.1.3.1 Existing Subsurface Utility Density and Location of Major Facilities

The route consists of two circuits installed in separate concrete encased duct banks, each circuit having its own ROW. The minimum ROW required for the 230-kV is approximately 38 feet in width. At vault locations, the minimum required ROW is approximately 52 feet. This assumes that 15 feet of working space is required on both sides of the trench limits and outer vault edge. Overhead lines

run along the majority of the route 606 corridor with a substation near the intersection of Route 606 and Ladbrook drive.

Based on the utility survey received from DEV, a few number of UG utilities exist along the north side of the Route 606 corridor. Leveraging the survey data, the route alignment has been adjusted to avoid as many subsurface utilities and structures as possible, while staying out of the Route 606 pavement. However, due to the high congestion of utilities, the proposed UG Route 3 is expected to cross a number of the existing utilities. The expected utility crossings include UG electrical lines, telecommunication lines, RCPs, and a foundation wall, amongst others as shown in Figure 4-4 through Figure 4-7 above. It is likely that with the footprint of the proposed duct bank, some level of utility relocation will be required to install the duct banks.

4.1.3.2 Land Acquisition and Private Property Encroachment

UG Route 3 remains in VDOT roads ROW for the majority of the route. However, there are some instances where the UG Route need to divert out of VDOT roads ROW to avoid an existing UG utility and to minimize impacts to Route 606. One location where the route leaves public ROW would require new land rights on the NOAA NWS parcel. ERM reported that during a September 27, 2024 meeting, NOAA informed Dominion that they would not grant new land rights, citing viable alternative routes that avoid NWS lands. Additionally, due to the location of Mars Substation and TS2 outside of public ROW, some private property encroachments are expected near the stations. Near TS2, the route travels briefly through the Amazon IAD property where the two circuits were brought as close together as possible to minimize the width of the encroachment. While the 500-kV circuit leaves Mars Substation on Route 857, the 230-kV routes travels briefly through Prologis-Exchange property. In total, easements from three (3) unique parcel owners will be required for UG Route 3 (Prologis- Exchange and Digital Realty, and Amazon IAD). Figure 4-22 and Figure 4-23 below shows the location where easements will be needed for duct bank placement.

Figure 4-22: Route 3 Easements near Mars Substation

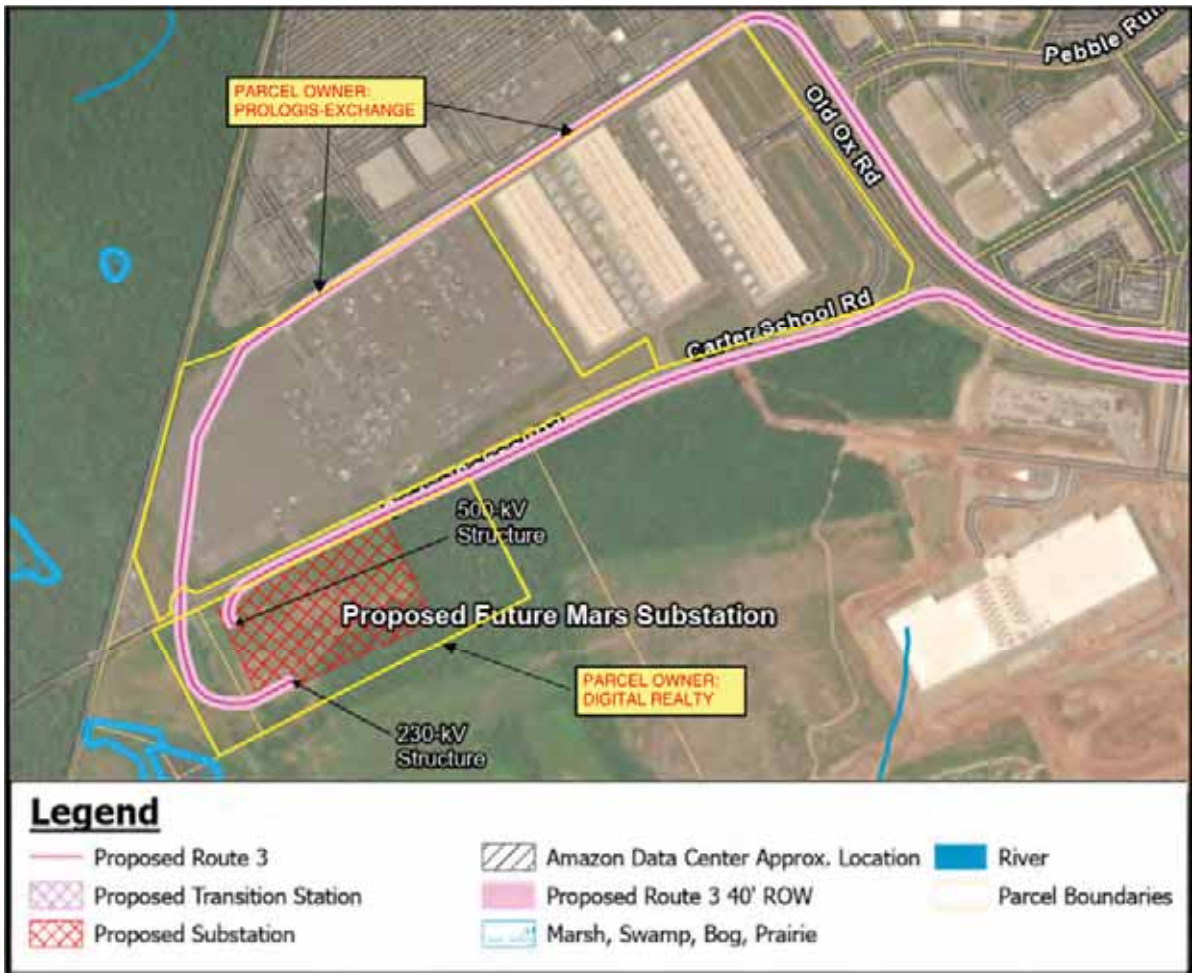
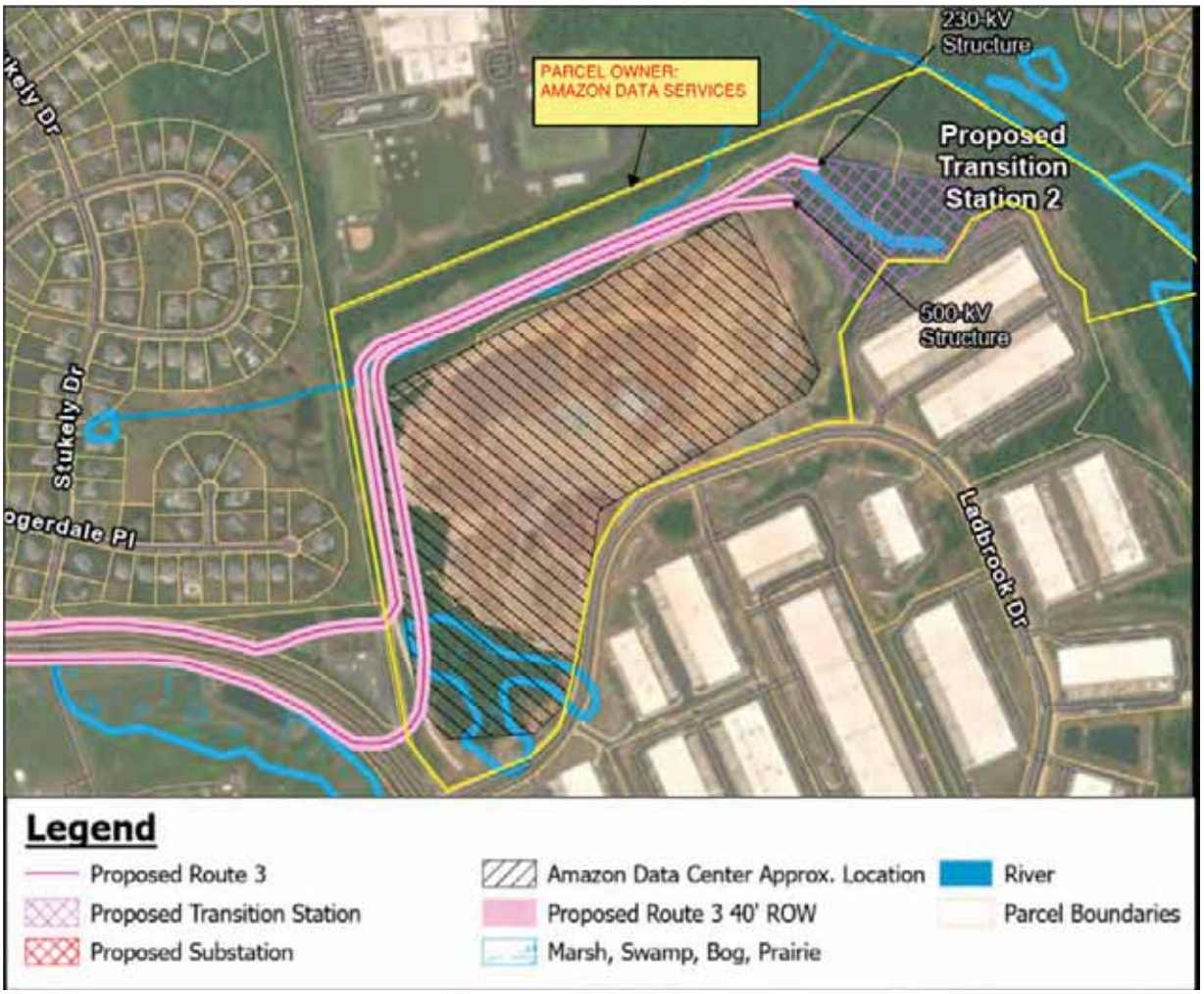


Figure 4-23 Route 3 Easements near Transition Station



4.1.3.3 Road Details

The main corridor for this route is Route 606 which is a four-lane road with a separation median. Route 606 is approximately 100 feet wide, and the duct bank installation can be completed in phases where a couple of lanes can remain open for traffic flow during construction. Reference Figure 4-10 above for an image of the Route 606 corridor. Since Route 606 is a secondary highway, the proposed UG must minimize impact by avoiding placing trenches on the asphalt where possible and limiting the traffic disturbance during construction to only one (1) lane of traffic. For the proposed UG Route 3, the alignment has been adjusted so the duct bank trench does not require digging into the asphalt on Route 606. At the crossings with Route 606 west of Ladbrook Drive shown in Figure 4-24 below and at the crossing with Route 606 west of Pebble Run Place open-cut crossing through all traffic lanes is required.

ERM reported that during a September 16, 2024 meeting and in a follow-up email on September 26, 2024, VDOT expressed concerns about open-cut installation along Route 606, citing three key issues: traffic disruption, conflicts with existing utilities, and potential impacts to road integrity.

For some locations, if splice vaults are stacked adjacently, the vault trenches may need to occupy up to approximately 2 feet of the asphalt on the Route 606 shoulder. At these locations, excavation is only expected on the road shoulder, and no trenching is expected within the ongoing traffic lanes. However, a staggered configuration may be used to minimize impact to Route 606 and avoid excavating the asphalt. The route crosses a total of six (6) other roads where they intersect with Route 606. When crossing these intersections, the duct bank installation will need to be performed in phases to avoid obstruction to the entire intersection. Night work may also be required to reduce obstruction. For UG Route 3, the 230-kV circuit and 500-kV circuit are installed in separate concrete encased duct banks, each circuit having its own ROW. The minimum ROW required for the 230-kV circuit is approximately 38 feet in width. At vault locations, the minimum required ROW for the 230-kV circuit is approximately 52 feet. The minimum ROW required for the 500-kV is approximately 48 feet in width. At vault locations, the minimum required ROW is approximately 78 feet. This assumes that 15 feet of working space is required on both sides of the trench limits and outer vault edge.

Figure 4-24: UG Route 3 Crossings with Route 606 at Existing Substation West of Ladbrook Drive

4.1.3.4 Impact to Traffic

Due to the road widths along the route, it appears that sufficient space should exist to allow for effective traffic management. At this stage of the design, it would be anticipated alternating lane closures and modified traffic patterns would be required to allow for construction of the proposed duct banks. Only up to a single lane of traffic would be impacted on the Route 606 corridor. It is important to note that splice vaults should not be located in intersections and the preliminary locations have been carefully located using the information on existing utilities included in the survey. For the 230-kV circuit, a total of six (6) splice vault locations are required. Since two (2) vaults are required for each location along the 230-kV circuit a total of twelve (12) 230-kV splice vaults are proposed. For the 500-kV circuit, a total of eight (8) vault locations are required. Since three (3) vaults are required for each location along the 500-kV circuit, a total of twenty-four (24)

500-kV splice vaults are needed for UG Route 3. If needed, splice vaults can be placed in phases to minimize traffic disruptions and lane closures.

4.1.3.5 Sensitive Areas and Facilities

Just like UG Route 1, two (2) water drainage ditch locations were identified along crossings along UG Route 3. One (1) at the intersection of Route 857 and Route 606, and one (1) on Route 606 between Ladbrook Drive and Stuckely Drive. No trenchless crossings are anticipated near these drain ditches, as the circuit paths will avoid the ditches by routing around them. Special consideration must be taken near ditches to minimize impact on the water bodies by the proposed route. See Figure 4-11 above for an image of the drainage ditch on Route 857. Figure 4-12 and Figure 4-13 above shows aerial maps views of the drainage ditch locations on UG Route 3.

4.1.3.6 Constructability

UG Route 3 uses transition station location TS2, which is situated upon a flood plain. See section 5.2.2 below for more details on the flood plain effects on TS2. On the way to TS2, UG Route 3 runs above a riverine for approximately 1,700 feet, a National Wetland Inventory (NWI) identified wetland. According to the US Fish and Wildlife Service, the riverine may be subject to seasonal flooding. It is unknown how the wetland and seasonal flooding may affect soil conditions. Construction activities will need to be coordinated to avoid times where high-water levels are present.

One major issue affecting the constructability of one segment of the UG Route 3 is the crossing with Route 606 around the existing substation west of Ladbrook Drive shown in Figure 4-24. The proposed UG Route will be passing through different OH distribution lines dead-end structures from where the OH conductor enter the substation, will be encroaching partially into different OH high-voltage transmission lines power corridors and traveling through a narrow path between existing OH power corridors. To build this segment, DEV would need to acquire permits to plan phased outages, demolish and relocate different OH line support structures and their foundations, which may impact the substation yard design receiving those OH lines. These challenges amplify the risk of redesigning up to some extent the existing substation.

UG Route 3 has been reviewed for constructability and feasibility for this project. Throughout this review different challenges have been identified in the previous Sections: UG utility congestion

along Route 606, presence and depth of diabase rock formations, soil conditions, construction work area availability, VDOT limitations on Route 606 and traffic control along Route 606, encroachments into private property, water drainage ditches located close to the proposed alignment, crossings through OH distribution lines dead-end structures from existing substation on Route 606, and ERM noted that VDOT indicated to Dominion in writing their opposition to any open-cut crossing of Route 606 as well as the inability to obtain new land rights across the NOAA parcel. Based on these factors, the UG Route 3 has been determined to not be constructable for this project.

4.1.4 UG Route 4

UG Route 4 begins at TS2 and travels south on the western side of Loudoun Valley Estates towards the new Mars Substation as shown in Figure 4-25. In this route both circuits are coexisting in the same ROW. The proposed route is approximately 15,900 feet in length. Through this desktop analysis BMcD has detected a number of constructability disadvantages greater than those of the other proposed routes. The disadvantages of the proposed UG Route 4 are as follows:

- Majority of route is outside of public ROW, and easements will be required from four (4) separate parcel owners: MWAA, Amazon Data Services, United States of America, and Digital Realty LLC
- Proximity to Broad Run Creek, parallels a riverine, and within the floodplain area at TS2, where there is increased risk for rocky soil and karst topography.
- 230-kV and 500-kV circuits share a ROW which may impact construction for future circuit repairs
- Constructability concerns such as utility congestion along Old Ox Road
- Requirements of open-cut trenching across Old Ox Road. VDOT will not allow open cut trenching through Old Ox Road and trenchless crossings will be required.
- The existing stormwater pond on NOAA property and the impact to NOAA’s security perimeter.

UG Route 4 passes Dulles International Airport (IAD) as it travels southwest toward Mars Substation and thereby encroaches on property owned by the Metropolitan Washington Airports Authority (MWAA) and the National Oceanic and Atmospheric Administration (NOAA). As these are federal lands, permanent easements are not possible without consent of those respective agencies and alternative land rights agreements would be required. NOAA has informed Dominion that such agreements would not be granted for a crossing of their property.

Given the significant and cumulative construction drawbacks outlined above, the UG Route 4 has been determined to not be constructable for this project and further in-depth analysis of this UG route was not performed.

4.1.5 UG Route 5

UG Route 5 travels south from TS2 on the eastern side of Loudoun Valley Estates towards the new Mars Substation as shown in Figure 4-25. In this route both circuits are coexisting in the same ROW. The proposed route is approximately 15,850 feet in length. Similarly to the proposed UG Route 4, through this desktop analysis BMcD has detected a number of constructability disadvantages greater than those of the other proposed routes. The disadvantages of the proposed UG Route 5 are as follows:

- Majority of route is outside of public ROW, and easements will be required from eleven (11) separate parcel owners including seven (7) limited liability companies (LLCs), Loudoun County Board of Supervisors, LVE III Homeowners Association, Microsoft Corporation, Loudoun County Public Schools and Amazon Data Services
- Parallels Broad Run Creek for approximately 4,322 feet placing approximately 30% of the route within a flood plain.
- 230-kV and 500-kV circuits share a ROW which may impact construction for future circuit repairs
- Constructability concerns such as utility congestion along Old Ox Road
- Requirements of open-cut trenching across Old Ox Road. VDOT will not allow open cut trenching through Old Ox Road and trenchless crossings will be required.

Any route crossing Loudoun County Public Schools (LCPS) property would require approval from the LCPS Board. During discussions, LCPS staff expressed opposition to any construction affecting the access road to Rosa Lee Carter Elementary School and Rock Ridge High School, as it provides the only entry point for both schools. Consequently, LCPS does not support any route that would require closing this access drive.

Given the significant and cumulative construction drawbacks outlined above, the UG Route 5 has been determined to not be constructable for this project and further in-depth analysis of this UG route was not performed.

Figure 4-25: Golden - Mars UG Routes 4 and 5 to TS2

4.1.6 UG Route 6

The proposed UG Route 6 starts from the proposed TS4 location. The 230-kV circuit travels west around the Ladbrook Drive loop, while the 500-kV Route travels south around the Ladbrook Drive Loop. Leaving Ladbrook Drivee, each circuit then travels southwest along Route 606 towards Mars Substation. The 230-kV and 500-kV circuits remain in separate ROWs for the entirety of the route. The 500-kV circuit remains on the southern side of route 606, then diverts south on to Route 857

before turning east into the Mars Substation. The 230-kV circuit remains on the northern side of route 606, then diverts through the Amazon Integrated Access Device (IAD) data center parking lot for approximately 3,700 feet towards Mars Substation. The line will then head towards the Mars Substation where the UG circuits will be terminated. The proposed route is approximately 21,300 feet in length for the 230-kV circuit and 19,400 in length for the 500-kV circuit. An aerial image of the proposed UG Route 6 is shown in Figure 4-26 below.

Figure 4-26: Golden-Mars UG Route 6

4.1.6.1 Existing Subsurface Utility Density and Location of Major Facilities

Overhead lines run along the majority of the route 606 corridor and a substation was also identified near the intersection of Route 606 and Ladbrook Drive. It is assumed that there will be underground utilities entering and leaving the identified substation. Figure 4-3 above shows the identified substation on Route 606. The UG duct bank will need to avoid foundation of existing overhead poles and any UG utilities along the route.

Based on the utility survey provided by DEV, a number of UG utilities exist along the north side of the Route 606 corridor. Leveraging the survey data, the route alignment has been adjusted to avoid as many subsurface utilities and structures as possible, while staying out of the Route 606 pavement. However, due to the high congestion of utilities, the proposed UG Route 6 is expected to cross a number of them.. The expected utility crossings include UG electrical lines, telecommunication lines, RCPs, and a foundation wall, amongst others as shown in Figure 4-4 through Figure 4-7 above. It is likely that with the footprint of the proposed duct bank, some level of utility relocation will be required to install the duct banks.

4.1.6.2 Land Acquisition and Private Property Encroachment

UG Route 6 remains in VDOT roads ROW for the majority of the route. However, there are some instances where the UG routes need to divert out of VDOT roads ROW to avoid an existing UG utility and to minimize impact to Route 606. Per ERM's review, the route would require new land rights where it deviates from public ROW onto a parcel owned by the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS). During a September 27, 2024 meeting, NOAA informed Dominion that they would not grant new land rights, citing the existence of viable alternative routes that avoid NWS lands.

Additionally, due to the location of the Mars Substation and TS4 outside of public ROW, some private property encroachments are expected near the stations. In addition, 230-kV circuit must route through private property, to avoid collocation with the 500-kV circuit on the Route 285 corridor. In total, easements from three (3) unique parcel owners will be required for UG Route 1 (Prologis- Exchange (Location for the Amazon IAD), Digital Realty, and Minalter Incorporated (Inc.)). Figure 4-8 and Figure 4-9 above shows the location where easements will be needed for duct bank placement near Mars Substation. These locations are the same as the easement locations for UG

Route 1. Minalter Inc. owns the parcel which TS4 is located, and this land would have to be acquired if UG Route 6 is selected for detailed design.

4.1.6.3 Road Details

The main corridor for this route is Route 606 which is a four-lane road with a separation median. Route 606 is approximately 100 feet wide, and the duct bank installation can be completed in phases where a couple of lanes can remain open for traffic flow during construction. Figure 4-10 below shows an image of the Route 606 corridor. Since Route 606 is a secondary highway, the proposed UG must minimize impact by avoiding placing trenches on the asphalt where possible and limiting the traffic disturbance during construction to only one (1) lane of traffic. For UG Route 6, the alignment has been adjusted so the duct bank trench does not require digging into the asphalt on Route 606. The crossing with Route 606 at Ladbrook Drive shown in Figure 4-27 below and the crossing with Route 606 west of Pebble Run Place will require open-cut trenching throughout all Route 606 traffic lanes. ERM reported that during a September 16, 2024 meeting and in a follow-up email on September 26, 2024, VDOT expressed concerns about open-cut installation along Route 606, citing three key issues: traffic disruption, conflicts with existing utilities, and potential impacts to road integrity.

For some locations, if splice vaults are stacked adjacently, the vault trenches may need to occupy up to approximately 2 feet of the asphalt on the Route 606 shoulder. At these locations, excavation is only expected on the road shoulder, and no trenching is expected within the ongoing traffic lanes. However, a staggered configuration may be used to minimize impact to Route 606 and avoid excavating the asphalt. The route crosses a total of eight (8) other roads where they intersect with Route 606. When crossing these intersections, the duct bank installation will need to be performed in phases to avoid obstruction to the entire intersection. Night work may also be required to reduce obstruction.

Figure 4-27: UG Route 6 Crossings with Route 606 at Ladbrook Drive

As mentioned above, the Ladbrook Drive corridor leading to TS4 may only be considered for single duct bank at a time. On the side of the loop which the 500-kV Route takes, the existing utilities running parallel on the corridor do not leave enough room for the 500-kV manhole location. The existing storm drainage and gravity sewer lines would need to be relocated if UG Route 6 is selected. To minimize impact on the existing utilities, a staggered configuration is proposed for the 500-kV splice vault location on Ladbrook Drive. Figure 4-28 and Figure 4-29 below shows the 500-kV splice vault to be utilized on the Ladbrook Drive corridor. For UG Route 6, 230-kV circuit and 500-kV circuit are installed in separate concrete-encased duct banks, each circuit having its own ROW. The minimum ROW required for the 230-kV circuit is approximately 38 feet in width. At vault locations, the minimum required ROW for the 230-kV circuit is approximately 52 feet. The minimum ROW required for the 500-kV is approximately 48 feet in width. At vault locations, the minimum

required ROW is approximately 78 feet. This assumes that 15 feet of working space is required on both sides of the trench limits and outer vault edge.

Figure 4-28 Staggered 500-kV Splice Vault Layout

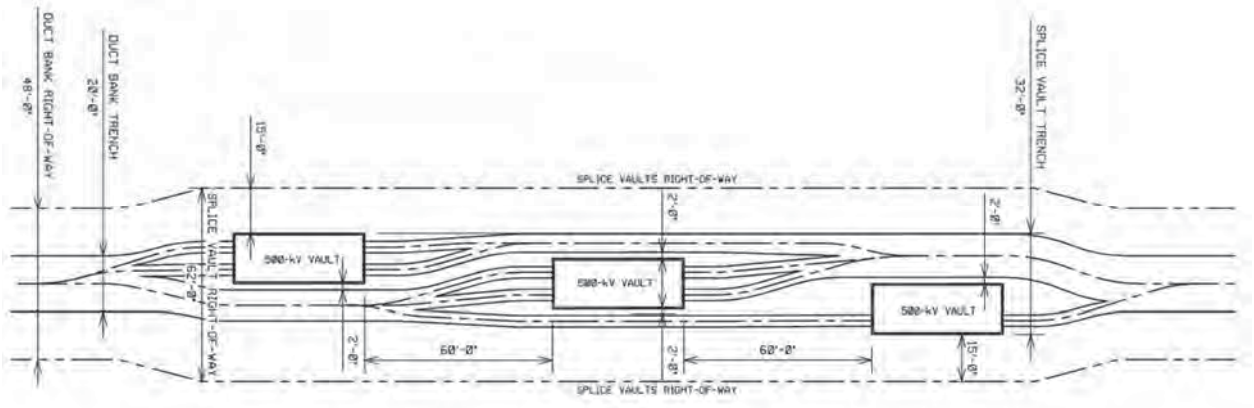
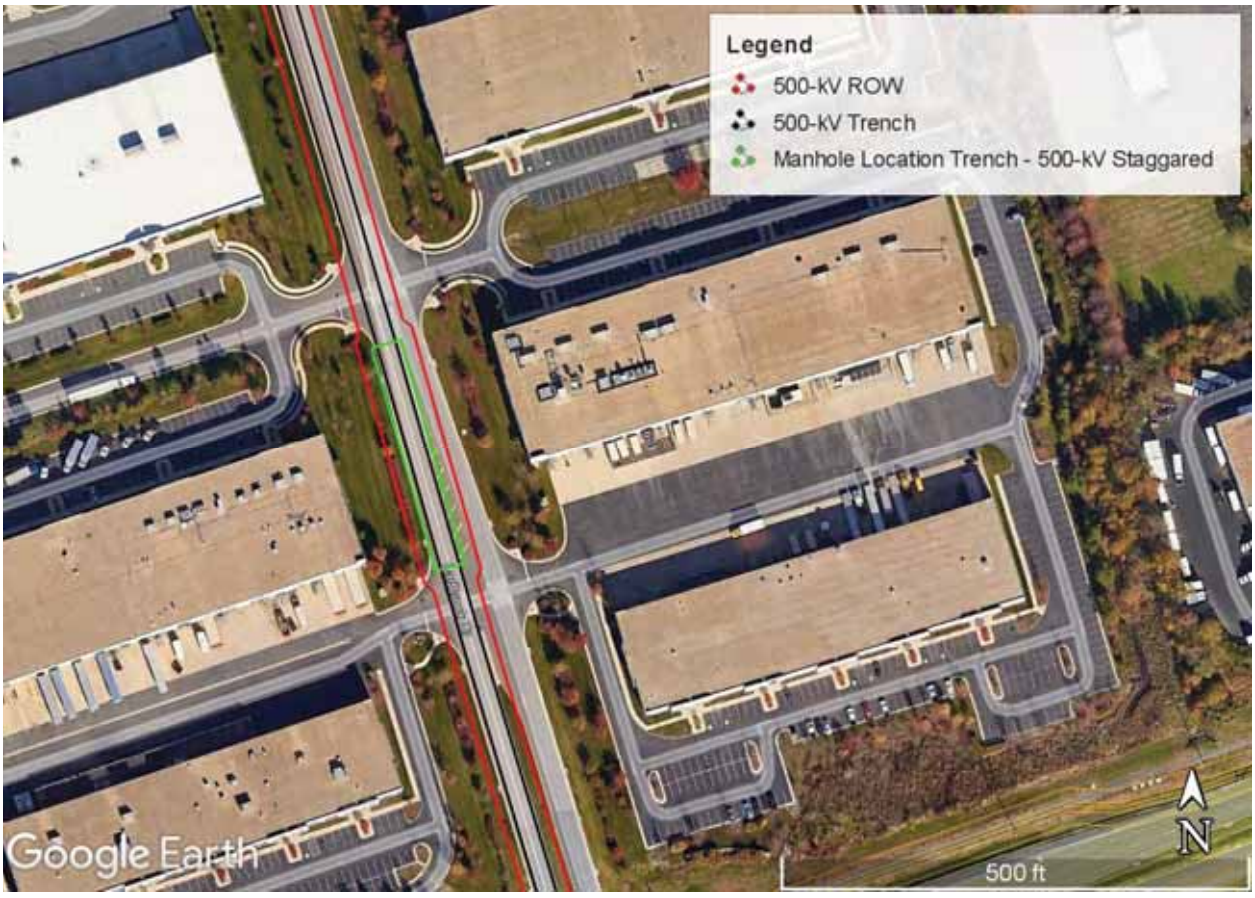


Figure 4-29: Staggered 500-kV Splice Vault Location



4.1.6.4 Impact to Traffic

Due to the road widths along the route, it appears that sufficient space should exist to allow for effective traffic management. However, it would be anticipated alternating lane closures and modified traffic patterns would be required to allow for construction of the proposed duct banks. Only up to a single lane of traffic would be impacted on the Route 606 corridor. On the Ladbrook Drive Corridor, it will be necessary to occupy at least two (2) of the four (4) lanes of traffic during construction. It is important to note that splice vaults should not be located in intersections and the preliminary locations have been carefully located using the information on existing utilities included in the survey. For the 230-kV circuit, a splice vault location will be placed every 2,400 feet, for a total of seven (7) vault locations. Based on the 230-kV system requirement, two (2) vaults are required for each vault location to splice the four (4) cables-per-phase circuit. For the 500-kV circuit, a splice vault location will be placed every 1,700 feet, for a total of eight (8) vault locations. Based on the 500-kV system requirement, three (3) vaults are required for each vault location, to splice the five (5) cables-per-phase circuit. A total of fourteen (14) 230-kV splice vaults and twenty-four (24) 500-kV splice vaults will be needed for UG Route 6. If needed, splice vaults can be placed in phases to minimize traffic disruptions and lane closures.

4.1.6.5 Sensitive Areas and Facilities

Two (2) water drainage ditch locations were identified along UG Route 6. One (1) at the intersection of Route 857 and Route 606, and one (1) on Route 606 between Ladbrook Drive and Stuckely Drive. No trenchless crossings are anticipated near these drain ditches, as the circuit paths will avoid the ditches by routing around them. There is an existing stormwater retention basin/pond in the middle of the TS4 site. If UG Route 6 is selected for detailed design, the retention basin/pond would need to be relocated before construction of the transition station can begin. See Figure 4-11 above for an image of the drainage ditch on Route 857. Figure 4-12 and Figure 4-13 above shows aerial maps views of the drainage ditch locations on UG Route 6. Figure 4-30 below shows an aerial view of the retention basin/pond located at the TS4 site.

Figure 4-30: Pond at the TS4 Site

4.1.6.6 Constructability

Factors that affect constructability include depth to bedrock, soil conditions, construction work area availability and route installation type. Constructability is also affected by utility density and traffic congestion. The utility congestion along the Route 606 and Ladbrook Drive corridors will add complexity to the UG route.

UG Route 6 has been reviewed for constructability and feasibility for this project. Throughout this review different challenges have been identified in the previous Sections: UG utility congestion along Route 606 and Ladbrook Drive, presence and depth of diabase rock formations, soil conditions, construction work area availability, VDOT limitations on Route 606, traffic control along Route 606 and Ladbrook Drive, encroachments into private property, water drainage ditches located close to the proposed alignment, existing pond in the transition station area, and the inability to obtain new land rights across the NOAA parcel. Based on these factors, the UG Route 6 has been determined to not be constructable for this project.

4.1.7 UG Route 7

UG Route 7 travels south from TS4 with both the 230-kV and 500-kV duct banks occupying the eastern side of the Ladbrook Drive Loop. The circuits split on Route 606, placing each circuit on opposite sides of the median, travelling southwest towards the new Mars Substation as shown in Figure 4-31 below. The proposed route is approximately 16,200 feet in length for the 230-kV circuit and 13,330 in length for the 500-kV circuit. The public ROW width on Ladbrook Drive is approximately 70 feet. This is not wide enough to fit both the 230-kV and 500-kV duct banks, reference Figure 3-5 above. However, due to the route's length of run on the corridor, a splice vault will need to be placed on Ladbrook drive for both circuits. The ROW is not wide enough to house all the splice vaults, as the minimum required width for vault locations is 115-feet.

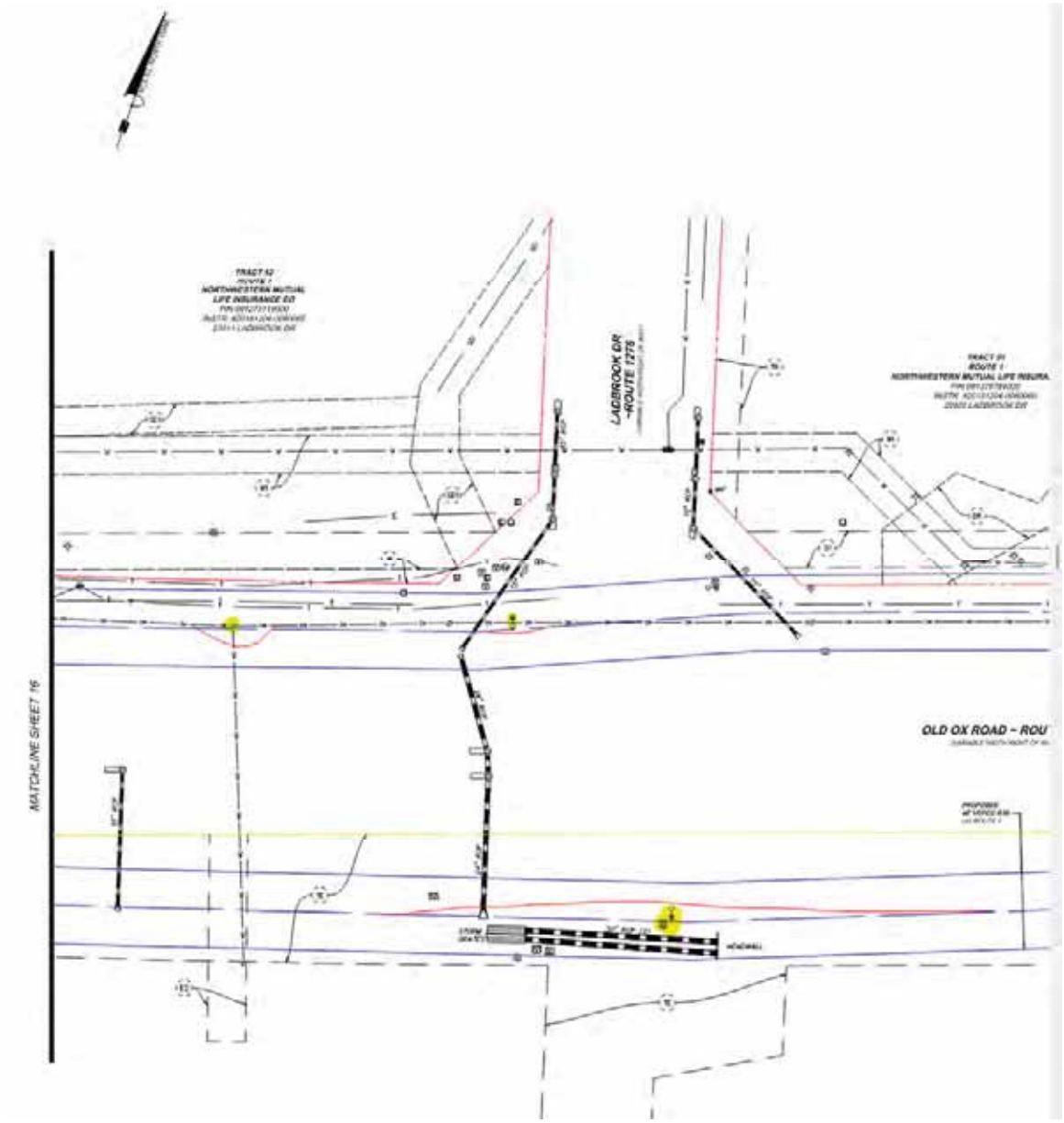
Figure 4-31 Golden - Mars UG Route 7 to TS4

Another constraint for this route is that installing both circuits in this corridor would take the entire road out of operation and will affect traffic in this corridor thus impacting all the nearby businesses. Additionally, based on the provided survey there are three (3) existing utilities that run parallel on Ladbrook Drive as indicated in Figure 4-32 below, a storm drainage system, a gravity sewer system

and a water line system. This reduces the working width for placement of the proposed UG Route to approximately 28-feet, which is inadequate spacing for the two duct banks. Installing both circuit duct banks along this corridor would not be possible without relocating these utilities along the entire length of route on Ladbrook Drive.

Per ERM analysis, a significant constraint for Underground Route 7 is the requirement for new land rights on the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) parcel. During a September 27, 2024 meeting, NOAA informed Dominion that they would not grant new land rights, citing the availability of viable alternative routes that avoid NWS lands.

Figure 4-32 Existing Utilities on Ladbrook Drive



The summary of constructability disadvantages of the proposed UG Route 7 are as follows:

- Three (3) existing utilities running parallel on Ladbrook Drive limit space for placement of both 230-kV and 500-kV duct banks within corridor
- Survey data incomplete on Ladbrook Drive and other unidentified existing utilities are expected in the study area
- At splice vault locations, route would need to exist partially outside of public ROW

- Constructability concerns such as utility congestion along Old Ox Road
- VDOT will not allow open cut trenching on Old Ox Road
- NOAA has confirmed they will not grant land rights for this project.

Given the significant and cumulative construction drawbacks outlined above, the UG Route 7 has been determined to not be constructable for this project and further in-depth analysis of this UG route was not performed.

4.1.8 UG Route R1 – (MWAA Route) Loudoun Water Sewer Route

The proposed UG Route R1 has been defined by DEV and ERM and starts from the proposed future Mars Substation located northeast of Carters School Road and Perimeter Road intersection, traveling then northeast through forested lands (MWAA, Digital Reality), until Route 606 (Old Ox Road) where proposed UG Route R1 turns northwest towards the proposed TS1 location. The 230-kV and 500-kV circuits remain in the same ROW for the entirety of the route.

Both circuits exit the Mars Station south paralleling Carters School Road until the existing freshwater pond north of W Perimeter Road, where they turn northeast after crossing the pond via trenchless technology. The proposed UG line continues northeast for approximately 1,780 feet where other trenchless crossing may be required to traverse the stream north of Hellcat Drive. The proposed UG line will continue northeast and then turn north following the east side of the existing fence in the MWAA land until crossing another stream located south of Beaver Meadow Road. Both circuits continue north paralleling that existing fence until the intersection with Beaver Meadow Road, where they head north paralleling the permanent ROW of a future sewer line project crossing a freshwater forested wetland. The proposed UG line heads northeast parallel to the future sewer line crossing an existing stream and pond system at the west exit of Instrument Road culverts. The proposed route keeps going northeast paralleling the future sewer line where it crosses a stream connecting two freshwater forested wetland systems located on east and west sides of Operations Road. Then, both circuits divert north parallel to Operations Road and the future sewer line until south of WMATA Dulles Rail Yard, where they head northeast crossing through the Horsepen Pond, the future sewer line pond and the railway overpass where large trenchless crossings are anticipated. The line will head then northwest through a forested area until the intersection with Route 606 where it crosses the road overpass. Finally, the UG Route continues toward the

proposed transition station where the UG circuits will be terminated. The proposed route is approximately 22,090 feet in length for both, 230-kV and 500-kV circuits. The preliminary trenchless crossings identified through this desktop analysis are listed in Table 4-2 below and the feasibility analysis of each crossing is detailed in Appendix E. Some route alternatives and installation options are also outlined in Table 4-3 for crossings where trenchless installations could be avoided, provided site-specific conditions, environmental and permitting constrains allow that. An aerial image of the proposed UG Route R1 is shown in Figure 4-33 below.

Figure 4-33: Golden-Mars UG Route R1 – (MWAA Route) Loudoun Water Sewer Route

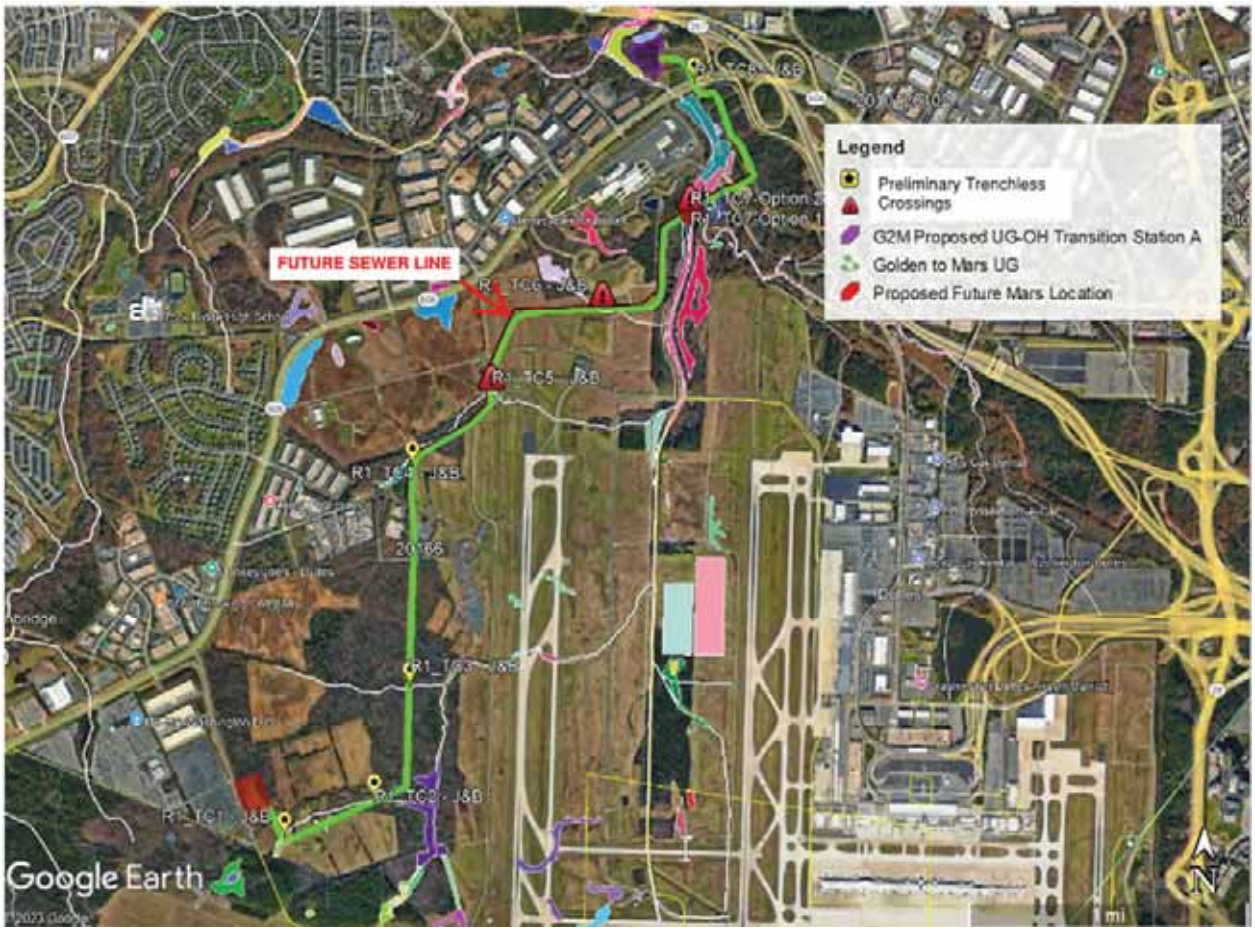


Table 4-2 UG Route R1 - Preliminary Trenchless Crossings List

Trenchless Crossing	Description
R1_TC1	Crossing through existing pond northwest of W Perimeter Road.

Trenchless Crossing	Description
R1_TC7	Crossing through Horsepen pond, future sewer line pond and railway overpass.

Table 4-3 UG Route R1 – Potential Open-Cut Crossings List

Crossing	Description
R1_TC2	Crossing through small stream west of freshwater wetland area north of Hellcat Drive. Pending site visit, site specific information, permitting and environmental assessment, open-cut installation may be feasible if the route segment is shifted north to avoid crossing the stream. If temporary stream water deviation is feasible and allowed to be used by the agencies with jurisdiction during installation, then open-cut installation may be feasible.
R1_TC3	Crossing through small stream south of Beaver Meadow road. If temporary stream water deviation is feasible and allowed to be used by the agencies with jurisdiction during installation, then open-cut installation may be feasible.
R1_TC4	Crossing through wetland north of Beaver Meadow road. Pending site visit, site specific information, permitting and environmental assessment, open-cut installation may be feasible if the route segment is shifted east to avoid crossing the wetland area.

Crossing	Description
R1_TC5	Crossing through existing pond west of a group of existing culverts below Instrument Road. Pending site visit, site specific information, permitting and environmental assessment, open-cut installation may be feasible if the route can be shifted east to avoid crossing the ponds.
R1_TC6	Crossing through stream south of Operations Drive. If temporary stream water deviation is feasible and allowed to be used by the agencies with jurisdiction during installation, then open-cut installation may be feasible.
R1_TC8	Crossing through highway 606 overpass. Crossing below highway 606 overpass: pending on the type of overpass foundation (raft mat or piles, etc.) and upon permission from VDOT, open-cut installation may be feasible

4.1.8.1 Existing Subsurface Utility Density and Location of Major Facilities

Survey along route R1 was not provided to BMcD for this assessment, therefore it is not possible to identify in this desktop analysis the existing UG utilities along the proposed route. However, since the proposed Route R1 runs almost entirely through private lands of the Metropolitan Washington Airport Authority and due to the proximity of Dulles International Airport it can be inferred that some UG telecommunication, electrical, water and sewer lines, amongst other existing utilities may run near or through portions of the proposed route. Future development in these areas could introduce new utilities and infrastructure along the route, that may require future relocation of the proposed UG transmission circuits.

4.1.8.2 Land Acquisition and Private Property Encroachment

The proposed Route R1 is located outside of VDOT roads ROW for all the route, therefore different property easements are expected. In total, easements from two (2) unique parcel owners will be required for the proposed Route R1 (MWAA and Digital Realty). Since it is federal land, permanent easements are not an option for MWAA property, and a special license would be required. In general, easements for government property may be more difficult to obtain and duct bank construction as well as trenchless installations must be careful to avoid disruption to the airport operations, this is a factor weighing heavily at trenchless crossings where the preliminary ROW minimum widths range from 270 feet up to 420 feet requiring larger easements than the open-cut segments. The map book developed in Appendix A for R1 shows the location where easements will be needed for 230-kV and 500-kV duct banks and trenchless crossings placement along the UG route.

4.1.8.3 Road Details

The UG route travels through private lands consisting of private roadways, parking lots, and forestry. There is just a single instance where the proposed UG Route R2 crosses a public road, it happens south of TS1 where the UG line passes below Route 606 overpass. To define the impact on this overpass existing VDOT bridge foundations and details will need to be reviewed. In this route, the 230-kV Circuit and 500-kV Circuit are collocated within the same ROW. The minimum ROW required for the collocated duct banks is 90.5 feet at 100% DLF, see Section 3.4.3 for details. At vault locations, the minimum required ROW for the dual circuit is approximately 115 feet in width. For trenchless installations identified through this alignment, the minimum ROW required varies from 270 feet up to 420 feet in width depending on the location and anticipated trenchless technology required, see Appendix F for details. This assumes that a minimum 15 feet of working space is required on both sides of the trench limits and outer vault edge.

4.1.8.4 Impact to Traffic

As described in previous sections, since the proposed Route R1 travels through private lands consisting of private roadways, parking lots, and forestry, impacts to public traffic and roads is not anticipated. Even though the proposed UG Route R1 is out of the public ROW, there are some private roads and parking lots along the route, and they may be affected by the location of splice vaults depending on trenchless final lengths and site-specific conditions which are factors determining the proposed splice vault final locations. For the proposed 230-kV Circuit nine (9)

preliminary vault locations are required and for the proposed 500-kV Circuit thirteen (13) preliminary vault locations are required. If needed, splice vaults can be placed in phases to minimize traffic disruptions and lane closures of those private roads.

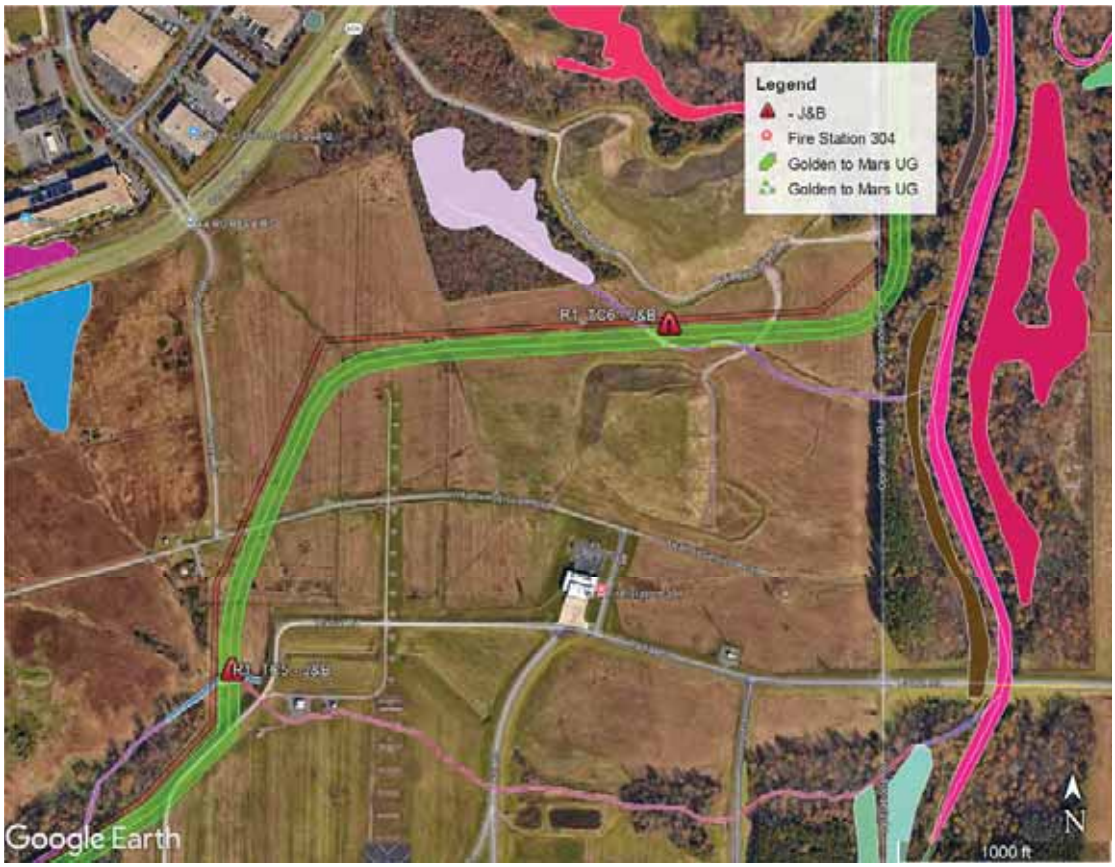
4.1.8.5 Sensitive Areas and Facilities

South of WMATA Dulles Rail Yard, the proposed UG Route R1 crosses the Horsepen Pond and the future sewer line pond, as well as other crossing through an existing pond that have been preliminary identified in Table 4-2 and studied in Appendix E, requiring trenchless crossings to minimize impacts on these water bodies.

Per ERM's permitting review, the proposed underground Route R1 would cross the Horsepen Dam spillway both north and south of Route 606. VDCR has classified this as a high-risk dam. Any spillway crossing, regardless of construction method, would require inundation preparedness measures and pose significant operational risks. Additionally, the crossing would require permits from MWAA, which may not grant such approvals.

The proposed UG Route R1 will pass Fire station 304, located on MWAA property. This fire station is specially placed to protect IAD property and provides services such as aircraft rescue, firefighting, and emergency services. UG Route R1 may impact unit deployment in and out of the fire station as it crosses the private roadway, Weather Service Road. This roadway provides a path from the fire station to the main road, Route 606. If this route is selected, coordination with the fire station will be required, to minimize the impact on public safety. Note that there are also other roadways leaving the fire station that will not be impacted by the proposed UG Route R1, and they provide direct paths to IAD. See Figure 4-34 for an aerial view of the location of Fire Station 304 along the proposed UG Route R1.

Figure 4-34 Fire Station 304 Along UG Route R1



4.1.8.6 Constructability

Factors that affect constructability include depth to bedrock, soil conditions, construction work area availability, and utility density amongst other factors. These factors are unknown for this feasibility study since site-specific geotechnical studies and survey have not been performed for the segments outside the public ROW, which comprise most of the route, and therefore cannot be assessed at this moment with certainty. Additionally, the proposed 230-kV and 500-kV circuits share the same ROW. This may impact construction for future circuit repairs.

UG Route R1 has been reviewed for constructability and feasibility for this project. Throughout this review different challenges have been identified in the previous Sections: UG utility congestion along Route 606, presence and depth of diabase rock formations, soil conditions, construction work area availability, trenchless crossings through hard and abrasive rock, encroachments into private property and federal lands, water drainage ditches located close to the proposed alignment, crossings through streams and the significant permitting, construction, and operational

risk of crossing of Horsepen Dam and spillway. Based on these factors, the UG Route R1 has been determined to not be constructable for this project.

4.1.9 UG Route R2 – MWAA Perimeter Road Route

The proposed UG Route R2 starts from the proposed future Mars Substation located northeast of Carters School Road and Perimeter Road intersection, traveling then northeast through forested lands (MWAA, Digital Reality), until the intersection with the future sewer line where the alignment turns north until Route 606 (Old Ox Road) where the proposed Route R2 runs northeast parallel to the southeast side of Route 606 turning then northwest towards the transition station TS1.

The 230-kV and 500-kV circuits remain in the same ROWs for the entirety of the route. The proposed Route R2 shares the same segment of Route R1 option from the Mars Substation up to the intersection between Thunder Road and Weather Service Road, where the proposed UG Route crosses the future sewer line, at this location a trenchless crossing is anticipated. The proposed UG line proceeds northward up to the southeast side of Route 606 roadway to continue traveling northeast between WMATA Dulles Rail Yard northwest side and Route 606. Throughout this segment, the proposed UG Route passes through private ROW. The proposed UG line will then cross Route 606 over the Horsepen Run culvert, and since VDOT prohibits having any lane closure, a trenchless crossing is warranted to cross below the culvert to exit at the north side of Route 606. Finally, the proposed UG Route continues toward the proposed transition station where the UG circuits will be terminated. The proposed route is approximately 19,013 feet in length for both 230-kV and 500-kV circuits. The preliminary trenchless crossings identified through this desktop analysis are listed in Table 4-4 below and the feasibility analysis of each crossing is detailed in Appendix E. Some route alternatives and installation options are also outlined in

Table 4-5 for crossings where trenchless installations could be avoided, provided site-specific conditions, environmental and permitting constraints allow that. An aerial image of the proposed UG Route R2 is shown in Figure 4-35 below.

Figure 4-35 Golden-Mars UG Route R2 - MWAA Perimeter Road Route

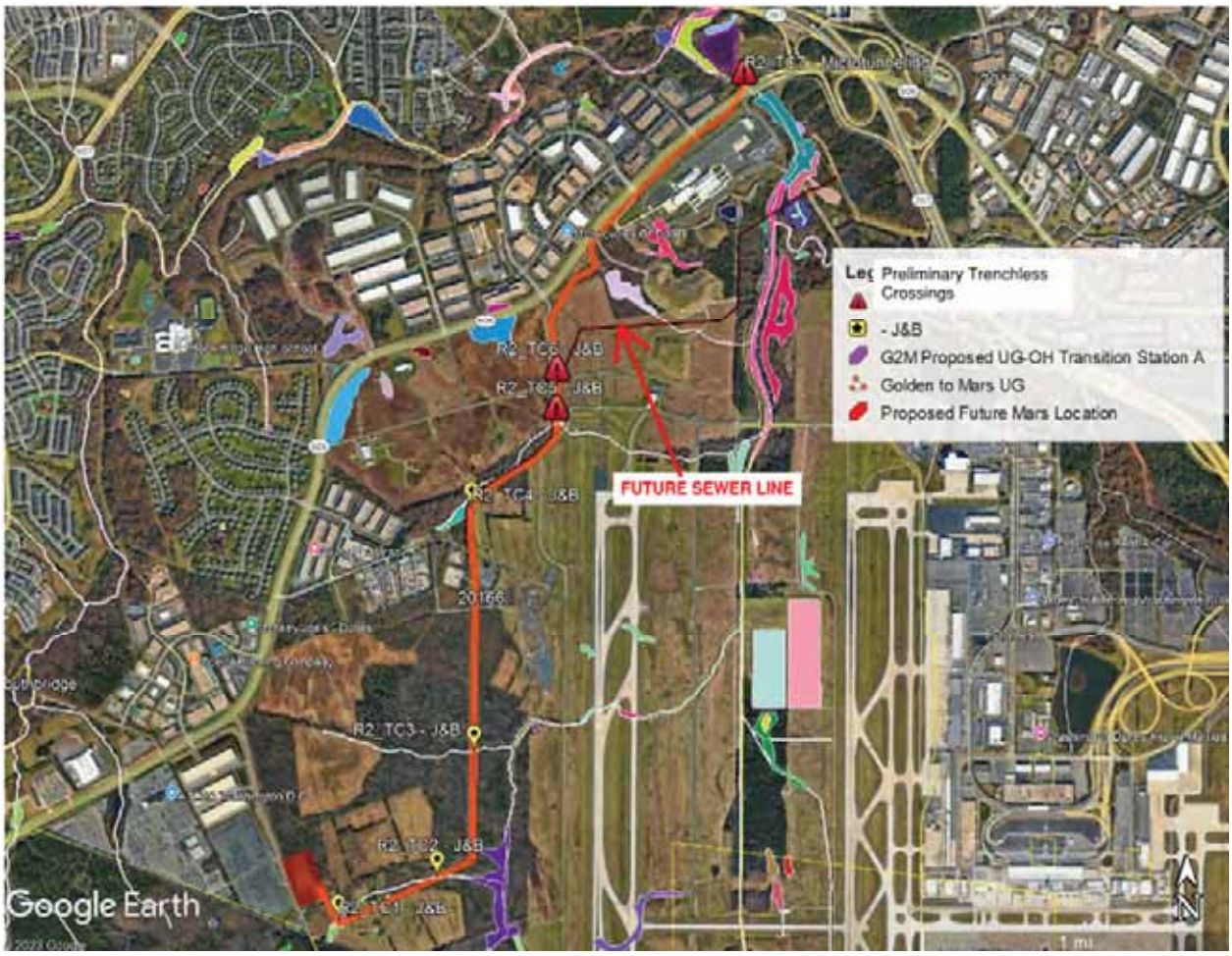


Table 4-4 UG Route R2 - Preliminary Trenchless Crossings List

Trenchless Crossing	Description
R2_TC1	It is the same R1_TC1 crossing from Route R1 crossing list table. Crossing through existing pond northwest of W Perimeter Road. Pending site visit, site specific information, permitting and environmental assessment, open-cut installation may be feasible if the route segment is shifted north to avoid crossing the pond.
R2_TC6	Crossing through future 24” PVC DR-25 sewer line and future permanent sanitary sewer easement.
R2_TC7	Crossing through highway 606 and existing Horsepen Run culvert below 606.

Table 4-5 UG Route R2 - Potential Open-Cut Crossings List

Crossing	Description
R2_TC2	It is the same R1_TC2 crossing from Route R1 crossing list table. Crossing through small stream west of freshwater wetland area north of Hellcat Drive. Pending site visit, site specific information, permitting and environmental assessment, open-cut installation may be feasible if the route segment is shifted north to avoid crossing the stream. As an alternative, if temporary stream water deviation is feasible and allowed to be used by the agencies with jurisdiction during installation, then open-cut installation may be feasible.

Crossing	Description
R2_TC3	It is the same R1_TC3 crossing from Route R1 crossing list table. Crossing through small stream south of Beaver Meadow road. If temporary stream water deviation is feasible and allowed to be used by the agencies with jurisdiction during installation, then open-cut installation may be feasible.
R2_TC4	It is the same R1_TC4 crossing from Route R1 crossing list table. Crossing through wetland north of Beaver Meadow road. Pending site visit, site specific information, permitting and environmental assessment, open-cut installation may be feasible if the route segment is shifted east to avoid crossing the wetland area. As an alternative, if the agencies with jurisdiction provide a permit to cut through the freshwater forested wetland, then open-cut installation may be feasible.
R2_TC5	It is the same R1_TC5 crossing from Route R1 crossing list table. Crossing through existing pond west of a group of existing culverts below Instrument Road. If temporary stream water deviation is feasible and allowed to be used by the agencies with jurisdiction during installation, then open-cut installation may be feasible.

4.1.9.1 Existing Subsurface Utility Density and Location of Major Facilities

Survey of existing UG utilities for the segment between Mars Station and Route 606 traveling through private ROW belonging to MWAA and Digital Reality is not available at the time of this report, therefore similar to the analysis in Section 4.1.8.1, a desktop analysis of the existing UG utilities along this portion of proposed Route R2 was not conducted. In contrast, for the UG route

portion between Route 606 northeast side and WMATA Dulles Rail Yard northwest side, QL-C and QL-D survey were provided to BMcD on July 29th, 2024. This survey shows moderate density of existing UG utilities with unknown elevations to be expected from Route 606 and Mercure Circle intersection all the way up to the UG line crossing through Route 606 towards TS1, see Figure 4-36 through Figure 4-40. Two (2) important clusters of existing UG utilities are identified in this desktop analysis, one at the intersection of R2 and Route 606 other at R2 and Commerce Center Court intersection, according to Figure 4-36 and Figure 4-39 correspondingly. The first one consists of water and sanitary sewer lines, the latter corresponds to water lines, storm water lines ranging from 15" reinforced concrete pipe (RCP) to 30" RCP and manholes. Additional information will be required to determine if trenchless crossings will be required in these areas. Additional congested UG utilities are found before the UG line starts crossing Route 606 where manholes, water lines and storm water lines with sizes up to 36" RCP are identified in Figure 4-40. The congested utility density in this area could introduce challenges during detailed design and extend the anticipated Route 606 trenchless crossing underneath the congested utility area. In any scenario, it will be challenging to collocate all the nine (9) bore pits without relocating some of the longer UG utilities as discussed in Appendix E.

This desktop analysis anticipates approximately 3,700 feet of electrical chain-link fence at the north of WMATA Dulles Rail Yard will need to be demolished and reconstructed for the proposed Route R2 open-cut installation of 230-kV Circuit and 500-kV Circuit coexisting in the same ROW. The typical electrical chain-link fence is shown in Figure 4-41.

Installing the proposed UG route via open-cut trenching between Route 606 and Rail Operations Drive requires challenging measures. These measures are derived from the restriction imposed by VDOT, which prohibits the use of Route 606 roadway, and from the congestion of existing UG utilities described above. These measures include: relocation of some of the major existing UG utilities, acquisition of permanent easements from WMATA Dulles Rail Yard, which may not be possible or may take a prohibitively long time to obtain, getting all 230-kV and 500-kV splice vaults staggered, and in some areas where the existing utilities are deep, the duct banks ampacity may need to be revised if the depth of cover (DOC) exceeds the limits indicated in Sections 3.4.1 and 3.4.2.

Figure 4-36 Existing Subsurface Utility Density at Route R2 and Route 606 Intersection

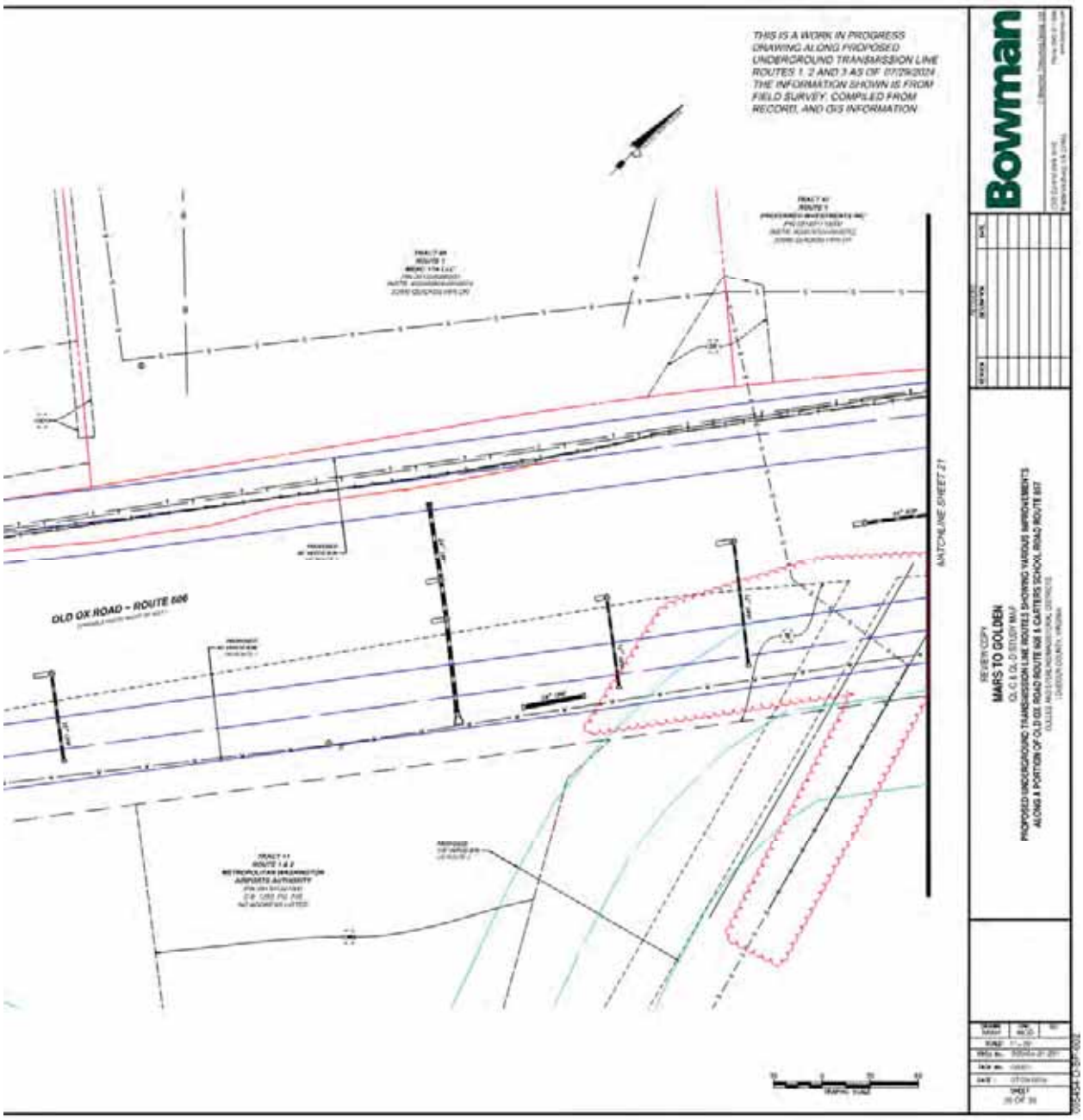


Figure 4-37 Existing Subsurface Utility Density Along Northeast Side of Route 606. 1 of 4

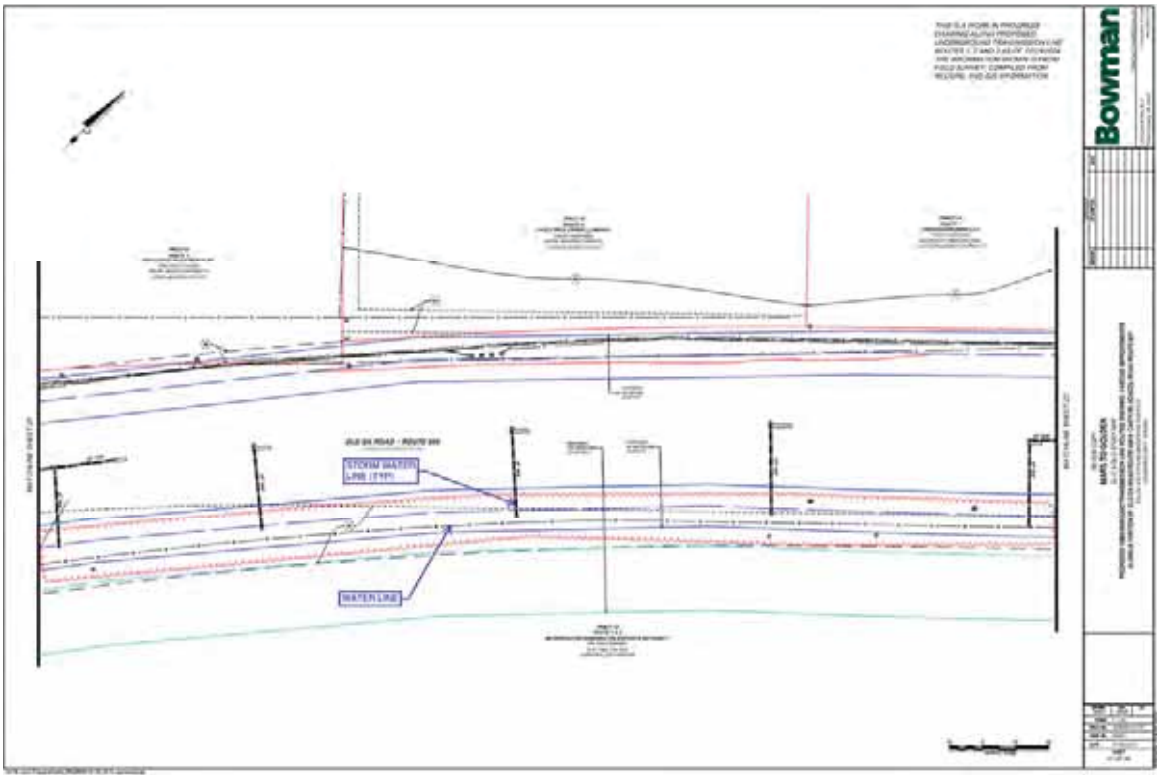


Figure 4-38 Existing Subsurface Utility Density Along Northeast Side of Route 606 (Mercure Circle and Route 606 Intersection). 2 of 4

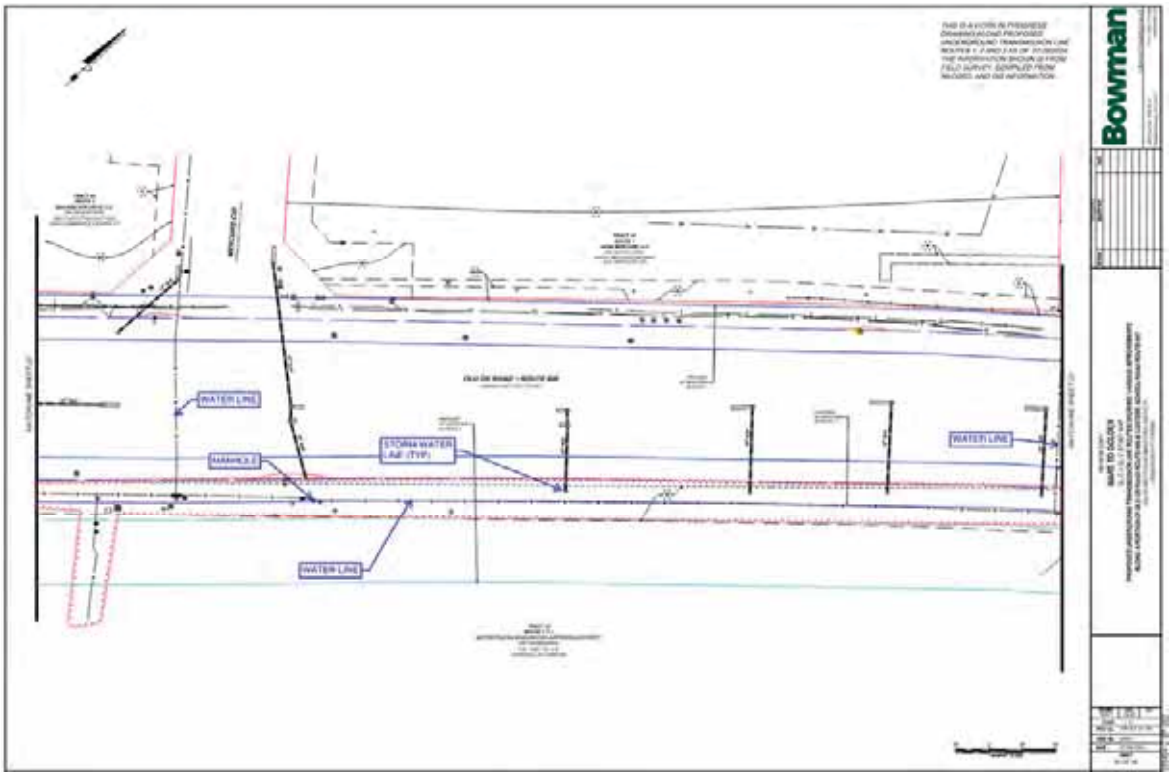


Figure 4-39 Existing Subsurface Utility Density Along Northeast Side of Route 606 (Commerce Center Court and Route 606 Intersection). 3 of 4

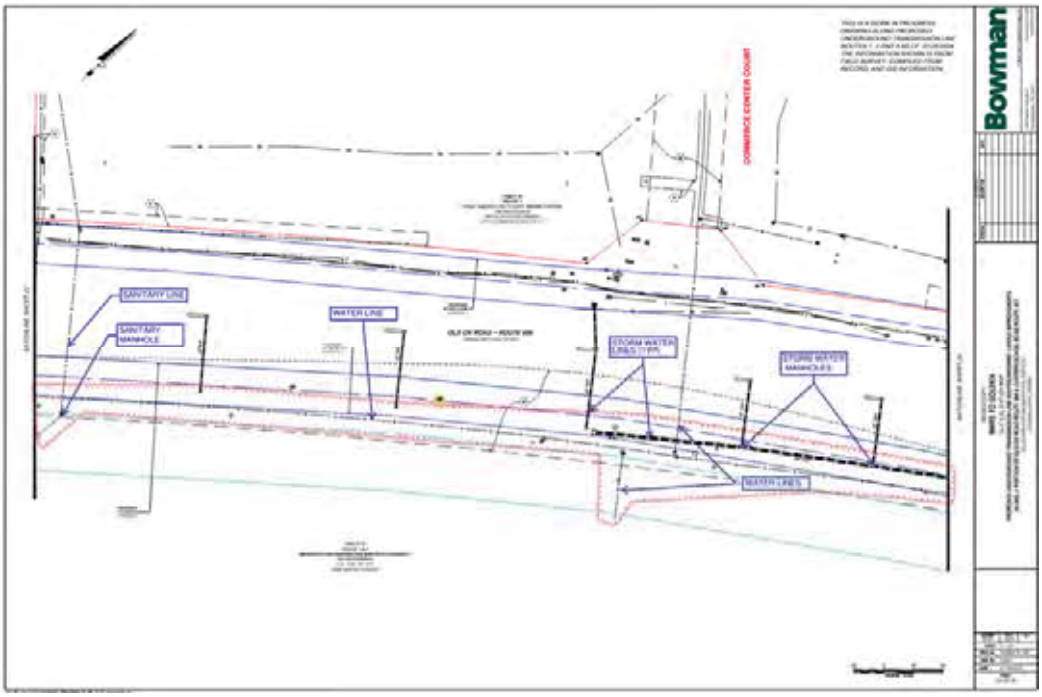


Figure 4-40 Existing Subsurface Utility Density Along Northeast Side of Route 606. 4 of 4

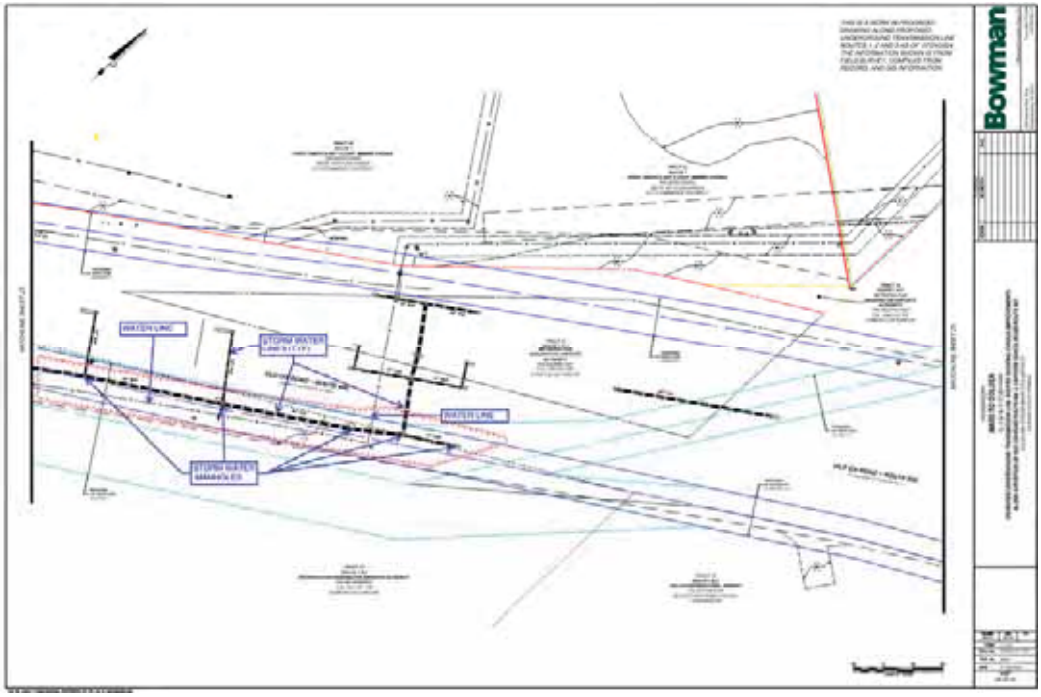


Figure 4-41 WMATA Dulles Rail Yard North Electrical Chain-Link Fence

4.1.9.2 Land Acquisition and Private Property Encroachment

The analysis performed in Section 4.1.8.2 is applicable to the proposed Route R2 segment between Mars Substation and Route 606 intersection. Due to VDOT's restriction of not using open-cut trenching in Route 606 lanes, it is anticipated that 230-kV Circuit and 500-kV Circuit installations on northeast side of Route 606, will require property easement from MWAA for the power corridor running on the north side of WMATA Dulles Rail Yard as shown on Figure 4-42 below. Permanent easement may not be attainable due to being government owned, therefore special permit will likely be required.

ERM stated that, WMATA informed Dominion that while crossing their rail yard facility might be possible in principle, they oppose any crossing of their lease area that would require facility relocations, including the perimeter fence. Given the uncertain timeline for obtaining such agreements, WMATA recommended avoiding any crossing between their rail yard facility and Route 606.

Figure 4-42 Route R2 Segment Inside the Metropolitan Wash Airport Authority Property

4.1.9.3 Road Details

The UG line segment length parallel to Route 606 shown on Figure 4-42 is 3,355 feet long approximately. Although Route 606 has a large corridor width, around 100 feet, and four (4) traffic lanes, VDOT prevents to use any of the lanes for open-cut installation nor to close any traffic lane. Therefore, the UG line duct banks and anticipated splice vaults in this segment will need to be installed entirely in private property allowing all Route 606 lanes to remain open during

construction. This route will impact the traffic lights located on the northeast side of Route 606 at intersections with Mercure Circle and Commerce Center Court. The lights will need to be removed during the UG line installation and then replaced with new foundations and structures.

4.1.9.4 Impact to Traffic

As indicated above, the Route 606 is anticipated to remain open during the UG line installation and the ductbank crossings at Mercure Circle and Commerce Center Court requiring temporary removal and replacement of traffic lights shown on Figure 4-43 and Figure 4-44 correspondingly. It should be anticipated that alternating lane closures for the incoming traffic to WMATA Dulles Rail Yard through Mercure Circle and Commerce Center Court will be required for construction of the proposed duct banks. It is important to note that splice vaults should not be located in these intersections.

The impact to traffic analysis performed in Section 4.1.8.4 is applicable as well to R2 segment between Mars Substation and Route 606 intersection.

Figure 4-43 Route 606 (Old Ox Road) and Mercure Circle Intersection

Figure 4-44 Route 606 (Old Ox Road) and Commerce Center Court Intersection

4.1.9.5 Sensitive Areas and Facilities

The UG line crosses Route 606 as it reaches TSA. As shown in Figure 4-45, Route 606 crosses over an existing concrete culvert that is part of Horsepen Dam. Due to VDOT's restrictions, a trenchless crossing is anticipated at this location, as detailed in Appendix E. Careful settlement monitoring shall be implemented during bore drilling processes to reduce the risk of differential settlement affecting the culvert and road. Per ERM analysis, a trenchless crossing of Horsepen Dam would pose significant operational risks and may not receive permitting approval from MWAA and VDCR.

Along the Route 606 northeast side there are existing fire hydrants inside the minimum ROW width required for the duct bank. Fire protection needs to be maintained in the area during construction and coordination with the municipality will need to occur to ensure the public's safety.

The sensitive areas and facilities analysis done in Section 4.1.8.5 is applicable to proposed Route R2 segment between the Mars Substation and Route 606 intersection.

Figure 4-45 Route 606 Existing Concrete Culvert North of WMATA Dulles Rail Yard

4.1.9.6 Constructability

Factors such as depth of bedrock, soil conditions and construction work area are key factors affecting the Constructability of the UG Route trenchless crossings, as well as the Constructability of the open-cut installation where utility density becomes another important consideration for the segment paralleling Route 606. All the UG line uses private ROW, therefore the land availability is a key factor weighing against the Constructability of the proposed Route R2.

On the other hand, VDOT restrictions and the location of the existing WMATA Dulles Rail Yard play a detrimental factor against the robustness of the proposed 230-kV and 500-kV cable systems since maintenance and future expansions will be limited.

UG Route R2 has been reviewed for constructability and feasibility for this project. Throughout this review different challenges have been identified in the previous Sections: UG utility congestion along the Route 606 segment, presence and depth of diabase rock formations, soil conditions, construction work area availability, traffic control along Route 606, trenchless crossings through hard and abrasive rock, encroachments into private property and federal lands, water drainage ditches located close to the proposed alignment, and crossings through streams. Additionally per ERM's review, timing of land acquisition and relocation of facilities on the WMATA Dulles Rail Yard lease area, and the significant permitting and operational risk of crossing of Horsepen Dam. Based on these factors, the UG Route R2 has been determined to not be constructable for this project.

4.1.10 UG Route R3 – Loudoun County Parkway Route

The proposed UG Route R3 starts from the proposed transition station TS5 located southeast of the Route 607 (Loudoun County Parkway) and Winterday Drive intersection, traveling north and then northeast paralleling Route 607 on the roadway's edge always through private lands (multiple owners), until Route 607 and Barrister Street intersection where the proposed UG Route turns southeast towards the proposed transition station TS6.

The 230-kV and 500-kV circuits remain in the same ROW, and parallel Loudoun County Parkway for the majority of the route. Both circuits exit the proposed transition station TS5 paralleling the south side of Route 607 crossing the freshwater pond located north of Greeley Square. The proposed UG line continues north crossing two (2) manmade ponds located west of Madison Heights Terrace until Route 607 and Evergreen Ridge Drive intersection. The proposed route turns east crossing a freshwater pond and a freshwater forested wetland with streams. This group of waterbodies is located northwest of Addlestone Place and Caterham Drive intersection. The proposed UG line continues traveling east and then northeast parallel to Route 607 until the intersection with Gleedsville Manor Drive. In this segment, the alignment crosses two (2) Route 607 culverts. After Gleedsville Manor Drive, the 230-kV and 500-kV circuits turn northwest crossing the west shore of a pond and Route 607 to be collocated on the north side of that road. The UG line keeps traveling east parallel to Route 607 up to the intersection with Centergate Drive, crossing three (3) culverts

below Route 607 along the way. Before crossing Centergate Drive, the alignment crosses a freshwater pond, and after Centergate Drive the UG line turns south to pass through Route 607. Then, the proposed UG line keeps traveling south between Barrister Street and The Ashburn Healthplex Emergency parking lot crossing a set of concrete culverts, one of them parallels Barrister Street. The alignment continues south for another 700 feet approximately. Finally, the proposed UG Route turns east towards the proposed transition station TS6 where the UG circuits will be terminated.

The proposed route is approximately 23,990 feet in length for both, 230-kV and 500-kV circuits. The preliminary trenchless crossings identified through this desktop analysis are listed in Table 4-6 below and the feasibility analysis of each crossing is detailed in Appendix E. Some route alternatives and installation options are also outlined in Table 4-7 for crossings where trenchless installations could be avoided, provided that site-specific conditions as well as environmental and permitting constraints allow that. An aerial image of the proposed UG Route 3 is shown in Figure 4-46 below.

Figure 4-46 Golden-Mars UG Route R3 - Loudoun County Parkway Route

Table 4-6 UG Route R3 - Preliminary Trenchless Crossings List

Trenchless Crossing	Description
R3_TC2	Crossing through existing ponds between Route 607 and Madison Heights Terrace.
R3_TC3	Crossing through existing pond, stream and forested wetland between Route 607 and Addlestone Place.
R3_TC5	Crossing through existing concrete culvert exit on east side of Route 607 and stream between Route 607 and Zulla Chase Place.

Trenchless Crossing	Description
R3_TC6	Crossing through Route 607 and west margin of existing pond. Crossing located north of Route 607 and Gleedsville Manor Drive intersection.
R3_TC10	Crossing through existing pond at northwest side of Centergate Drive and Route 607 intersection.
R3_TC11	Crossing through Route 607 and existing concrete culvert parallel to Barrister Street.

Table 4-7 UG Route R3 - Potential Open-Cut Crossings List

Crossing	Description
R3_TC1	Crossing through existing Lake Birchwood Dock pond and wetland pond east of Route 607. Pending site visit, site specific information, permitting and environmental assessment, open-cut installation may be feasible if the route segment can be shifted east to avoid crossing the pond and emergent wetland. Pond and wetland drain to Lake Birchwood Dock
R3_TC4	Crossing through existing Route 607 concrete culvert exit on south side of Route 607, stream and forested wetland between Route 607 and Addlestone Place. Pending site visit, site specific information, permitting and environmental assessment, open-cut installation may be feasible if the route segment can be shifted south to avoid crossing the Route 607 concrete culvert exit, and provided temporary stream water deviation is feasible and allowed

Crossing	Description
	to be used by the agencies with jurisdiction during installation.
R3_TC7	Crossing through the existing stream between Goshen Run Square and north side of Route 607. If temporary stream water deviation is feasible and allowed to be used by the agencies with jurisdiction during installation, then open-cut installation may be feasible.
R3_TC8	Crossing through existing stream draining to Duck Pond Walk and north discharge slope of concrete culvert below Route 607. If upon consultation with VDOT they allow open-cut at this location impacting Route 607 concrete culvert, and if temporary stream water deviation is feasible and allowed to be used by the agencies with jurisdiction during installation, then open-cut installation may be feasible. If VDOT prevents open-cut trenching close to the culvert, then the UG route may need to be shifted north which may impact the pond concrete retention wall.
R3_TC9	Crossing through existing stream draining to pond between Centergate Drive and Route 607, and north discharge slope of concrete culvert below Route 607. If upon consultation with VDOT they allow open-cut at this location impacting Route 607 concrete culvert, and if temporary stream water deviation is feasible and allowed to be used by the agencies with jurisdiction during installation, then open-cut installation may be feasible. If VDOT prevents open-cut trenching close to the culvert,

Crossing	Description
	then the UG route may need to be shifted north which may impact the pond concrete retention wall.

4.1.10.1 Existing Subsurface Utility Density and Location of Major Facilities

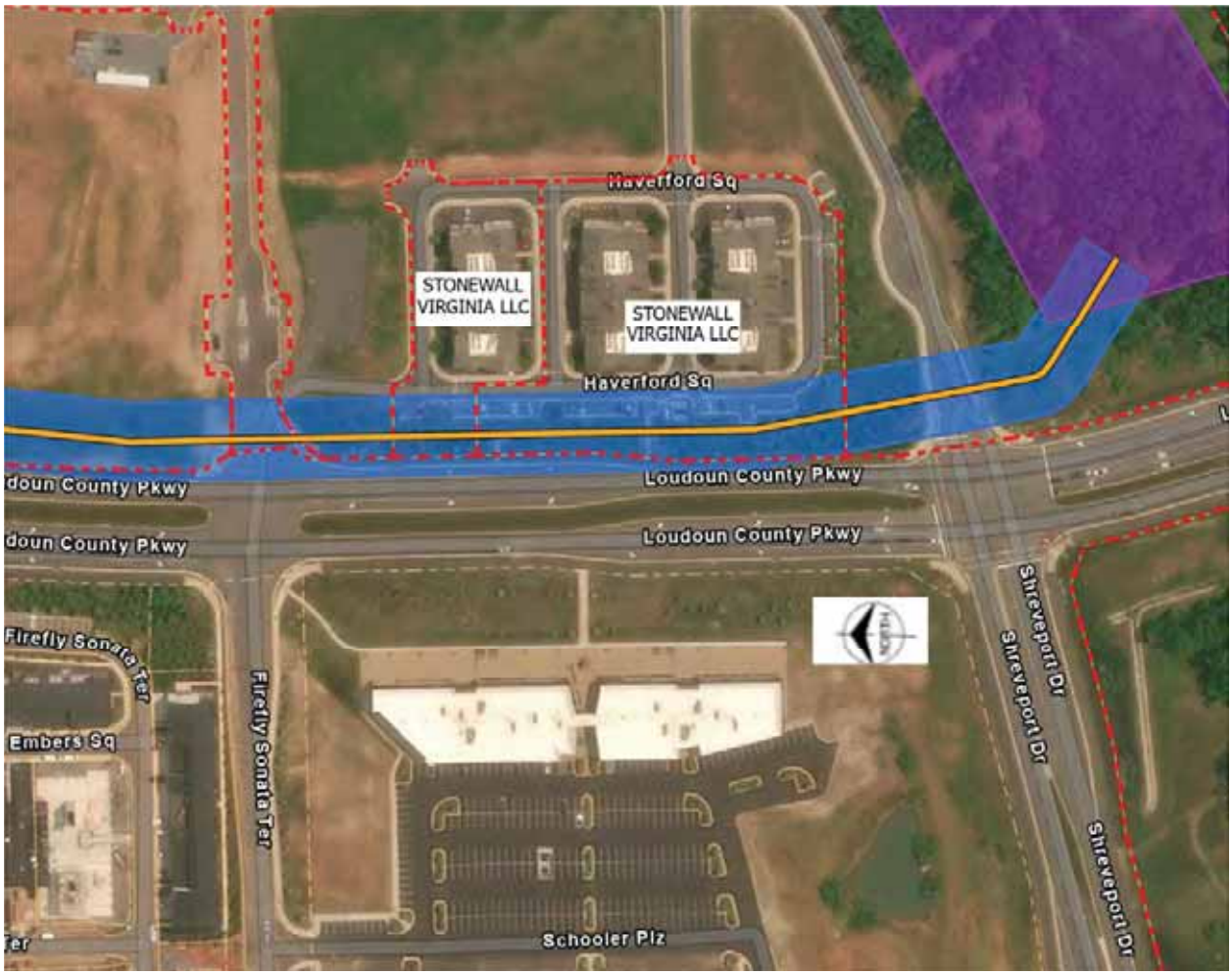
QL-C and QL-D surveys have not been performed for this route to date. However, due to the residential density along both sides of Route 607 roadway, a high existing UG utilities density is expected along Route 607 corridor, especially at intersections with other roads. Depending on the size, nature and depth of cover of these unknown existing UG utilities, relocation of some of them is anticipated and trenchless crossings may be required at some specially congested locations.

Several overhead lines are identified along the UG line, therefore relocation of them is anticipated since it may not be possible to thread with large duct banks through existing overhead line structures and their foundations while maintaining the minimum duct bank separation and the ROW width.

4.1.10.2 Land Acquisition and Private Property Encroachment

The majority of the proposed UG line travels through private lands, therefore permanent easements from landowners are anticipated along the majority of the alignment. However, there is a segment north of Transition station TS5 between Shreveport Drive and Firefly Sonata Terrace encroaching into Route 607 corridor as shown on Figure 4-47. VDOT has restricted the use of Route 607 and will not allow for any of 230-kV Circuit and 500-kV Circuit open-cut installation in the roadway or to close traffic lanes, therefore this route would need to be shifted east completely into private lands requiring permanent easements from the landowner (Stonewall Virginia LLC).

Figure 4-47 UG Line Power Corridor Encroachment Into Route 607 (Loudoun County Parkway) Roadway



South of the intersection between Route 607 and Barrister Street, the UG line installation will require permanent easement from a private owner (Inova Health Care Services) to install 920 feet of duct bank approximately through a facility providing emergency care services to the public, see Figure 4-48. It is anticipated that acquiring these easements may not be possible due to the nature of the facility's services.

Figure 4-48 UG Line Power Corridor Encroachment Into Ashburn Health Plex Emergency Center Lands

Installing the parallel 230-kV and 500-kV UG circuits in the same ROW using proposed Route R3 will have alignment locked in between VDOT's restrictions of using any portion of Route 607 roadway and several private landlords. This will make any future UG cable system expansion more difficult. Overall, this will play a detrimental factor on the UG system robustness.

4.1.10.3 Road Details

The proposed UG 230-kV Circuit and 500-kV Circuit follow Route 607 throughout most of the alignment. Route 607 has an average corridor width between 110 feet and 120 feet approximately with four (4) to seven (7) traffic lanes. The proposed UG line crosses several two (2) and four (4) lane roadways perpendicular to Route 607 and most of these routes are public roadways. Phased open-cut installation could be used through them (unless crossing Route 607) to maintain traffic flow at these intersections. However, this may change upon future DEV's consultations with VDOT.

Most of the proposed UG line crossings with these roads have traffic signs and traffic lights that will require removal and replacement for open-cut installations. It is anticipated that splice vault locations can be set to avoid these intersections, and if necessary, staggered splice vaults can be considered.

4.1.10.4 Impact to Traffic

As described above, the proposed UG Route passes through several Route 607 and other secondary public roads intersections. It is anticipated that traffic flow can be maintained at these crossings while doing open-cut installation of 230-kV Circuit and 500-kV Circuit coexisting on the same ROW since a phased-construction method can be used to maintain at least one traffic lane open all the time. A comprehensive traffic management plan in conjunction with this phased-construction will be required to accommodate the traffic flow in the area during the UG line installation. The traffic management plan will also need to incorporate temporary traffic signals and temporary traffic detours during work at these intersections.

4.1.10.5 Sensitive Areas and Facilities

One (1) school has been identified on the west side of Route 607 and Mooreview Parkway intersection, whose main access is through Mooreview Parkway, see Figure 4-49. The proposed UG line runs parallel to the opposite side of Route 607 and then crosses the road via trenchless installation with entry and receiving pits off the roadway, therefore it is not anticipated that construction works will be impacting the school normal operations.

Along Route 607 fire hydrants are located on both sides of the roadway and some of them fall within the minimum ROW width required for the duct bank. Fire protection needs to be maintained in the area during construction and coordination with the municipality will need to occur to ensure the public's safety.

In addition, at least eight (8) different freshwater ponds are discovered throughout the alignment as shown on Figure 4-49 through Figure 4-54. The proposed UG line installation plan must minimize detrimental repercussions on these waterbodies, for such purpose some route strategies may be implemented during detailed design:

1. Trenchless installations to cross: the freshwater ponds close to Gleedsville Manor Drive and Route 607 intersection (Figure 4-49), between Route 607 and Madison Heights

Terrace (Figure 4-51), between Route 607 & Addlestone Place (Figure 4-52), and at northwest side of Centergate Drive and Route 607 intersection (Figure 4-53, & Figure 4-54).

2. Shifting the route to avoid the pond located south of Evergreen ridge Drive & Route 607 intersection (Figure 4-50).

Nevertheless, as detailed in the trenchless feasibility analysis (Appendix E) for the crossings listed above in bullet point 1, due the minimum bore center-to-center separation dictated by the ampacity ratings required for each circuit, some of the bores would need to be installed below private residences, yielding these segments not constructible. At the location of these crossings the alignment will need to be rerouted to avoid private residences conflicts.

Figure 4-49 Primrose School at Moorefield Station & Freshwater Pond

Figure 4-50 Lake Birchwood Dock Pond and Wetland Pond East of Route 607

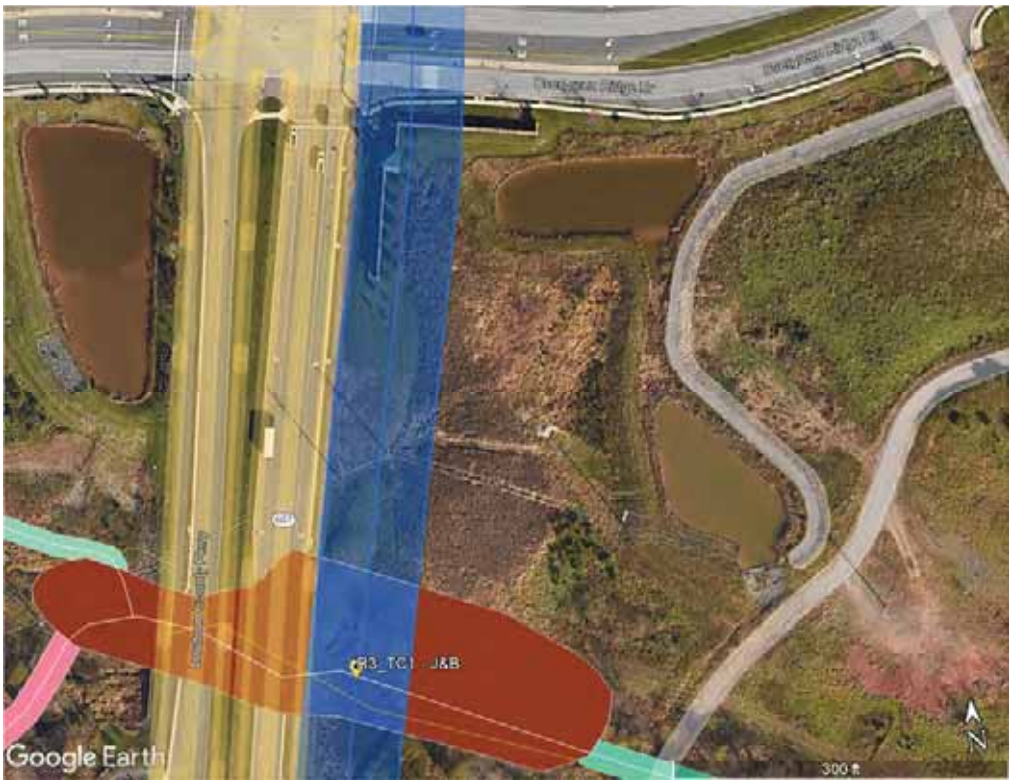


Figure 4-51 Freshwater Ponds Between Route 607 and Madison Heights Terrace

Figure 4-52 Freshwater Pond, Stream and Forested Wetland between Route 607 and Addlestone Place

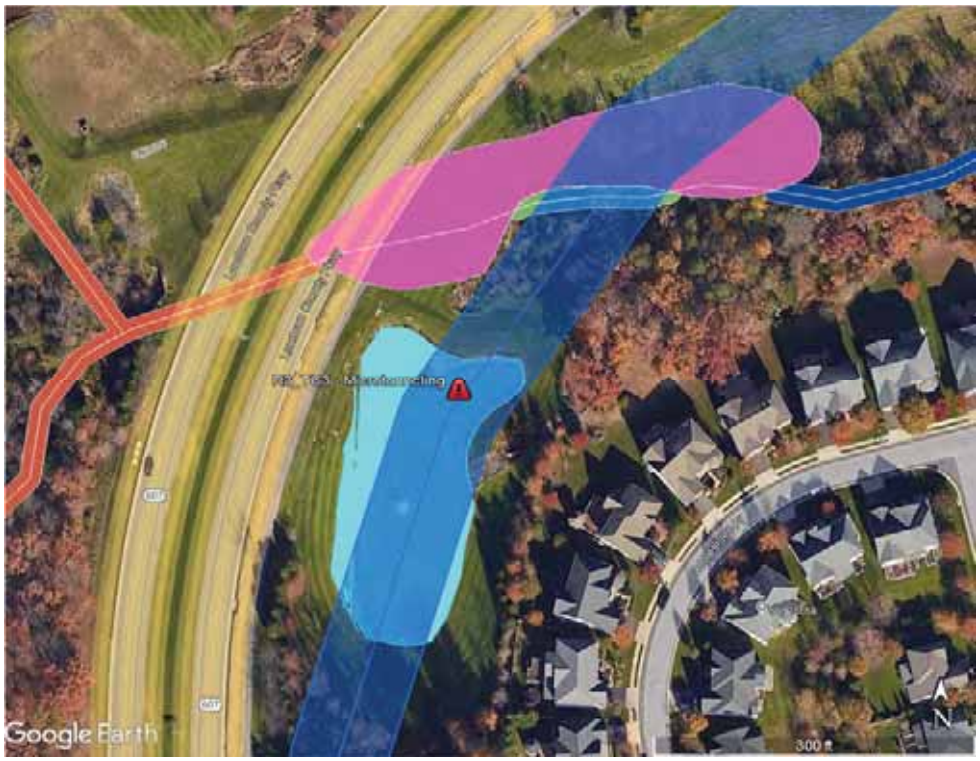


Figure 4-53 Freshwater Pond at Northwest Side of Centergate Drive and Route 607 Intersection – Aerial View

Figure 4-54 Freshwater Pond at Northwest Side of Centergate Drive and Route 607 Intersection – Street View

In the case of the Duck Pond Walk identified on Figure 4-55 and the pond between Centergate Drive and Route 607 identified on Figure 4-56 below, the proposed UG alignment would likely need to be shifted north such as to prevent encroaching into the north section of the existing culverts under Route 607 draining streams to these ponds. However, while this proposed UG alignment shift reduces the need of trenchless crossings, getting the open-cut installation closer to the ponds may affect the concrete retaining walls located on the south shore of these ponds. Figure 4-57 shows a street view of these typical concrete retaining walls.

Figure 4-55 Duck Pond Walk

Figure 4-56 Freshwater Pond Between Centergate Drive and Route 607 – Aerial View

Figure 4-57 Freshwater Pond Between Centergate Drive and Route 607 – Street View

In addition to the group of waterbodies described above, a sensitive facility providing health emergency services has been identified on the east side of the UG line, parallel to Barrister Street as indicated on Figure 4-58 below. As the proposed UG Route travels south parallel to this emergency center, it crosses an existing concrete culvert, it is anticipated then that a long trenchless installation would be required to pass underneath the existing culvert and to avoid any impact on Barrister Street and Landmark Court that may affect the traffic flow. These are the only roads providing access to this facility. However, as detailed in the feasibility analysis of Appendix E for trenchless crossing, due to the high ampacity requirements imposed over 230-kV Circuit and 500-kV Circuit, some of the bores would be passing underneath the emergency center. Therefore, this segment is not constructible and will need to be rerouted to avoid this facility altogether.

Figure 4-58 Ashburn Health Plex Emergency Center

4.1.10.6 Constructability

The proposed UG Route R3 faces several challenges as described in previous sections such as: VDOT restrictions to use Route 607 roadway, VDOT restrictions on Route 607 lane closures during installation and maintenance operations, the need to acquire permanent easements from private land owners and sensitive facilities along the UG Route, the need to shift and reroute several segments of the alignment due to open-cut installation requirements as well as trenchless crossing feasibility risks detailed in Appendix E. These challenges for the proposed Route R3 alignment make the risks of the UG system constructability increase, and inhibit any future expansion works over both 230-kV Circuit and 500-kV Circuit.

Although a review of existing utilities was conducted along Route 607, which identified water, sewer, and fiber utilities that both cross and run parallel to the road. This infrastructure would require significant service disruption and relocations for both open-cut and trenchless

construction methods assuming that the incumbent utilities and landowners were willing to accommodate a new UG transmission ROW. Based on these factors, the UG Route R3 has been determined to not be constructable for this project.

4.1.11 UG Route R4 – Rock Ridge Route

The proposed UG Route R4 starts from the proposed transition station TS7 located northwest of Route 606 and Overland Drive intersection, traveling northwest paralleling the Broad Run waterway up to the intersection with Loudoun Reserve Drive, there it turns east up to an existing overhead transition line power corridor trough private lands (different owners), diverting then north towards the proposed transition station TS2 using Amazon Data Services Inc. lands. The 230-kV and 500-kV circuits remain in the same ROW, and parallel Broad Run and the existing overhead transmission line ROW for the majority of the route. Both circuits exit the proposed transition station TS7 northwest through the forested area between Broad Run waterway and Meadowvale Glen Court up to the intersection with Loudoun Reserve Drive, which is the access road to Rosa Lee Carter Elementary School and Rock Ridge High School, property of Loudoun County School Board. The proposed UG line diverts east through Loudoun Reserve Drive and then along the south side of the High Scholl's soccer and baseball fields up to the existing overhead transmission line ROW between the High School and Light Speed Plaza. The proposed UG circuits turn north paralleling the east side of the existing overhead transmission line power corridor throughout 1,400 feet approximately of streams carrying water from the Broad Run waterway to Loudoun Valley Estates' freshwater pond system. Finally, the proposed UG Route turns northeast to the proposed transition station TS2 where the UG circuits will be terminated. The proposed UG Route is approximately 8,290 feet in length for both, 230-kV and 500-kV circuits. The preliminary trenchless crossing identified through this desktop analysis is listed in Table 4-8 below and the feasibility analysis of this crossing is detailed in Appendix E. An aerial image of the proposed UG Route R4 is shown in Figure 4-59 below.

Figure 4-59 Golden-Mars UG Route R4 (Alternative Route) – Rock Ridge Route

Table 4-8 UG Route R4 - Preliminary Trenchless Crossings List

Trenchless Crossing	Description
R4_TC1	Crossing through existing stream between Rock Ridge High School football field and Light Speed Plaza. If temporary stream water deviation is feasible and allowed to be used by the agencies with jurisdiction during installation, then open-cut installation may be feasible.

4.1.11.1 Existing Subsurface Utility Density and Location of Major Facilities

Utility survey along the proposed power corridor is not available at the moment to assess the existing UG utilities density, especially along the segment through the private forested lands. However, Loudoun Reserve Drive is the only access road to the Rock Ridge High School complex,

and it may be expected to encounter water, sanitary and electrical UG lines amongst others along the road corridor to serve the school. Therefore some relocation may be required to install both circuits in the same ROW and depending on the site specific utility density, shifting the UG line ROW completely south of the roadway may be necessary.

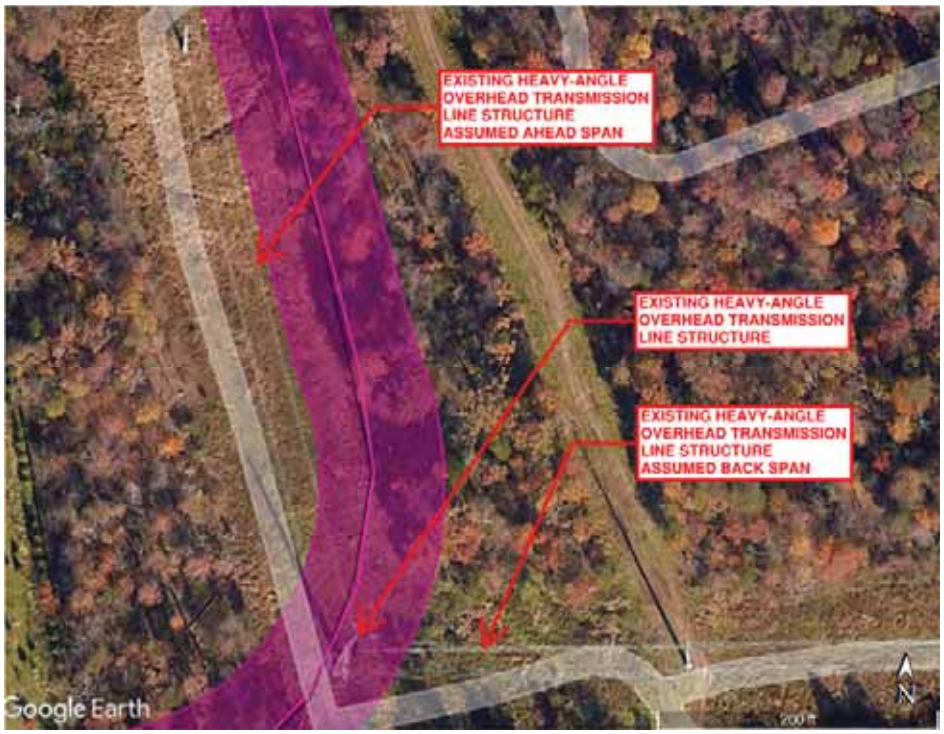
The proposed UG line parallels the east side of an existing overhead transmission line power corridor for 1,400 feet approximately. This overhead transmission line comes from the northwest H-frame of the Substation located southwest of Route 606 and Ladbrook Drive intersection, and from the line support pole configuration it may correspond to a 115-kV or 230-kV overhead transmission line system, see Figure 4-60 through Figure 4-62 below. After exiting the High-School area, the route crosses this existing overhead line corridor when turning north towards the transition station TS2. At that specific crossing, there is an existing heavy-angle overhead transmission line structure as shown on Figure 4-63. It is anticipated then this heavy-angle overhead transmission line structure may need to be relocated due to the size of the UG duct banks. This relocation would imply modifications on the transmission line structures and overhead conductors at ahead and behind spans from that particular heavy-angle transmission structure. Placing splice vaults in this UG line segment would introduce the risk of working with heavy lifts near or below existing overhead high-voltage conductors.

Figure 4-60 Existing Substation and Overhead Transmission Line Corridor

Figure 4-61 Existing Substation and Overhead Transmission Line Exiting the Substation Connection Yard – Aerial View

Figure 4-62 Existing Substation and Overhead Transmission Line Exiting the Substation Connection Yard – Street View

Figure 4-63 UG Route R4 Crossing with Existing Heavy-Angle Overhead Transmission Line Structure



4.1.11.2 Land Acquisition and Private Property Encroachment

Most of the proposed UG Route R4 travels through private forested lands and encroaches onto Loudoun County School Board property when using the same roadway of Loudoun Reserve Drive as shown on Figure 4-64 below. Therefore, the installation of 230-kV and 500-kV UG Circuits coexisting on the same ROW will require permanent leases from different private landowners and the School Board. LCPS property cannot be avoided at this location due to existing homes situated approximately 70 feet from the southern parcel boundary. ERM has stated that LCPS staff has opposed underground construction along Loudoun Reserve Drive because it provides the only access to both school buildings, and significant construction-related road closures would severely impact school operations.

Figure 4-64 UG Route R4 Property Encroachment

4.1.11.3 Road Details

The only roadway this proposed UG line would be impacting is the Loudoun Reserve Drive, Figure 4-65 below. With only two (2) traffic lanes and an average roadway width 26 feet, this road is the only access to and from Rosa Lee Carter Elementary School and Rock Ridge High School. Therefore, both UG circuits will not be able to coexist in the same roadway for this segment.

Figure 4-65 UG Route Segment Trough Rosa Lee Carter Elementary School and Rock Ridge High School Access Road

4.1.11.4 Impact to Traffic

It is anticipated that the impact to traffic will occur when installing the proposed Route R4 segment along Loudoun Reserve Drive. As described above, this road only has two traffic lanes and provides the only access to the school complex located on the north side of the roadway. Therefore, due to the size of the duct banks the route segment will need to be shifted south such that the reminder portion of the UG ROW staying on the roadway allows to maintain a traffic lane open always. In addition, splice vaults cannot be located along this segment due to the size and quantity of vaults needed at each UG line splicing location.

4.1.11.5 Sensitive Areas and Facilities

As described in Sections 4.1.11.1 through 4.1.11.4, one portion of the proposed UG Route will pass through the only access to and from Rosa Lee Carter Elementary School and Rock Ridge High

School. ERM has stated that LCPS staff has stated their opposition to any construction that would significantly impact access to either school. Installing this route segment is likely to impact existing UG utilities serving the school complex and to close one of the two available traffic lanes permanently during construction works. In addition to this school complex, 1,400 feet approximately of streams carrying water from the Broad Run waterway to Loudoun Valley Estates' freshwater pond system are identified along the proposed Route R4 ROW. To cross below this waterbody, a large HDD through shallow diabase is anticipated according to the trenchless crossing assessment from Appendix E.

4.1.11.6 Constructability

The need to acquire permanent easements from private landowners and sensitive facilities owners along the proposed UG line increases the challenges to the constructability of the proposed UG system. Furthermore, the proposed route as it stands would require a reroute of more than half of the segments due to the challenges described in previous sections such as:

- Encroaching entirely over the High-School only access road
- Crossing through high-voltage transmission line corridor
- The need of a large HDD to cross below the stream system drilling through potential shallow diabase as detailed in Appendix E, Section E.6.1.1
- The splice vaults long distances to avoid the School Board lands and the existing overhead line corridor

Based on these factors, the UG Route R4 has been determined to not be constructable for this project.

5.0 TRANSITION STATION

The primary purpose of the transition station is to provide a point where the overhead transmission lines can be converted to underground. This conceptual layout follows DEV standard substation design requirements for the 230-kV, 3,950 Amp rated line and for the 500-kV, 5,000 Amp rated line. The general arrangement for transition stations TS1 and TS2 is shown in Figure 5-1 and Figure 5-2. It is assumed the general arrangement proposed for either TS1 or TS2 may be utilized for TS3, TS4, TS5, and TS6 locations. After this general arrangement was developed, DEV requested to create a new arrangement for transition station TS7 as shown in Figure 5-3. The transition station layouts can also be seen in Appendix D. If an UG Route to TS3, TS4, TS5, TS6 or TS7 is selected, a detailed transition station layout will be developed to accommodate the respective areas. For each transition station location, it is assumed that a minimum of approximately seven (7) acres of land is required to locate all of the 230-kV and 500-kV equipment excluding the area for SWM pond, county required setbacks and buffer.

5.1 General Design Considerations

The equipment layout and overall footprint of the transition stations are intended to provide a balance between flexibility and conservatism. To accommodate the entry of the overhead lines from multiple directions, independent of the yard orientation, the backbones can be shifted lengthwise along the long main bus runs with minimal impact to the overall design. If the backbones were to be rotated 90 degrees, both the parcels would not have enough space to accommodate station equipment considering the limitation of UG cables routing into the station. Utilization of single and double cable per phase termination structures, with dedicated switches for each cable set, allows for faster isolation of a compromised cable and operation of the line at a reduced capacity, should it be required. Two (2) drive gates plus a full turnaround inside the yard provide sufficient space for vehicular access and maintenance activities. Gates can be shifted around the perimeter near any corner with little to no impact to accessibility or cost.

It is assumed that the station will have security design level one fence and integrator package. A power voltage transformer (PVT) is connected to the tubular bus runs of Phase A and C and provides dual, independent sources for station service. The fence will be 20 feet in height with Level 1 Security requirements.

The shunt reactor sizing study and vendor prints were not available during the transition station parcel evaluation. A conservative approach was taken into consideration for the sizing of these equipment. For 230 kV shunt reactors, a previously installed 100MVAR fixed shunt reactor was assumed for a footprint approximation. Three (3) single phase and a spare reactor was assumed for 500 kV shunt reactor. The sizing of these 500 kV reactors was assumed to be approximately 52'x40'each phase per the discussion with Dominion Shunt Reactor Equipment team. It is assumed that the actual reactors may fit into the space allotted for these reactors in this study.

Additional land outside the station fence would likely need to be acquired to meet storm water, permitting buffer, and any additional changes per system protection philosophy. It is assumed for the purposes of this study that the area required is approximately equivalent to the area inside the station fence.

The presence of high-risk flood plains designated by the Federal Emergency Management Agency (FEMA) as well as the system of streams and ponds around Route 267, Route 606, Route 607 and other secondary roads in the general project area are stressors increasing the risks over detailed site-preparation and civil designs for transition stations located in this area. Furthermore, there are different existing overhead lines ramifying from existing substations on Route 606 and existing distribution lines along secondary roads. These existing overhead structures and foundations will become a factor to account for the transition station construction planning and relocation of some of them may be warranted. In addition, a number of existing UG utilities (stormwater lines, sewer lines, water lines, concrete culverts below roads or between ponds, etc.) serving the parcels around Route 267, Route 606, Route 607 and secondary roads are likely to be encountered, therefore relocation of these existing utilities must be factored in the design and construction planning of the transition station.

Figure 5-1: Transition Station 1 Arrangement (Parcel 1)

Figure 5-2: Transition Station 2 Arrangement (Parcel 2)

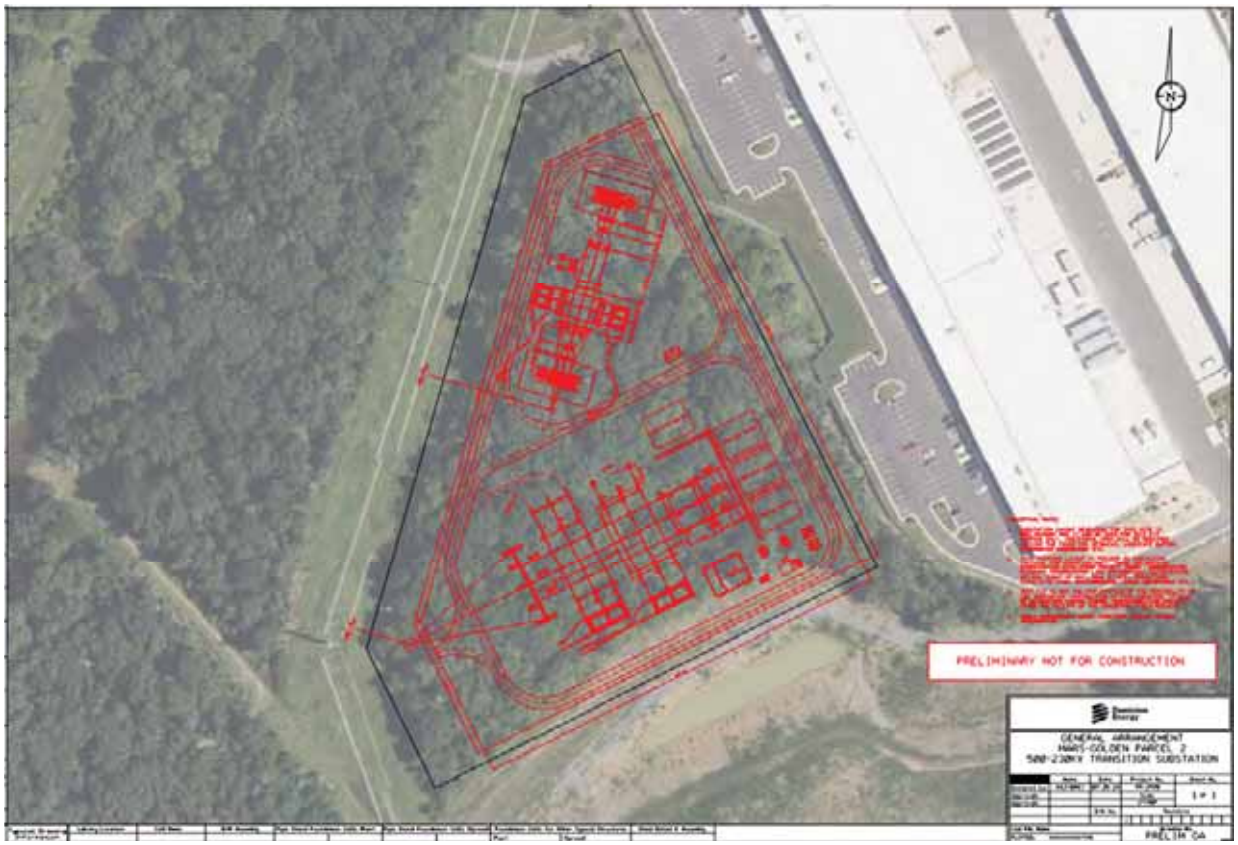


Figure 5-3: Transition Station 7 Arrangement (Parcel 3)

5.2 Proposed Transition Station Locations

All proposed transition station locations have been provided by DEV for BMcD route evaluations.

5.2.1 Proposed Transition Station 1

Proposed TS1 is located north of Route 606 and west of Route 267 as shown on the route map where the OH line will transition to UG, see Figure 5-4 below. The area for TS1 is approximately 7.0 acres. TS1 is further away in distance from the Mars Substation than TS2 and TS4, and as a result the routes to TS1 are longer than the routes to the other proposed transition station locations.

The TS1 site is located at the Horsepen Run spillway outfall. Due to its position relative to Horsepen Run, Route 606, and MWAA property, any route from TS1 would require crossing Horsepen Run dam. As detailed in Section 4, such a crossing presents significant operational and permitting risks. Additionally, the site's location makes it vulnerable to major flood events, creating further risks for infrastructure critical to grid reliability

Figure 5-4: Proposed Transition Station #1 Location - Amazon

5.2.1.1 Land Acquisition

The TS1 site cannot accommodate both a transition station and the planned substation needed to serve the landowner's data center development. DEV and the landowner have been unable to identify suitable alternative sites, as adjacent areas are constrained by floodplains, public lands, and planned development. Consequently, this parcel is not viable for a transition station location.

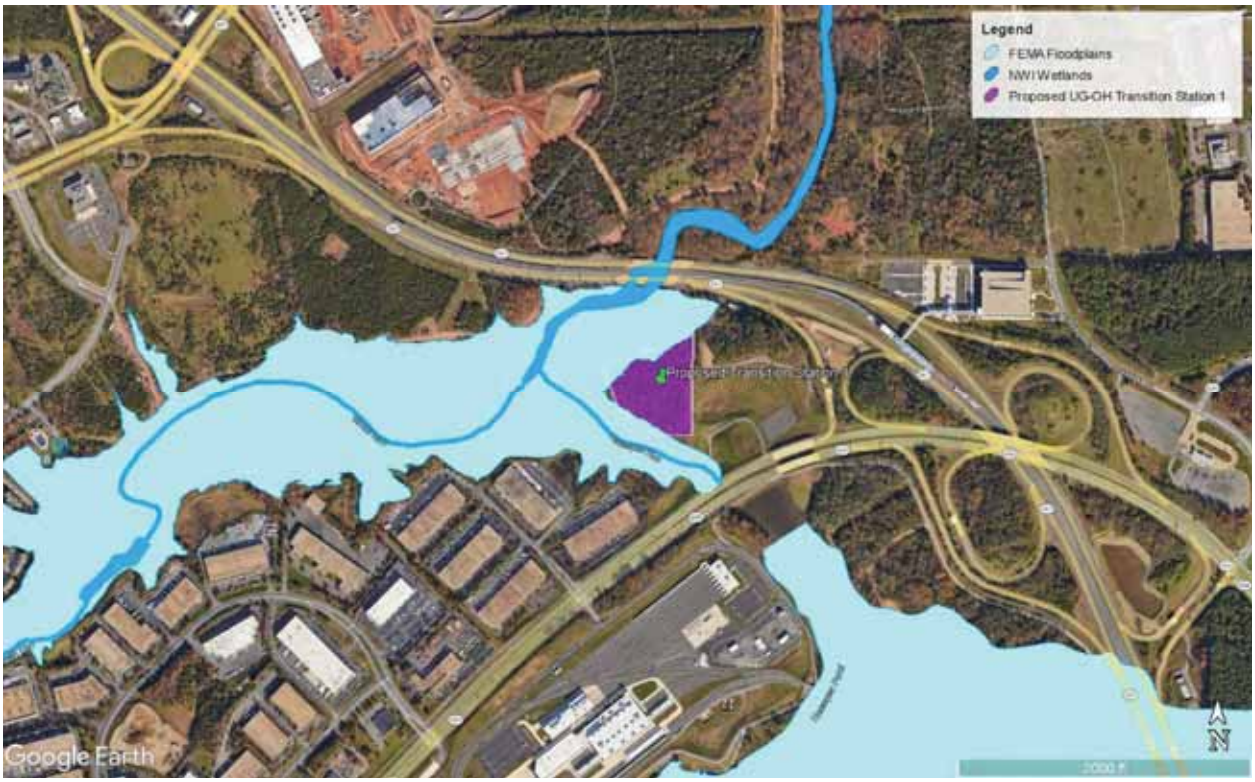
5.2.1.2 Sensitive Areas and Environmental Impacts

There is sufficient area on the parcel for placement of the new transition station, however a portion of it is occupied by the flood plain areas and the Horsepen Run water body that is on the property. There is a large concrete culvert below Route 606 connecting Horsepen Pond and Horsepen Run located near the southeast corner of this parcel. TS1 sits just barely outside of the flood plain area and there is enough room on the parcel property to adjust the transition station during detailed design to avoid impact accordingly. The rest of the area is primarily covered with heavy foliage and would likely require major clearing efforts during construction. Due to the surrounding foliage, the transition station would have minimal line of sight visibility from the highway. In addition, another substation already exists on Route 606 so the visual impact would not be inconsistent with existing

surroundings. The identified water bodies lie on the southwest side of the station location, but the station will likely be able to avoid impacting those areas. Access roads to the Parcel already exist, from Highway 267 on the east, and from Route 606 on the south. See Figure 5-5 below for an image of the site location for TS1. See Figure 5-6 below for the wetlands and flood plains near TS1.

Figure 5-5 Transition Station 1 Location

Figure 5-6: Wetland and Flood Plains near TS1



5.2.2 Proposed Transition Station 2

TS2 is located north of Route 606 and west of Ladbrook Drive as shown in Figure 5-7 below. The area for TS2 is approximately 7.4 acres. This transition station is closer to the Mars Substation site than TS1, therefore the routes are shorter and provide a more direct path to Mars Substation The TS2 site, while currently undeveloped forested land, lies almost entirely within the Broad Run floodplain. This location cannot be permitted due to restrictions on floodplain development.

Figure 5-7: Transition Station 2 Location

5.2.2.1 Land Acquisition

TS2 is also located on a parcel owned by a data center company, Amazon Web Services (AWS). There is sufficient area on the parcel, however, the transition station placement is limited by existing infrastructure and planned future development. AWS is planning to build a new data center on the same parcel that will take up the majority of the south side of property space. This leaves only the northern side of the parcel for TS2. While it may be possible to obtain this land, the only undeveloped land in the area is located within the Broad Run floodplain and would not be permittable based on ERMs experience.

5.2.2.2 Sensitive Areas and Environmental Impacts

The west side of TS2 parcel is parallel to an existing high-voltage overhead line stemming from Shellhorn Substation located east of Highway 267 and Route 607 intersection as shown in Figure 5-8 below. Construction planning may need to consider and synchronize with Shellhorn Substation stakeholders a phased outage of that existing line along with probable relocation of some of the existing transmission poles to build TS2. A large portion of the northern side of the parcel lies within a floodplain. Because of the area needed for the placement of the transition station, TS2 must be

built primarily upon the flood plain. There is a shrub wetland passing directly through the transition station area, which may impact construction on the site. The rest of the area is primarily covered with heavy foliage and would likely require major clearing efforts. Due to the surrounding foliage and location, the station would have no line-of-sight visibility from the highway. New access roads will likely be required and will need to be placed in coordination with the planned future development by AWS on the same parcel. See Figure 5-9 below for an image of the site location for TS2. See Figure 5-10 below for the wetlands and flood plains near TS2.

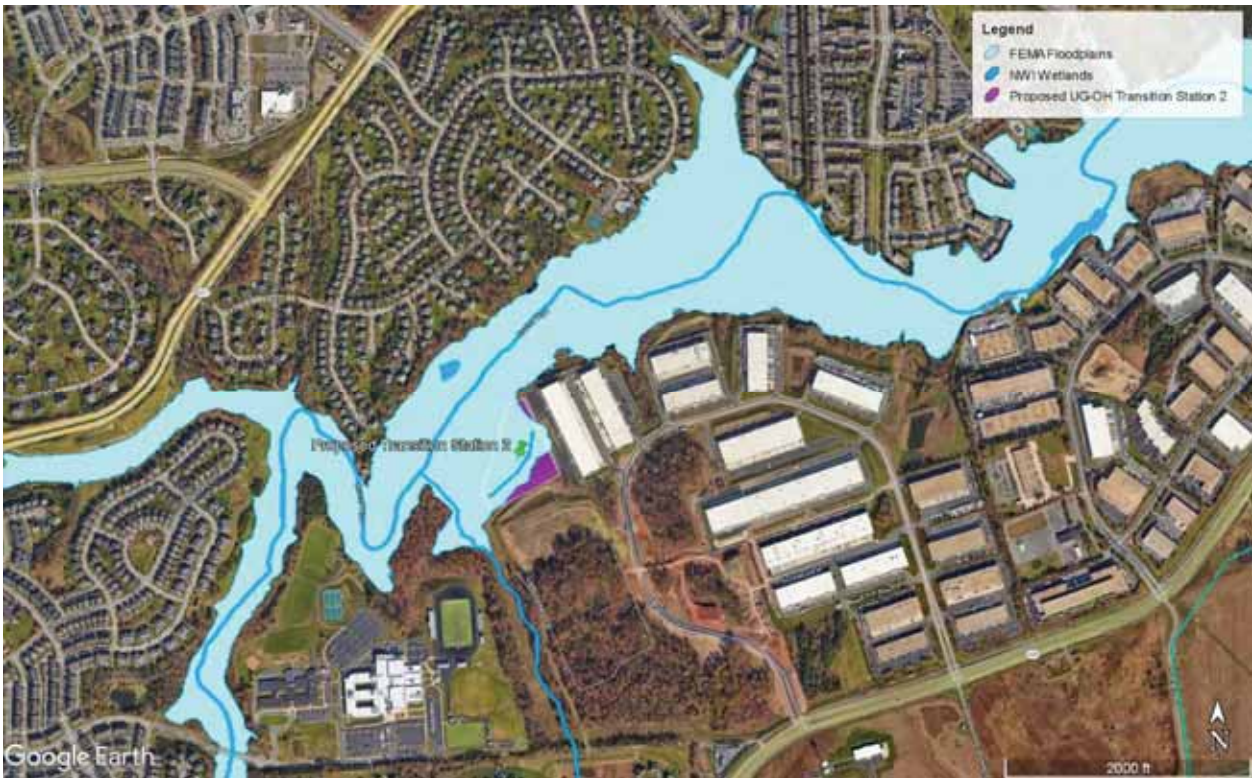
Summarizing, TS2 location is being affected by the main constructability stressors listed below. They increase the risk level over TS2 detailed design and execution.

- Planned future development of a large data center on the same parcel which TS2 will occupy
- Development of the parcel is unlikely to be permitted due to County floodplain regulations
- Wetland at the center of the transition station location driving concerns for permitting and construction
- Existing high-voltage overhead transmission line adjacent to TS2 parcel would require outages and relocations.

Figure 5-8: Existing Overhead Transmission Line Alongside Transition Station 2 Location

Figure 5-9: Transition Station 2 Location, Facing Northwest

Figure 5-10: Wetlands and Floodplains Near TS2



5.2.3 Proposed Transition Station 3

The proposed TS3 is located directly adjacent to TS1 on the east side of the route map. It is considered as an alternate location to TS1 location if the TS1 parcel cannot be acquired. TS3 is to be located north of Route 606 and west of Route 267 as shown on the route map in Figure 5-11 below. TS1 is also pictured as a reference. TS3 is further away in distance from the Mars Substation than TS2 and TS4. Like the routes to TS1, the route to TS3 is longer than the other proposed routes.

TS3 was incorporated into this study after the site visit was performed. Information on the station locations was pulled using Google Earth analysis, the provided survey data, and publicly available information.

TS3 is located entirely on public land owned by MWAA, and the site is bisected by the Horsepen Run dam spillway, which crosses under Route 606. Site grading and installation of transition station equipment would compromise the spillway's essential function. Furthermore, modifying the dam and constructing the transition station would require MWAA approval, introducing significant permitting delays and uncertainties. Additionally, any route from TS3 would need to

cross either the dam or spillway, creating substantial construction, operational, and permitting risks.

Figure 5-11 Transition Station 3 Location- MWAA

5.2.3.1 Land Acquisition

TS3 is located on a parcel that is owned by MWAA and the area is approximately 10.7 acres. There is sufficient area on the parcel for placement of the new transition station. Access roads to the Parcel already exist, from Highway 267 on the east, and from Route 606 on the south. However, it is unclear if this parcel can be acquired due to the complex permitting process with MWWA. ERM reported that , although MWAA expressed willingness to coordinate with Dominion on the Project, they were not responsive to specific questions about their permitting process or approval timelines, including NEPA permitting. This uncertainty creates significant risk for both acquiring land rights and obtaining necessary permits within the Project schedule.

5.2.3.2 Sensitive Areas and Environmental Impacts

Around 1,200 feet of existing overhead distribution lines traverse the parcel and will need to be demolished and relocated, if this parcel is used to build TS3. This overhead line demolition includes support structures, foundations and phased outages.

Unlike the other transition station locations, no portion of TS3 area is occupied by the flood plains or water bodies. The rest of the area is occupied by minimal foliage when compared to the other TS1 and TS2. Some clearing efforts would be required during construction. A large portion of the TS3 site lies within the Horsepen Run dam spillway. ERM stated that altering this area would require MWAA permission and would introduce significant operational and permitting risks to the Project.

5.2.4 Proposed Transition Station 4

TS4 is located just northeast of the Ladbrook Drive loop off Route 606, as shown in Figure 5-12 below. TS4 is closer to the Mars Substation site than TS1 and TS3, but farther away than TS2. TS4 was evaluated due to its adjacency to the existing overhead route corridor and its lack of buildings. However, the site contains a large stormwater pond that provides required stormwater management for surrounding development.

TS4 was incorporated into this study after the site visit was performed. Information on the station locations was pulled using Google Earth analysis, the provided survey data, and publicly available information.

Figure 5-12 Transition Station 4 Location - Minalter Inc.

5.2.4.1 Land Acquisition

TS4 is located on a parcel that is owned by Minalter Inc and the area is approximately 11.5 acres, which is estimated to be sufficient for placement of the new transition station. Ladbrook Drive is the only public ROW corridor leading to the TS4 location from Route 606, and as outlined in Section 4.1.7 above, there is minimal spacing on this corridor due to existing sewer and storm lines. Therefore, the routing of both UG circuits into the TS4 location may need additional private easements. There is an alternate path to TS4 on the station location east side that was reviewed. However, most of the path width is within existing natural gas and storm water easements.

5.2.4.2 Sensitive Areas and Environmental Impacts

A portion of TS4 is occupied by the flood plain areas and there is an existing water retention basin/pond at the site. This retention basin/pond at the site would need to be relocated and resurfaced during construction of the transition station. TS4 sits just barely outside of the flood plain area and there is enough room on the parcel property to adjust the transition station during detailed design to avoid impact accordingly. The rest of the area is occupied by minimal foliage

when compared to TS1 and TS2. Some clearing efforts would be required during construction. Since the TS4 site is off Ladbrook Drive, the transition station would have minimal line of sight visibility from Route 606 highway. In addition, another substation already exists on Route 606 so the visual impact would not be inconsistent with existing surroundings. The only existing access road to the parcel is on Ladbrook Drive to the west. An additional access road may be required if a route to TS4 is selected for detailed design. See Figure 5-13 below for the wetlands and flood plains near TS4.

Summarizing, TS4 location is being affected by the main constructability stressors listed below. They increase the risk level over TS4 detailed design and execution.

- Existing storm water retention basin/pond at the transition station location would introduce additional time for permitting as well as during construction for relocating the retention basin/pond, if it is even possible to relocate the stormwater pond to meet the needs of the adjacent developed areas and TS4 entirely within the site.

- The biggest challenge with TS4 is routing both circuits into the TS4 location. The Ladbrook Drive corridor may only be considered for the single circuit duct bank configuration.

- Landbrook Drive is congested with UG structures (reinforced concrete pipes (RCPs), an overhead pole foundation, utility vaults, a storm structure, a utility pedestal, and light poles) near the entrance of alternate path where the proposed UG Route would need to cross Route 606.

Figure 5-13 Wetlands and Flood Plains Near TS4

5.2.5 Proposed Transition Station 5

TS5 is located southeast off Evergreen Mills Road and Route 607 intersection, as shown in Figure 5-14 below. TS5 was developed for DEV by ERM as an intermediate location to have both, 230-kV and 500-kV circuits, in OH installation instead of UG installation from the Mars Substation up to where TS5 is. At TS5, both OH circuits will transition to UG installation following the Route R3 described above in Section 4.1.3 up to transition station TS6. Although TS5 is closer to the Mars Substation than TS2, any routing option considering TS5 will involve an OH segment with two (2) circuits carrying large loads. TS5's location was selected because it lies south of residential areas and could connect to TS6 without requiring a trenchless crossing of Broad Run, enabling use of Loudoun County Parkway as an underground route.

TS5 was incorporated into this study after the site visit was performed. Information on the station locations was pulled using Google Earth analysis, and publicly available information.

Figure 5-14: Transition Station 5 Location (Crestnet 2 LLC)

5.2.5.1 Land Acquisition

TS5 parcel is owned by Crestnet 2 LLC and the area is 6 acres which may not be sufficient for placement of the new transition station. Access roads to the Parcel would need to be developed stemming from Route 607 on the west, or Winterday Drive on the north. Available space is further constrained by a large sewer main south and the Broad Run floodplain.

5.2.5.2 Sensitive Areas and Environmental Impacts

Almost all the parcel lies within a floodplain as shown in Figure 5-16. Because of the area needed for the placement of the transition station, TS5 must be built primarily upon the flood plain. The rest of the area is primarily covered with heavy foliage and would likely require major clearing efforts. There is a pond near to the northwest corner of the Parcel which will need to be considered during the site preparation and earthworks design. Due to the surrounding foliage and location, the station

would have no line-of-sight visibility from the highway. New access roads will be required and will need to be placed in coordination with the planned future development by Crestnet 2 LLC around TS5 Parcel. See Figure 5-15 below for an image of the site location for TS5. Subsurface survey is not available for this Parcel, therefore it is unknown if existing UG utilities traverse TS5 area.

Summarizing, TS5 location is being affected by the main constructability stressors listed below. They increase the risk level over TS5 detailed design and execution.

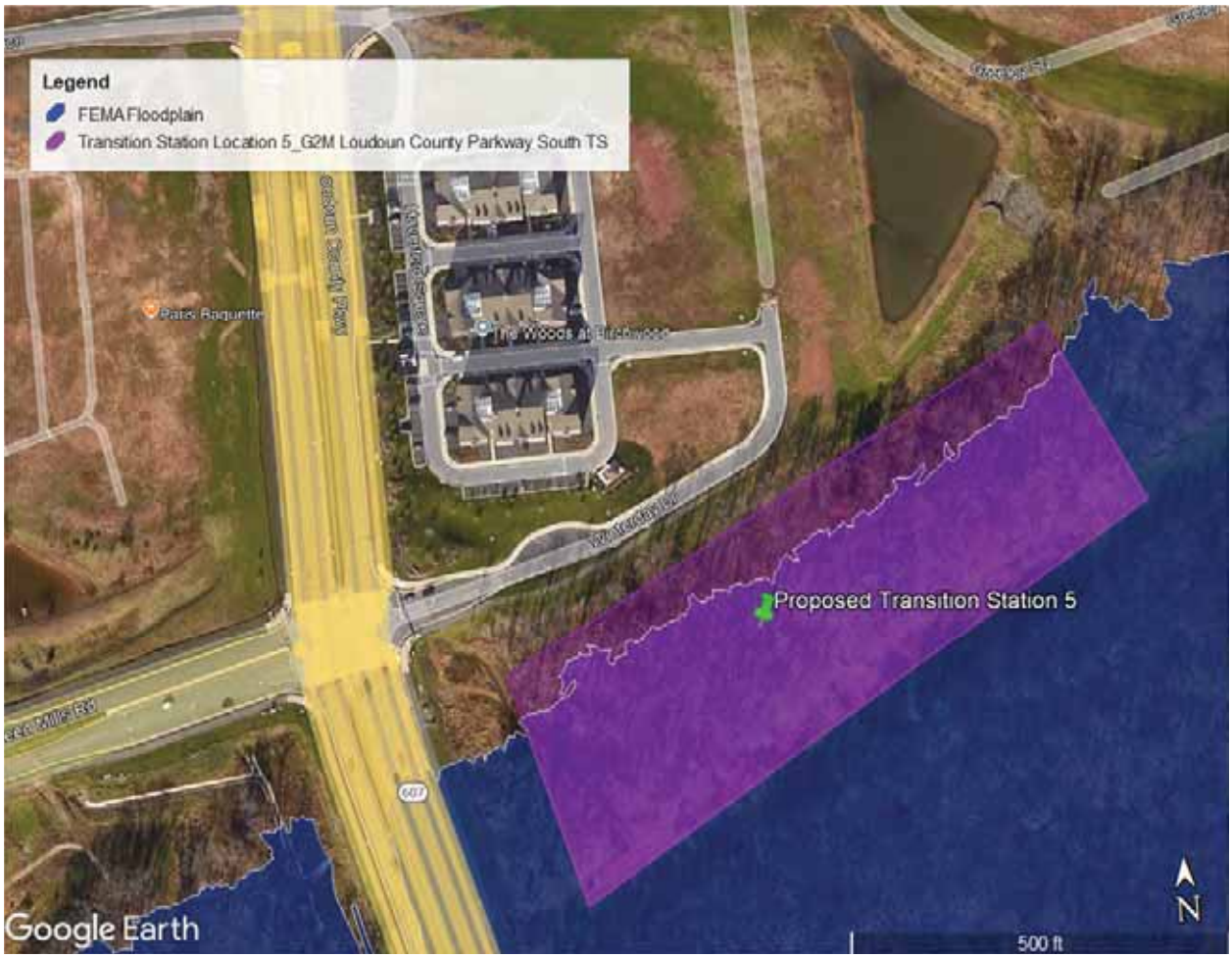
- Parcel size may be inadequate for TS5 installation. Additional land may need to be acquired but location of additional land is limited by a large diameter existing sewer main and floodplain.

- Parcel is located within a flood plain, which would require a complex permitting process for construction which is not permittable.

- Unknow UG utilities may be present in the Parcel and would need relocation impacting the station construction schedule. Overall transition station design may be affected if relocation is not allowed by stakeholders.

Figure 5-15: Transition Station 5 Location, Facing Northwest

Figure 5-16: Wetlands and Floodplains Near TS5



5.2.6 Proposed Transition Station 6

Figure 5-17 shows the transition station TS6 located northwest of Route 606 and Highway 267 intersection, further west from TS1 location described in Section 5.2.1 above. TS6 was developed for DEV by ERM as the transition station for the UG Route originated from TS5 in the southwest, see Section 5.2.5. At TS6, both UG circuits will transition from UG installation to OH installation towards Golden Substation. Any routing option leading to TS6 will have a greater length compared to those leading to TS1, TS2, TS3 and TS4. TS6 was evaluated as a potential route option along Loudoun County Parkway that would connect to TS5 without requiring a trenchless crossing of Broad Run.

TS6 was incorporated into this study after the site visit was performed. Information on the station locations was pulled using Google Earth analysis, and publicly available information.

Figure 5-17: Transition Station 6 Location (SA Associates South LLC)

5.2.6.1 Land Acquisition

TS6 parcel is owned by SA Associates South LLC and the area is 3.6 acres which may not be sufficient for placement of the new transition station. Access roads to the Parcel would need to be developed stemming from Highway 267 to the north. Based on EEM's discussions,, the landowner indicated that the TS6 site will be dedicated to Loudoun County as an open space easement as part of the adjacent Silver District West development. Once dedicated, the site would not be viable location for a transition station.

5.2.6.2 Sensitive Areas and Environmental Impacts

The west side of TS6 parcel is parallel to an existing high-voltage overhead line stemming from Shellhorn Substation located east of Highway 267 and Route 607 intersection as shown in Figure 5-18 below. Based off the pole configuration of the existing OH line shown in Figure 5-19, at a

minimum a double-circuit OH structure and foundation can be anticipated. Construction planning may need to consider and synchronize with Shellhorn Substation stakeholders a phased outage of that existing line along with probable relocation of some of the existing transmission poles to build TS6. TS6 sits just barely outside of the flood plain area. Since the Parcel may not have enough area to install the transition station, additional land may be required for the placement of TS6. If the additional area that can be acquired is on the east side of the current location, TS6 would be built primarily upon the flood plain which may impact the permitting process. In contrast, if the additional area is on the west side, TS6 would be built mostly outside of the flood plain. The area is primarily covered with heavy foliage and would likely require major clearing efforts. Due to the surrounding foliage and location, the station would have no line-of-sight visibility from the highway. New access roads will be required and will need to be placed in coordination with the planned future development by SA Associates South LLC on the same parcel. See Figure 5-19 below for an image of the site location for TS6. See Figure 5-20 below for the wetlands and flood plains near TS6. Subsurface survey is not available for this Parcel, therefore it is unknown if existing UG utilities traverse TS6 area.

Summarizing, TS6 location is being affected by the main constructability stressors listed below. They increase the risk level over TS6 detailed design and execution.

- Parcel size may be inadequate for TS6 installation. Additional land may need to be acquired. Since this parcel is planned for dedication as an open space easement to Loudoun County, a transition station would likely not be permittable.
- If the additional land is located in a floodplain, it would increase the permitting process complexity.
- Existing high-voltage overhead transmission line adjacent to TS6 parcel would require outages and relocations.
- Unknow UG utilities may be present in the Parcel and would need relocation impacting the station construction schedule. Overall transition station design may be affected if relocation is not allowed by stakeholders.

Figure 5-18: Existing Overhead Transmission Line Alongside Transition Station 6 Location

Figure 5-19: Transition Station 6 Location, Facing Southeast

Figure 5-20: Wetlands and Floodplains Near TS6

5.2.7 Proposed Transition Station 7

The proposed TS7 is located northwest of Route 606 and Overland Drive intersection between residential and industrial areas, as shown in

Figure 5-21 below. Similar to TS5, TS7 was developed for DEV by ERM as an intermediate location to have both, 230-kV and 500-kV circuits, in OH installation instead of UG installation from the Mars Substation up to where TS7 is. At TS7, both OH circuits will transition to UG installation following the proposed Route R4 described above in Section 4.1.11 up to transition station TS2. Although TS7 is closer to the Mars Substation than TS2, any routing option considering TS7 will involve an OH segment with two (2) circuits carrying large loads. TS7 was evaluated because it would provide the shortest underground route across Loudoun County Public School land to connect with TS2.

TS7 was incorporated into this study after the site visit was performed. Information on the station locations was pulled using Google Earth analysis, the provided survey data, and publicly available information.

Figure 5-21: Transition Station 7 Location (Loudoun Valley Estates III (LVE III) Homeowners Association Inc.)

5.2.7.1 Land Acquisition

TS7 parcel is owned by Loudoun Valley Estates III (LVE III) Homeowners Association Inc. and the area is 7.0 acres which is estimated to be sufficient for placement of the new transition station. Access roads to the Parcel would need to be developed stemming from Overland Drive in the south or from the pond road in the east stemming from Route 606, see Figure 5-22. ERM's review found that, the area lies within an existing open space easement dedicated to Loudoun County and

owned by LVE III. Permitting TS7 would require approval from both Loudoun County and the landowner, which is unlikely to be obtained. Additionally, placing a transition station in a residential zone would require a special use permit, introducing significant schedule risk.

5.2.7.2 Sensitive Areas and Environmental Impacts

All the Parcel is primarily covered with heavy foliage and would likely require major clearing efforts. There is a pond near to the northeast corner of TS7 location which will need to be considered during the site preparation and earthworks design. Due to the surrounding foliage and location, initially the station would have no line-of-sight visibility from the Route 606 and the existing residential area, however the station west and south fences would be visible from the industrial area, see

Figure 5-21 above. The transition station would be clearly visible from the future residential developments on the north and east sides of the Parcel planned by the current landowner. New access roads will be required and will need to be placed in coordination with the planned future development by LVE III Homeowners Association Inc. around TS7 Parcel. See Figure 5-22 below for an image of the site location for TS7. Subsurface survey along Route 606 is available, however the surveyed area does not cover Overland Drive and this Parcel. Nevertheless, from the Route 606 surveyed segment east of TS7 shown in Figure 5-23, existing UG utilities (storm drainage lines, water lines and gas lines) are derived from Route 606 into the industrial area and LVE III Homeowners Association Inc. Parcel, therefore permitting and construction planning must take into account potential UG utilities relocation to build the transition station in this location.

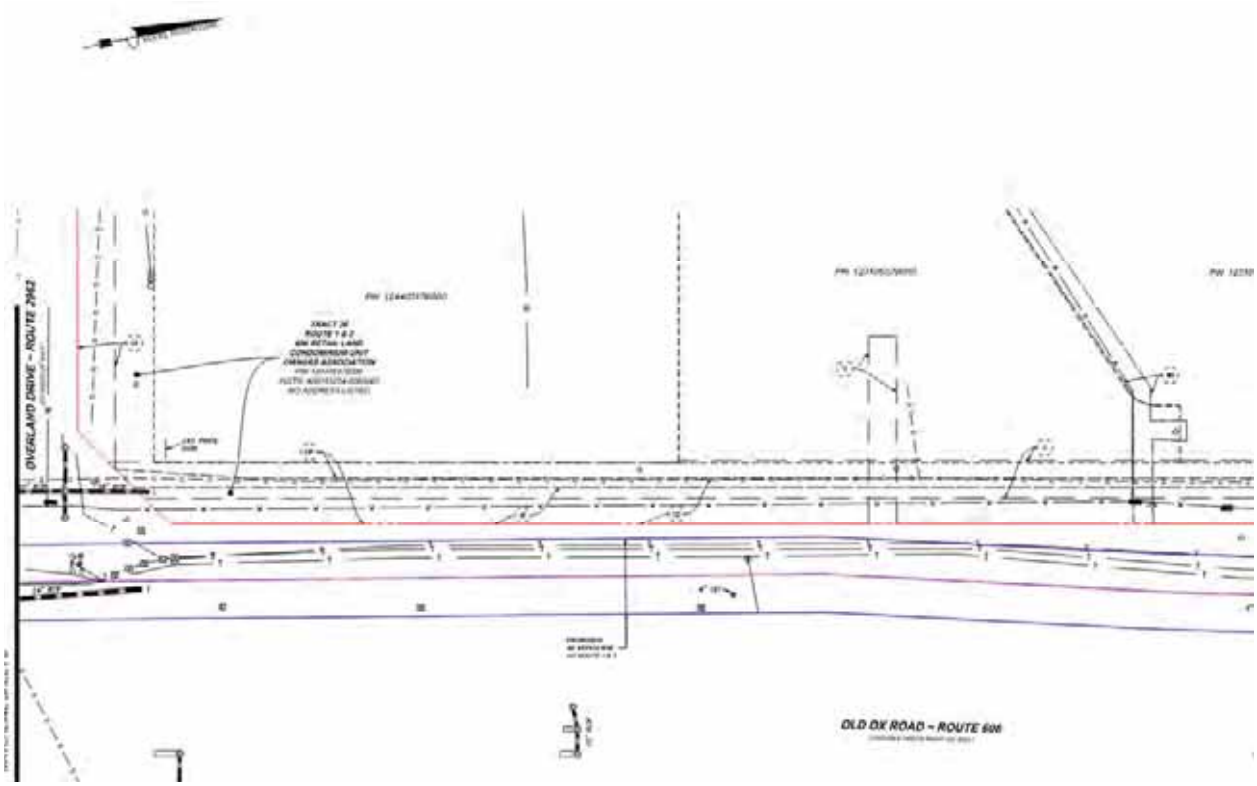
Summarizing, TS7 location is being affected by the main constructability stressors listed below. They increase the risk level over TS7 detailed design and execution.

- Parcel location would make TS7 visible from future residential developments planned by the current landlord.
- Access roads would need to use the existing pond road conflicting with the future residential developments planned by the current landlord.
- UG utilities may be present in the Parcel and would need relocation impacting the station construction schedule. Overall transition station design may be affected if relocation is not allowed by stakeholders.

- The site lies within an existing open space easement and residential zone district, both of which are land uses generally considered incompatible with major utility infrastructure based on discussions with ERM.

Figure 5-22: Transition Station 7 Location, Facing West

Figure 5-23: Route 606 Surveyed Segment East of TS7 Between Overland Drive and Beaver Meadow Road



5.3 Mars Substation Location

During a site visit to project area, the proposed location of Mars Substation was observed, pictured in Figure 5-24 below. The terrain appears largely flat with some trees and shrubbery coverage. Additionally, new constructions south of the proposed substation location were noted that did not appear in Google Earth. As a result, there is introduced high tuck traffic along Route 857, pictured in Figure 5-25 below. Given the UG 500-kV and 230-kV cables, it was not possible to develop an appropriate configuration for the Mars Substation, including switches, that would meet Dominion's reliability standards.

Figure 5-24: Mars Substation Location

Figure 5-25: New Construction Truck Traffic Near Mars Substation

5.3.1 Land Acquisition

ERM's review found that while Dominion has obtained the Mars Substation land, additional space would be needed to accommodate transition station equipment beyond the existing footprint. This expansion is constrained by planned transmission lines, existing ponds, and MWAA property to the south. Consequently, sufficient space for transition station equipment may not be available or obtainable.

5.3.1.1 Sensitive Areas and Environmental Impacts

ERM found that the area directly south of Mars Substation contains an existing pond, an unnamed waterbody, and planned transmission lines, with MWAA property further south. The pond likely cannot be relocated, and acquiring MWAA land would introduce uncertain schedule and permitting risks.

6.0 COST ESTIMATE ANALYSIS

A conceptual cost estimate was developed for all the proposed routes. See Appendix C for the detailed summary of the estimates.

6.1 Cost Estimate Assumptions

At this stage of design, assumptions have been made to obtain preliminary cost estimates. These assumptions are organized by major project area.

6.1.1 Underground Assumptions

Major assumptions for establishing the civil and electrical cost estimates under consideration are as follows:

6.1.1.1 230-kV UG Assumptions

1. Based upon the ampacity calculation results, the cables to be procured for the 230-kV circuit would be a 5,000 kcmil XLPE copper cable with insulated conductor wires.
2. For the 230-kV circuit, one (1) circuit installation with four (4) cables per phase.
3. Two (2) vaults will be needed for each 230-kV vault location.
4. It is assumed that the duct bank will consist of 8-inch Schedule 40 PVC conduits with four (4) spare conduits.

6.1.1.2 500-kV UG Assumptions

1. Based upon the ampacity calculation results, the cables to be procured for the 500-kV circuit would be a 5,000 kcmil XLPE copper cable with insulated conductor wires.
2. For the 500-kV circuit, one (1) circuit installation with five (5) cables per phase.
3. Three (3) vaults will be needed for each 500-kV vault location.
4. It is assumed that the duct bank will consist of 8-inch Schedule 40 PVC conduits with five (5) spare conduits.

6.1.1.3 General UG Assumptions

1. Three percent (3%) escalation over one year assuming 2024-dollars and assuming construction to start in 2026.
2. FTB Backfill 100% throughout entire open-cut trench installation length.
3. One (1) communication handhole required at each vault location and one (1) at each station.
4. Groundwater elevation has been assumed to be 5 feet below grade.
5. Contaminated Material Disposal based upon 5% of total Civil Cost.
6. Utility relocation based upon 5% of total Civil Cost.
7. Rock removal based upon 5% of Civil Excavation length for UG Route 2.
8. Rock removal based upon 10% of Civil Excavation length for UG Routes 1, 3, 4, 5, 6, 7, R1, R2, R3 and R4.
9. Traffic Control assumed to be two (2) crew, per circuit.
10. It is assumed that sheath grounding shall be single point bonded.
11. Estimates based on combined city cost index of (0.926) for Sterling, Virginia from the 2024 RSMeans.
12. Tax rate of 6.0%
13. Project contingency of twenty percent (20%) assumed.
14. Permitting and land acquisition costs have not been included in the estimate.

6.1.2 Transition Station Assumptions

The transition station cost estimate was developed using DEV's Success Enterprise estimating tool. All costs have been developed in alignment with typical estimating processes for DEV internal projects. Other major assumptions are:

1. Security design level 1 fencing and integrators
2. 15’ average spacing of ground grid conductors
3. Spread footers and raised control enclosure foundations
4. The cost and design for 230 kV series reactors is assumed from Dominion Equipment group per the recent projects.
5. The 500 kV series reactors cost is assumed from Dominion Equipment group per their discussion with the vendors. The cost and design to be provided by the vendors once the project is going for AFE approval

The transition station and substation costs provided in Section 6.2 do not include the following items:

1. Real Estate
2. Permitting
3. Site prep (Grading, clearing, E&S controls, storm water management facilities, etc.)
4. Survey
5. Public Communications & Outreach

6.2 Summary of Cost Estimates - Including Engineering and Construction Management

This section contains a summary of the cost estimate for all of the proposed UG routes and stations. See Table 6-1 and Table 6-2 below for the cost estimate summaries which include engineering and construction management support. See Appendix C for the detailed cost estimate reports.

Table 6-1: UG Route Total Project Cost Estimate Summary, 85% DLF

Circuit Route	Transition Station Cost[1][2]	Mars Substation Cost[1][2]	230-kV Cost[1][2]	500-kV Cost[1][2]	TOTAL COST ($USD)[1][2]
UG Route 1	$52,273,000	$21,891,000	$239,445,000	$320,041,000	$633,650,000
UG Route 2	$52,273,000	$21,891,000	$200,824,000	$302,279,000	$577,266,000
UG Route 3	$52,273,000	$21,891,000	$290,278,000	$229,405,000	$593,847,000
UG Route 4	$52,273,000	$21,891,000	$175,832,000	$264,723,000	$514,719,000
UG Route 5	$52,273,000	$21,891,000	$176,853,000	$268,766,000	$519,783,000
UG Route 6	$52,273,000	$21,891,000	$203,787,000	$228,195,000	$506,146,000
UG Route 7	$52,273,000	$21,891,000	$185,046,000	$231,947,000	$491,157,000

Notes: 1. Cost estimates displayed are rounded to the nearest $1,000.
2. Cost estimates do not include any trenchless crossings along UG Route 1 through UG Route 7.

Table 6-2: UG Route Total Project Cost Estimate Summary, 100% DLF

Circuit Route	Transition Station Cost[1]	Mars Substation Cost[1]	230-kV Cost[1]	500-kV Cost[1]	TOTAL COST ($USD)[1]
UG Route 1[4]	$52,273,000	$21,891,000	$239,445,000	$328,591,000	$642,200,000
UG Route 2[4]	$52,273,000	$21,891,000	$200,824,000	$320,981,000	$595,969,000
UG Route 3[4]	$52,273,000	$21,891,000	$290,278,000	$235,882,000	$600,324,000
UG Route 4[4]	$52,273,000	$21,891,000	$175,832,000	$272,016,000	$522,012,000
UG Route 5[4]	$52,273,000	$21,891,000	$176,853,000	$276,070,000	$527,087,000
UG Route 6[4]	$52,273,000	$21,891,000	$203,787,000	$235,694,000	$513,645,000
UG Route 7[4]	$52,273,000	$21,891,000	$185,046,000	$238,016,000	$497,226,000
UG Route R1[2]	$52,273,000	$21,891,000	$241,355,000	$370,087,000	$685,606,000
UG Route R2[2]	$52,273,000	$21,891,000	$211,809,000	$321,561,000	$607,534,000
UG Route R3[2]	$52,273,000	$21,891,000	$280,670,000[3]	$438,796,000[3]	$793,630,000[3]
UG Route R4[2]	$52,273,000	$21,891,000	$96,927,000[3]	$152,211,000[3]	$323,302,000[3]

Notes: 1. Cost estimates displayed are rounded to the nearest $1,000.
2. Cost estimates for UG Route R1 through UG Route R4 were developed for 100%DLF.
3. The trenchless crossings identified along this route are not constructible, see Appendix E. Therefore, this cost does not include trenchless construction cost, does not consider the re-routing cost required to avoid those crossings, nor the cost of other trenchless crossings derived from the new alignment.
4. Cost estimates do not include any trenchless crossings along UG Route 1 through UG Route 7.

7.0 NEXT STEPS

The following steps should be taken during detailed design phase if an underground route is required.

7.1 Perform Field Investigation

The following sections provide further detail of the specific investigations that would be required to begin design of the underground installation of this project.

7.1.1 Survey

Even though DEV has recently provided a preliminary survey on certain segments of the project area, BMcD recommends that additional survey be acquired during detailed engineering to account for any new existing utilities that may have been added between now and the time detailed engineering starts. A survey of Quality Level B or Level C is recommended to present a more accurate depiction of the existing utilities along the alternative route and determine any additional project constraints. This level of survey would include field verifying of utility locations and would provide additional information up to and including vertical elevations, sizes, and materials of the utilities.

7.1.2 Geotechnical & Thermal Resistivity Testing

A detailed geotechnical investigation is recommended prior to further design. A geotechnical investigation is recommended to include the following:

- Thermal resistivity testing to confirm cable system parameters.
    - Laboratory testing shall be completed on samples taken from the depths as indicated in the project specifications. Testing shall include a description of the soils, moisture content, density and thermal dryout curves (thermal resistivity versus moisture content).
- Soil characterization for the proposed trench and trenchless portions to identify soil and bedrock conditions for the installation, operation of the facilities and to determine groundwater depth. For the proposed UG route(s), a test boring can be taken every 500 feet along the alignment or as project budget or risk tolerance

allow. Borings should be advanced to a depth of at least 10 feet below the bottom of the proposed UG installation depth.

- Laboratory Testing
    - Laboratory tests shall be assigned and performed to classify soils and obtain geotechnical physical characteristics for soils and rock such as strength, compressibility, and compaction characteristics. The quantity of tests to be performed shall be determined by the Engineer and will be dependent upon type of soil and/or rock encountered during drilling. Testing shall be in consideration of foundation types that may be required for proposed structures as required. Laboratory tests may include, but are not limited to, the tests listed below:
        - Moisture Content
        - Dry Unit Weight
        - Sieve Analysis
        - Percent Finer than No. 200 Sieve
        - Atterberg Limits
        - Organic Content
        - Unconfined Compression – Soil or Rock
        - Compaction Characteristics (Standard Proctor Test)
        - Thermal Testing (By Geotherm, Inc.)
        - Chemical Analyses
            - pH
            - Soluble Sulfates
            - Chloride Ion
            - Electrical Resistivity
            - Redox Potential
            - Sulfides

7.2 Further Stakeholder Involvement

DEV has established lines of communication with the entities that will be potentially impacted by the project and will continue to facilitate ongoing dialogue to ensure concerns are addressed and expectations are managed.

7.2.1 Permitting Coordination

- City of Dulles, Virginia
- Virginia Department of Transportation (VDOT)
- Local utility owners
- Local stakeholder groups that may include clubs, churches, businesses, and other organizations. Stakeholder identification will be required as per regulations.

7.2.2 Third Party Utility Coordination

Generally, in urbanized areas, such as the project area described above, coordination with third-party utilities on location and condition of existing facilities as well as future projects and plans along the proposed routes will be vital to confirm adequate space is available for the planned work.

7.2.3 Future Improvement Projects within Study Area

It will be beneficial for the design process to identify any future improvement projects that are being considered inside of the project study area to finalize routing.

7.2.4 Real Estate Acquisition

The need for real estate acquisition should be confirmed based on the above activities and preliminary investigations should be conducted to determine any potential risks for securing critical properties or easements. As required, real estate options should be obtained at critical locations along the route.

8.0 CONCLUSION

8.1 Feasibility Summary

Burns & McDonnell has reviewed the eleven (11) proposed underground routes developed by DEV and ERM for the proposed UG transmission line and identified various constructability challenges associated with each proposed UG route option. The challenges include:

- Construction through flood plains, wetlands, and ponds.
- Construction through existing concrete culverts below Routes 606 and 607.
- The need of significant number of easements since most of the routes will need to be installed outside of the public ROW.
- Permanent easements from sensitive facilities and federal lands probably not possible to obtain.
- Spacing concerns for duct bank and splice vault placement as well as impacts to traffic for proposed alignments paralleling Routes 606 and 607 roadways.
- Parcel acquisition issues for some of the transition station options.
- Potential relocation of existing UG utilities at congested areas.
- Relocation of existing overhead distribution and transmission lines foundations and supporting structures.
- Trenchless crossings with large ROW widths require demolishing existing private infrastructure to accommodate working spaces at launching/receiving pits.
- The probable presence of diabase rock, which is an abrasive and hard material to drill through at trenchless crossings, implying the need of large rigs and potential schedule risks due to the slow drilling process.

Based on the number and complexity of the identified constructability constraints, all of the studied UG routes are no longer considered constructable options for Golden to Mars project.

APPENDIX A UG ROUTE MAPBOOKS

Legend

- Proposed Route 1
- Proposed Route 1 ROW
- Proposed Manhole Location
- Proposed Transition Station
- Proposed Substation
- Amazon Data Center Approx. Location
- Marsh, Swamp, Bog, Prairie
- River
- Parcel Boundaries

NORTH

1,000 500 0 1,000

US Feet

BURNS McDONNELL

Golden to Mars 230-kV & 500-kV
UG Routing Project
Proposed Route 1
Dominion Energy
Loudon County, VA
Overview Aerial Map

Source: Esri, GPC and Burns & McDonnell

Issued: 8/21/2024

Legend

- Proposed Route 2
- Proposed Route 2 ROW
- Proposed Manhole Location
- Proposed Transition Station
- Proposed Substation
- Amazon Data Center Approx. Location
- Marsh, Swamp, Bog, Prairie
- River
- Parcel Boundaries

NORTH

1,000 500 0 1,000

US Feet

BURNS McDONNELL

Golden to Mars 230-kV & 500-kV
UG Routing Project
Proposed Route 2
Dominion Energy
Loudon County, VA
Overview Aerial Map

Source: Esri, GPC and Burns & McDonnell

Issued: 8/21/2024

Legend

- Proposed Route 3
- Proposed Route 3 ROW
- Proposed Manhole Location
- Proposed Transition Station
- Proposed Substation
- Amazon Data Center Approx. Location
- Marsh, Swamp, Bog, Prairie
- River
- Parcel Boundaries

NORTH

750 375 0 750

US Feet

BURNS McDONNELL

Golden to Mars 230-kV & 500-kV
UG Routing Project
Proposed Route 3
Dominion Energy
Loudon County, VA
Overview Aerial Map

Source: Esri, GPC and Burns & McDonnell

Issued: 8/21/2024

Legend

- Proposed Route 6
- Proposed Route 6 ROW
- Proposed Manhole Location
- Proposed Transition Station
- Proposed Substation
- Amazon Data Center Approx. Location
- Marsh, Swamp, Bog, Prairie
- River
- Parcel Boundaries

NORTH

750 375 0 750

US Feet

BURNS McDONNELL

Golden to Mars 230-kV & 500-kV
UG Routing Project
Proposed Route 6
Dominion Energy
Loudon County, VA
Overview Aerial Map

Source: Esri, DEV and Burns & McDonnell

Issued: 8/21/2024

Legend

- Proposed 230-kV & 500-kV UG Route
- Proposed 230-kV & 500-kV UG Route ROW (90' Wide)
- Proposed Substation
- Proposed Transition Station
- Proposed 230-kV Manhole Location
- Proposed 500-kV Manhole Location
- Jack & Bore
- Horsepen Pond-Future Pond-Railway Overpass HDD Crossing
- Parcel Boundaries
- Future Sewer Line (By Others)
- Future Permanent Easements (By Others)
- Future Pond (By Others)
- Marsh, Swamp, Bog, Prairie
- River

NORTH

1,000 500 0 1,000

US Feet

BURNS McDONNELL

Golden to Mars 230-kV & 500-kV UG Routing Project
Proposed Route R1 (MWAA Route)
Dominion Energy
Loudoun County, VA
Overview Aerial Map

Source: Esri, GPC and Burns & McDonnell

Issued: 12/5/2024

Legend

- Proposed 230-kV & 500-kV UG Route
- Proposed 230-kV & 500-kV UG Route ROW (90' Wide)
- Proposed Substation
- Proposed Transition Station
- Proposed 230-kV Manhole Location
- Proposed 500-kV Manhole Location
- Jack & Bore
- Guided Jack & Bore
- Parcel Boundaries
- Future Sewer Line (By Others)
- Future Permanent Easements (BY OTHERS)
- Marsh, Swamp, Bog, Prairie
- River

NORTH

1,000 500 0 1,000

US Feet

BURNS McDONNELL

Golden to Mars 230-kV & 500-kV UG Routing Project
Proposed Route R2
Dominion Energy
Loudoun County, VA
Overview Aerial Map

Source: Esri, GPC and Burns & McDonnell

Issued: 12/5/2024

Path: \\bmdfs\fs\Clients\TND\Dominion\Esri_Underground\170234_GoldenMarsFeasDesign\UG\CAD\Working\Arc\285\Golden Mars\Golden Mars.aprx jbarringer 12/5/2024

Legend

- Proposed 230-kV & 500-kV UG Route
- Proposed 230-kV & 500-kV UG Route ROW (90' Wide)
- Proposed 230-kV Manholes Location
- Proposed 500-kV Manholes Location
- Proposed Transition Station
- Jack & Bore
- Microtunneling
- Parcel Boundaries
- Inova Emergency Care Center
- Marine
- Estuary
- Marsh, Swamp, Bog, Prairie
- River
- Lake, Reservoir
- Pond

NORTH

1,000 500 0 1,000

US Feet

BURNS McDONNELL

Golden to Mars 230-kV & 500-kV
UG Routing Project
Proposed Route R3
Dominion Energy
Loudoun County, VA
Overview Aerial Map

Source: Esri, GPC and Burns & McDonnell

Issued: 12/5/2024

Legend

- Proposed 230-kV & 500-kV UG Route
- Proposed 230-kV & 500-kV Route ROW (90' Wide)
- Proposed Transition Station
- Proposed 230-kV Manhole Location
- Proposed 500-kV Manhole Location
- Trenchless Crossing
- Parcel Boundaries
- Schools
- Loudoun Valley Estates' Freshwater Pond System
- Marsh, Swamp, Bog, Prairie
- River

NORTH

500 250 0 500

US Feet

BURNS McDONNELL

Golden to Mars 230-kV & 500-kV
UG Routing Project
Proposed Route R4
Dominion Energy
Loudoun County, VA
Overview Aerial Map

Source: Esri, GPC and Burns & McDonnell

Issued: 12/5/2024

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APPENDIX B XLPE AMPACITY CALCULATIONS

Memorandum

Date: 6/14/2024

To: Shane Moulton

From: Gustavo Contreras

Subject: Dominion Golden to Mars - 230kV and 500-kV Underground Cable Preliminary Ampacity Study

In support of the 230-kV and 500-kV Dominion (DEV) Golden to Mars UG Transmission Line project, Burns & McDonnell Engineering Company, Inc. (BMcD) has performed preliminary ampacity calculations to identify the underground conductor size and the number of cables-per-phase (CPP) needed to meet the target circuit loading requirements. In a previous study, it was determined that a five (5) CPP configuration was required to meet the ampacity ratings for the 500-kV circuit, within a single duct bank. It was also determined that a four (4) CPP configuration was required for the 230-kV circuit, within a single duct bank. Dominion has requested BMcD additional ampacity calculations to evaluate two different cases, Case 1 and Case 2.

For Case 1, the 500-kV circuit is split into two (2) duct banks and the number of CPP is reduced to four (4) CPP. For Case 2, both the 230-kV and 500-kV single circuit duct banks are reduced by one (1) CPP to identify the maximum ampacity rating that can be achieved by running the cables to their maximum operating temperature of 90°C. The following writeup summarizes the results for both cases.

Ampacity calculations were computed using the CYMCAP ampacity program by CYME. The CYMCAP software utilizes the Neher-McGrath method of calculating the achievable ampacities of underground cables and conforms to IEC standards 60287 and 60853. This software is accepted as the industry standard for performing ampacity calculations for underground electrical systems. The individual CYMCAP execution reports for all calculations included as part of this Memo can be seen in Appendix A.

DESIGN PARAMETERS AND INSTALLATION CONDITIONS

The parameters for these ampacity calculations are based on engineering judgment and the design criteria established for this project during the preliminary analysis memo (PAM) phase. The design parameters used for the 230-kV and 500-kV circuits can be seen below in Table 1 and Table 2, respectively. The underground cable systems operating environment can be seen below in Table 3.

Table 1 230-kV Design Parameters

Design Parameter	Parameter Value	Source
Nominal Operating Voltage	230-kV	Dominion
Nominal Frequency	60 Hz	Industry Standard
Circuit Rating	3,950 A	Dominion
Maximum Normal Conductor Temperature	90°C	Industry Standard
Maximum Emergency Conductor Temperature	105°C	Industry Standard
Daily Load Factor (DLF)	85% and 100 %	Dominion
Sheath Bonding	Single Point	Assumed

Table 2 500-kV Design Parameters

Design Parameter	Parameter Value	Source
Nominal Operating Voltage	500-kV	Dominion
Nominal Frequency	60 Hz	Industry Standard
Circuit Rating	5,000 A	Dominion
Maximum Normal Conductor Temperature	90°C	Industry Standard
Maximum Emergency Conductor Temperature	105°C	Industry Standard
Daily Load Factor (DLF)	85% and 100 %	Dominion
Sheath Bonding	Single Point	Assumed

Table 3 Environmental Criteria

Description	Value	Source
Summer Ambient Earth Temperature (3'<= d < 8)	28°C	Assumed
Summer Ambient Earth Temperature (8'<= d < 20)	20°C	Assumed
Summer Ambient Earth Temperature (20'<= d)	12°C	Assumed
Native Soil Thermal Resistivity*	150°C-cm/W - 85% DLF 115°C-cm/W - 100% DLF	Assumed
Concrete Thermal Resistivity	0.60°C-m/W	Assumed
Thermal Backfill (FTB)	0.60°C-m/W	Assumed
Minimum Burial Depth to Top of Concrete	3 feet	Assumed
Installation Conditions	Concrete Encased Duct Bank	BMcD Preliminary Study

*Actual native soil thermal resistivity is unknown, and conservative values are being assumed. It is lower for the 100% DLF, as this is the maximum allowable value to meet ampacity requirements.

Constraints: Right-of-Way Width

To minimize the thermal effects of each circuit on the other, the spacing between each duct bank must be maximized. For this study, a maximum right-of-way (ROW) width of 115-feet is assumed based on results from a previous preliminary route study.

Open Trench Installation Types from Previous Study

A total of two (2) civil installation types were originally evaluated for this project. For each configuration, both 85% DLF and 100% DLF will be evaluated. The duct bank configurations for each circuit as evaluated in the previous study is shown Table 4 in below. The new circuits will be installed in concrete encased duct banks.

Table 4 Open Cut Trench Installation Types

Circuit Voltage	Conduit Size (SCH 40)	Vertical Spacing C-C*	Horizontal Spacing C-C*	Assumed Native Soil Thermal Resistivity**
230-kV, 85% DLF	8"	2'-0"	2'-0"	150 °C-cm/W
230-kV, 100% DLF	8"	2'-0"	2'-0"	115 °C-cm/W
500-kV, 85% DLF	8"	1'-6"	4'-0"	150 °C-cm/W
500-kV, 100% DLF	8"	2'-0"	4'-0"	115 °C-cm/W

*C-C = Centerline to Centerline
**Actual native soil thermal resistivity is unknown, and conservative values are being assumed. It is lower for the 100% DLF, as this is the maximum allowable value to meet ampacity requirements.

1. Each voltage class is installed in separate duct bank(s). The circuits are installed in separate ROWs and far enough apart to be considered thermally isolated.
   a. For 230-kV - 4x4 duct configuration (Figure 1)
   b. For 500-kV - 4x5 duct configuration (Figure 2 and Figure 3)

Figure 1 230-kV Single Circuit Duct Banks 85% DLF and 100% DLF

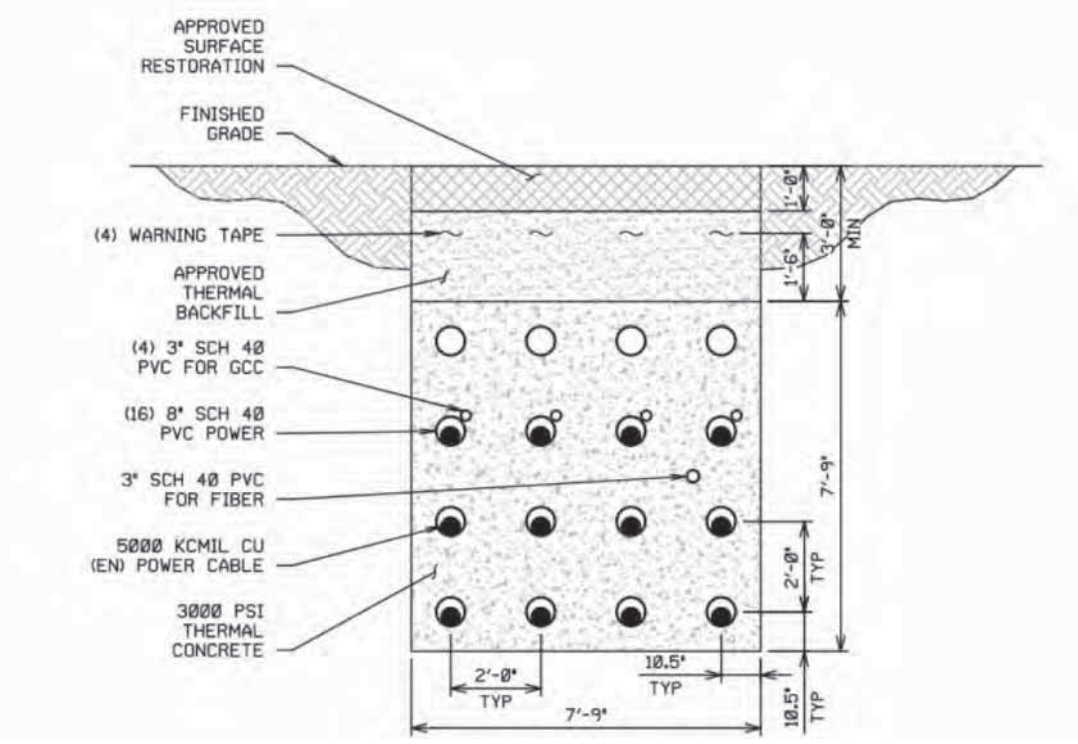


Figure 2 500-kV Single Circuit Duct Bank 85% DLF

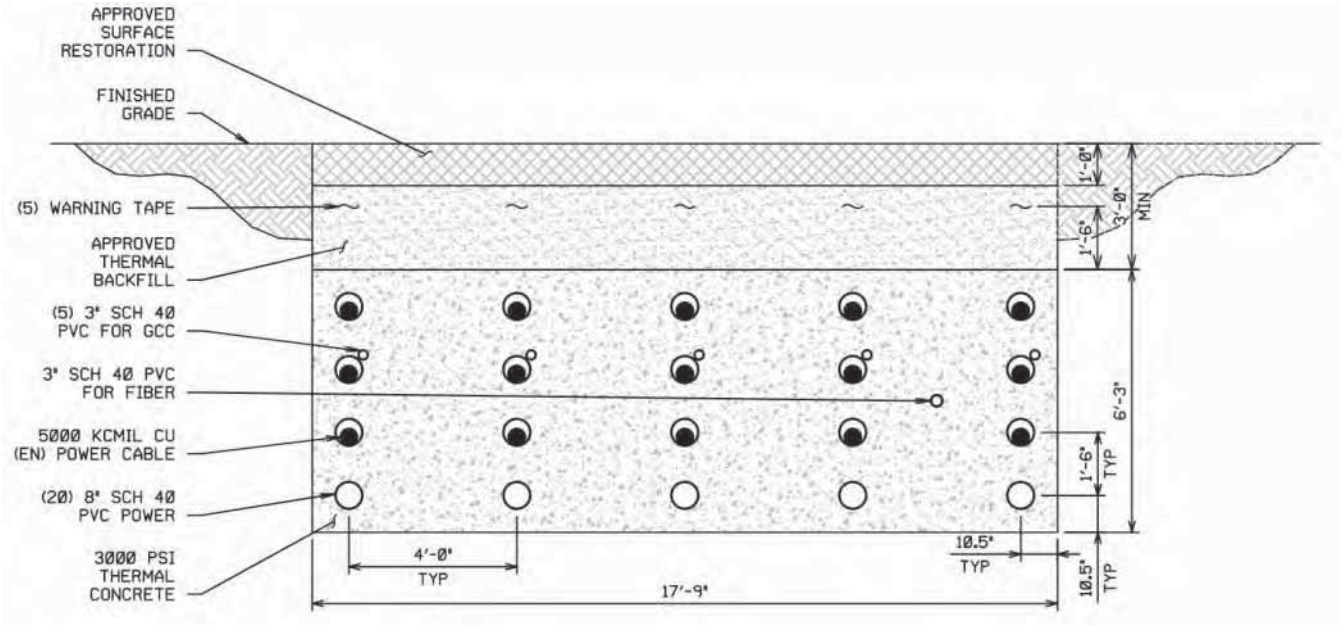
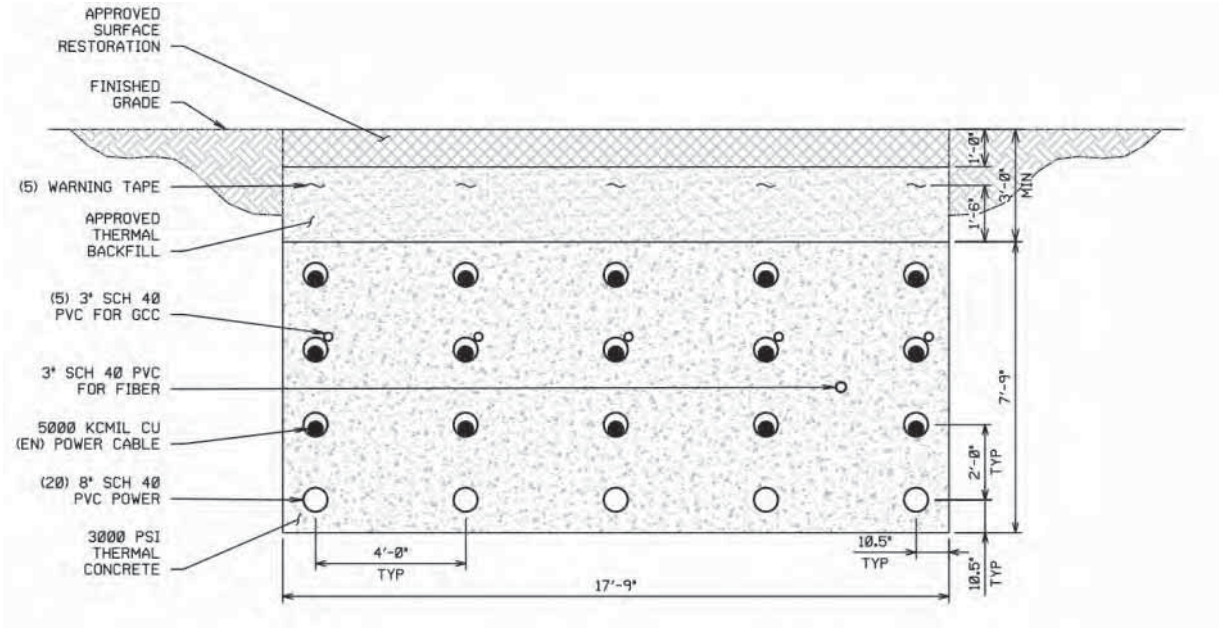


Figure 3 500-kV Single Circuit Duct Bank 100% DLF



THERMAL PINCH POINT IDENTIFICATION AND NEW INSTALLATION SCENARIOS

A previous study found that the 230-kV circuit would need four (4) cables per phase and 500-kV would need five (5) cables per phase to meet rating requirements. Following the request from DEV for additional calculations, Case 1 and Case 2 installation scenarios were computed. The following sections detail the installation scenarios for each case.

CASE 1 INSTALLATION SCENARIOS – 500-KV CIRCUIT SPLIT INTO TWO SEPARATE DUCT BANKS

As part of the new study request for Case 1, the 500-KV circuit CPP were reduced by one (1) and the duct bank was split into two (2) separate duct banks. Each smaller duct bank contains two CPP for a total of four (4) CPP for the 500-kV circuit. A baseline calculation was run with just the 500-kV circuit in the split duct bank configuration. After establishing the baseline, the 230-kV circuit was placed in parallel with the 500-kV split duct bank circuit and the maximum achievable ampacity ratings were calculated. All other design criteria from the previous study remained the same including thermal resistivity, ambient temperature, duct spacing, and depth of cover.

See the below installation scenarios that were modeled as a part of this Case 1 study:

1. 500-kV Circuit with four (4) CPP split into two duct banks
2. 230-kV and 500-kV Circuit Duct Banks within same ROW
    a. 115-foot assumed ROW

Case 1: Baseline – 500-kV Circuit Split Duct Bank with Four (4) Cables per Phase

To determine the spacing for the split circuit duct banks it was first necessary to identify the criteria for getting the minimum required amps (5,000A) using only four (4) CPP.

For the 100% DLF isolated case, the 500-kV circuit meets the minimum ampacity requirement with only four (4) CPP if a minimum of 27 feet separation is maintained between the duct bank edges. Figure 4 below shows the duct bank configuration for this case. See ampacity execution B1 for detailed results.

Figure 4 500-kV Duct Bank Configuration with Four Cables per Phase, 100% DLF

For the isolated case with DLF of 85%, the 500-kV circuit meets the minimum ampacity requirement with only four (4) CPP if a minimum of 30 feet separation is maintained between the duct bank edges. Figure 5 below shows the duct bank configuration for this case. See ampacity execution B2 for detailed results.

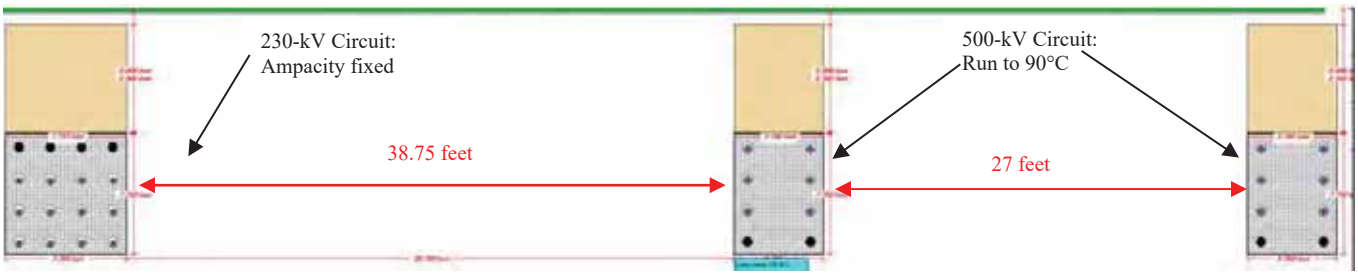
Figure 5 500-kV Duct Bank Configuration with Four Cables per Phase, 85% DLF

Please note that the difference in duct bank separation between the 85% and 100% DLF is due to the proposed change of native soil thermal resistivity (reduced native soil thermal resistivity to meet required ampacity) being used for the 100% DLF option.

Case 1: Two Circuits– 230-kV and 500-kV Duct Banks with Four Cables Per Phase

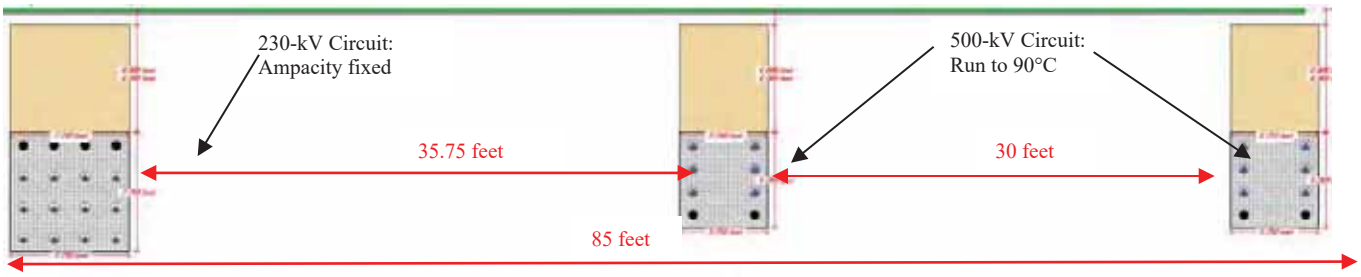
For the 100% DLF case, to maintain the proposed 115 feet ROW width, the 230-kV duct bank must be placed at a maximum of 38'-9" from the edge of the closest 500-kV duct bank, see Figure 6 below. The 230-kV circuit was set to meet the minimum ampacity requirement and the 500-kV circuit was run to 90°C. It was determined that the 500-kV circuit could not meet the required minimum ampacity given the space restriction and the 500-kV circuit was only able to achieve 4,906 A. See ampacity execution T4.1a for detailed results.

Figure 6 Double Circuit Duct Bank with Four Cables per phase, 100% DLF



For the 85% DLF case, to maintain the proposed 115 feet ROW width, the 230-kV duct bank must be placed at a maximum of 35' – 9" from the edge of the closest 500-kV duct bank, see Figure 7 below. The 230-kV circuit was set to meet the minimum ampacity requirement and the 500-kV circuit was run to 90°C conductor operating temperature. It was determined that the 500-kV circuit could not meet the required minimum ampacity given the space restriction and the 500-kV circuit was only able to achieve 4,926 A. See. See ampacity execution T4.1.b for detailed results.

Figure 7 Double Circuit Duct Bank with Four Cables per Phase, 85% DLF



CASE 2 INSTALLATION SCENARIOS – 230-KV AND 500-KV CIRCUITS REDUCED BY ONE CABLE PER PHASE

As part of an additional study request (Case 2), the cables per phase for both the 230-kV and 500-KV circuits were reduced by one (1) CPP and maximum achievable ampacity ratings are being provided based on this request for both circuits. For this Case 2 ampacity request, the 230-kV circuit was reduced to three (3) CPP and 500-kV was reduced to four (4) CPP. All other design criteria from the previous study remained the same including thermal resistivity, ambient temperature, duct spacing, and depth of cover.

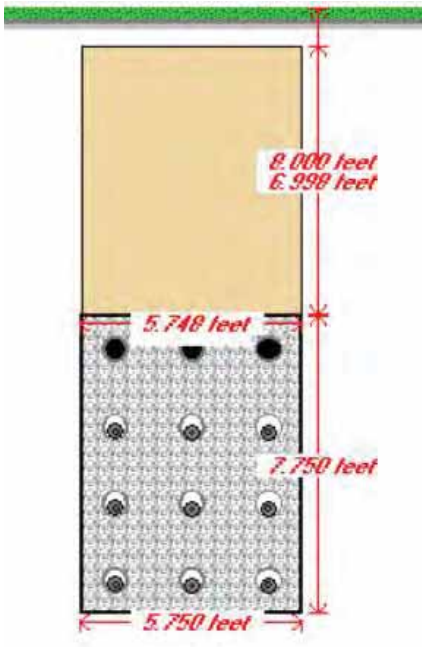
See the below installation scenarios that were modeled as a part of this Case 2 study:

1. 230-kV Circuit with three (3) CPP, in a single duct bank
2. 500-kV Circuit with four (4) CPP, in a single duct bank
3. 230-kV and 500-kV Circuit Duct Banks within same ROW
    a. 115-foot assumed ROW

Case 2: 230-kV Circuit with Three Cables per Phase, 100% DLF

For the 230-kV circuit, a duct bank consisting of three (3) CPP and a 100% DLF run to 90°C was used to determine the maximum achievable ampacity rating. With this configuration, the 230-kV circuit was able to achieve 3,548 A (see ampacity execution T1.1a1 for detailed results). Figure 8 below shows the duct bank configuration for this case.

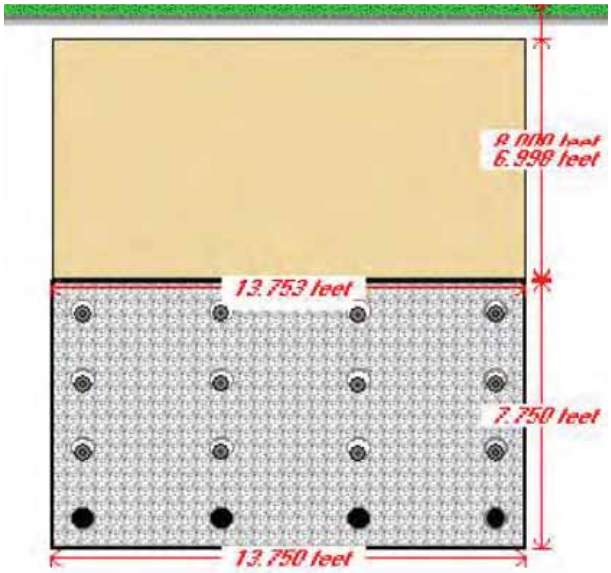
Figure 8: 230-kV, Three Cables per Phase, 100%DLF



Case 2 Study: 500-kV Circuit with Four Cables per Phase, 100% DLF

For the 500-kV circuit, a duct bank consisting of four (4) CPP and a 100% DLF run to 90°C was used to determine the maximum ampacity rating. With this configuration, the 500-kV circuit was able to achieve 4,331 A (see ampacity execution T2.1a1 for detailed results). Figure 9 below shows the duct bank configuration for this case.

Figure 9: 500-kV Circuit with Four Cables per Phase, 100% DLF



Case 2: 230-kV and 500-kV Circuits, 100% DLF

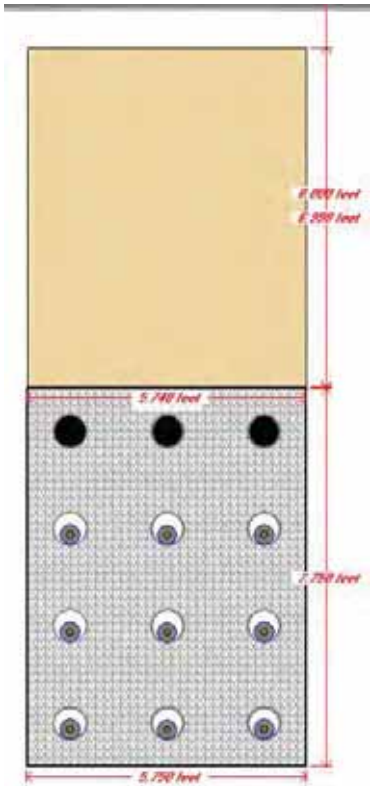
For the 230-kV and 500-kV duct bank systems, consisting of three and four CPP, respectively, a 100% DLF run to 90°C was used to determine the maximum ampacity rating. The circuits were separated 35 feet edge to edge. With this configuration, the 230-kV circuit was able to achieve 3,425 A and 500-kV circuit was able to achieve 4,194 A (see ampacity execution T3.1a1 for detailed results). See Figure 10 below.

Figure 10: Combined 230-kV and 500-kV, 100% DLF

Case 2: 230-kV Circuit with Three Cables per Phase, 85% DLF

For the 230-kV circuit, a system consisting of three CPP and an 85% DLF run to 90°C was used to determine the maximum ampacity rating. With this configuration, the 230-kV circuit was able to achieve 3,661 A (see ampacity execution T1.1a2 for detailed results). Figure 11 below shows the duct bank configuration for this case.

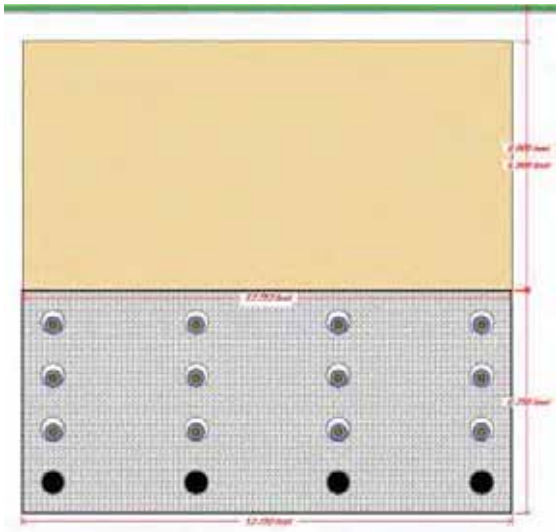
Figure 11: 230-kV, Three Cables per Phase, 85%DLF



Case 2: 500-kV Circuit with Four Cables per Phase, 85% DLF

For the 500-kV circuit, a system consisting of four (4) CPP and an 85% DLF run to 90°C was used to determine the maximum ampacity rating. With this configuration, the 500-kV circuit was able to achieve 4,415 A (see ampacity execution T2.1a2 for detailed results). Figure 12 below shows the duct bank configuration for this case.

Figure 12: 500-kV Circuit with Four Cables per Phase, 85% DLF



Case 2: 230-kV and 500-kV, 85% DLF

For the 230-kV and 500-kV duct bank systems, consisting of three (3) and four (4) CPP, respectively, an 85% DLF run to 90°C was used to determine the maximum rating. The circuits were separated 35' edge to edge. With this configuration, the 230-kV circuit was able to achieve 3,543 A and 500-kV circuit was able to achieve 4,266 A (see ampacity execution T3.1a2 for detailed results). Figure 13 below shows the duct bank configuration for this case.

Figure 13: Combined 230-kV and 500-kV, 85% DLF

SUMMARY OF RESULTS

The following summarizes the results of the additional ampacity case studies for the 230-kV and 500-kV cable systems when operating under the design parameters and installation conditions outlined in this memo.

Case 1 – 500-kV Duct Bank Split

The 500-kV circuit is only able to produce 4,926A and 4,906A for 85% DLF and 100% DLF, respectively, when in parallel with the proposed 230-kV Duct Bank. The 500-kV split duct bank circuit does not meet the required target rating of 5,000 amps.

Case 2 – 230-kV and 500-kV Duct Banks Reduced by One Cable per Phase

The results yielded an expected decrease in ratings from the preliminary study due to the reduction in cables per phase; 230-kV circuit was reduced to three (3) CPP and 500-kV to four (4) CPP.

For an 85% DLF, the single 230-kV duct bank system achieved 3,661A, while the single 500-kV duct bank system achieved 4,415A. The parallel 230-kV and 500-kV duct bank systems resulted in 3,543A and 4,266A, respectively.

For a 100% DLF, the 230-kV duct bank system achieved 3,548A, while the 500-kV system achieved 4,331A. The parallel 230-kV and 500-kV duct bank systems resulted in 3,425A and 4,194A, respectively.

For ampacity calculation summary table and detailed results of all executions refer to Appendix A. See Appendix B for UG cable cut sheets used for this ampacity analysis.

Sincerely,

Gustavo Contreras
Underground Lead Engineer, BMcD

Appendix A: Ampacity Execution Reports
Appendix B: UG Cable Cutsheets

APPENDIX A AMPACITY SUMMARY TABLE AND EXECUTION REPORTS

PROJECT NAME Golden to Mars
PROJECT NUMBER 170234

Akaylia Morgan DATE 6/11/2024
Gustavo Contreras DATE 6/14/2024

BURNS McDONNELL

Ampacity Calculation Summary Table

GENERAL

Execution Name	Installation Method	Duct Bank Configuration	Circuit Rated Voltage (kV)	Conductor Size (kcmil)	Duct Bank Edge-to-Edge Separation (ft)	Horizontal Conduit Center-to-Center Separation (ft)	Vertical Conduit Center-to-Center Separation (ft)	Season	Number of Circuits	Cables per Phase	Native Soil Thermal Resistivity (°C-cm/W)	Daily Load Factor	Required Normal Rating (Amps)	Calculated Normal Rating (Amps)
230-kV Circuit with 4 Cables Per Phase														
T1.1a	Duct Bank	4x4	230	5000	N/A	2	2	Summer	1	4	150	100%	3950	4196
T1.1b	Duct Bank	4x4	230	5000	N/A	2	2	Summer	1	4	115	100%	3950	4296
T1.1c	Duct Bank	4x4	230	5000	N/A	2	2	Summer	1	4	150	85%	3950	4444
500-kV Circuit with 5 Cables Per Phase														
T2.1a	Duct Bank	4x5	500	5000	N/A	4	1.5	Summer	1	5	150	100%	5000	4580
T2.1b	Duct Bank	4x5	500	5000	N/A	4	1.5	Summer	1	5	130	100%	5000	4790
T2.1c	Duct Bank	4x5	500	5000	N/A	4	2	Summer	1	5	150	100%	5000	4620
T2.1d	Duct Bank	4x5	500	5000	N/A	4	2	Summer	1	5	115	100%	5000	5025
T2.1e	Duct Bank	4x5	500	5000	N/A	4	1.5	Summer	1	5	150	85%	5000	5130
230-kV 4 cables per phase Single duct bank and 500-kV with 4 cables per phase (Single Duct Bank)														
T3.1a	Duct Bank	4x4	230	5000	35	2	2	Summer	1	4	115	100%	3950	4183
	Duct Bank	4x5	500	5000		4	2		1	5			5000	5005
T3.1b	Duct Bank	4x4	230	5000	21	2	2	Summer	1	4	150	85%	3950	4202
	Duct Bank	4x5	500	5000		4	1.5		1	5			5000	5008

ADDITIONAL AMPACITY EXECUTIONS - CASE 1

500-kV Circuit with 4 Cables Per Phase - Split Duct Banks														
B1	Duct Bank	two (2) 2x2	500	5000	27	4	2	Summer	1	4	115	100%	5000	5000
B2	Duct Bank	two (2) 2x2	500	5000	30	4	1.5	Summer	1	4	150	85%	5000	5000
230-kV 4 cables per phase duct bank and 500-kV with 4 cables per phase (Split Duct Banks)														
T4.1a	Duct Bank	4x4	230	5000	38.75	2	2	Summer	1	4	115	100%	3950	3952
	Duct Bank	two (2) 4x2	500	5000	36	4	1.5	Summer	1	4			5000	4906
T4.1b	Duct Bank	4x4	230	5000	35.75	2	2	Summer	1	4	150	85%	3950	3952
	Duct Bank	two (2) 4x2	500	5000	30	4	1.5	Summer	1	4			5000	4926

ADDITIONAL AMPACITY EXECUTIONS - CASE 2

230 kV Circuit with 3 Cables per Phase														
T1.1a1	Duct Bank	4x3	230	5000	N/A	2	2	Summer	1	3	115	100%	N/A	3548
T1.1a2	Duct Bank	4x3	230	5000	N/A	2	2	Summer	1	3	150	85%	N/A	3661
500-kV Circuit with 4 Cables Per Phase														
T2.1a1	Duct Bank	4x4	500	5000	N/A	4	2	Summer	1	4	115	100%	N/A	4331
T2.1a2	Duct Bank	4x4	500	5000	N/A	4	1.5	Summer	1	4	150	85%	N/A	4415
230-kV with 3 Cables per Phase and 500-kV with 4 Cables per Phase														
T3.1a1	Duct Bank	4x3	230	5000	35	2	2	Summer	1	3	115	100%	N/A	3425
	Duct Bank	4x4	500	5000	35	4	2	Summer	1	4			N/A	4194
T3.1a2	Duct Bank	4x3	230	5000	35	2	2	Summer	1	3	150	85%	N/A	3543
	Duct Bank	4x4	500	5000	35	4	1.5	Summer	1	4			N/A	4266

Constant Criteria:			
Backfill Thermal Resistivity	60 °C-cm/W		Meets Required Ratings
Concrete Thermal Resistivity	60 °C-cm/W		Does Not Meet Required Ratings
Ambient Soil Temperature	20 °C		
Depth of Cover	8 feet		
Temperature	90 °C		
230-kV Cable Size	5000 kcmil Copper (enameled)		
500-kV Cable Size	5000 kcmil Copper (enameled)		

General Summary Report

CYMCAP Version	8.2 Revision 2
Study:	Goldon to Mars
Execution:	T1.1a-230kV, 8_ DOC, 5000kcmil Cu, 100 DLF
Date:	4/10/2024 8:46:44 AM

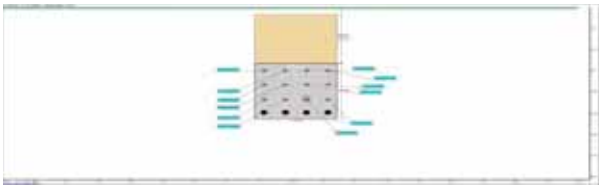
Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Equally Loaded
Ambient temperature [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.50
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits) [A]	0.00

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.50
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
DB 4X4	0.00	11.88	7.75	7.75	0.60
Backfill	0.00	4.50	7.75	7.00	0.60



General Cable Information

Cable ID	Number of Cores	Conductor Construction	Voltage [kV]	Conductor Area [mm²]	Cable Overall Diameter [in]	Maximum Steady-State Conductor Temperature [°C]	Maximum Emergency Conductor Temperature [°C]
230CS.00X1	Single Core	6 Segments	230.00	2535.92	5.22	90.00	105.00

Detailed Cable Information

Cable ID	Conductor	Insulation	Sheath / Tape	Concentric Wires	Filler	Armour	Jacket / Armour Serving
230CS.00X1	Copper	XLPE Unfilled	Copper	Copper	n/a	n/a	Polyethylene

General Input Data

Cable	Cable ID	Circuit No.	Phase	Fq [Hz]	X [ft]	Y [ft]	DLF [p.u.]	Sheath / Shield Bonding
Cable Index Number	Cable Equipment ID	Circuit No.	Cable Phase	Operating Frequency	X coordinate	Y coordinate	Daily Load Factor	Bonding Type
1	230CS.00X1	1	A	60.00	-3.00	8.99	1.00	1 Conductor 1 Point Bonded Flat
2	230CS.00X1	1	B	60.00	-3.00	10.99	1.00	1 Conductor 1 Point Bonded Flat
3	230CS.00X1	1	C	60.00	-3.00	12.99	1.00	1 Conductor 1 Point Bonded Flat
4	230CS.00X1	2	A	60.00	-1.00	12.99	1.00	1 Conductor 1 Point Bonded Flat
5	230CS.00X1	2	B	60.00	-1.00	8.99	1.00	1 Conductor 1 Point Bonded Flat
6	230CS.00X1	2	C	60.00	-1.00	10.99	1.00	1 Conductor 1 Point Bonded Flat
7	230CS.00X1	3	A	60.00	1.00	10.99	1.00	1 Conductor 1 Point Bonded Flat
8	230CS.00X1	3	B	60.00	1.00	12.99	1.00	1 Conductor 1 Point Bonded Flat
9	230CS.00X1	3	C	60.00	1.00	8.99	1.00	1 Conductor 1 Point Bonded Flat
10	230CS.00X1	4	A	60.00	3.00	8.99	1.00	1 Conductor 1 Point Bonded Flat
11	230CS.00X1	4	B	60.00	3.00	10.99	1.00	1 Conductor 1 Point Bonded Flat
12	230CS.00X1	4	C	60.00	3.00	12.99	1.00	1 Conductor 1 Point Bonded Flat

Ampacity and Temperatures

Cable	Cable ID	I [A]	θc [°C]	θs [°C]	θa [°C]	θsurf [°C]	θduct [°C]	θair / θcasing [°C]
Cable Index Number	Cable Equipment ID	Steady State Ampacity	Conductor temperature	Sheath/Shield temperature	Armour temperature	Cable surface temperature	Duct surface temperature	Mean air temperature in the tunnel / Casing surface temperature
1	230CS.00X1	1049.24	78.25	74.33	n/a	73.90	70.16	n/a
2	230CS.00X1	1049.24	85.91	81.92	n/a	81.47	77.73	n/a
3	230CS.00X1	1049.24	87.43	83.43	n/a	82.99	79.32	n/a
4	230CS.00X1	1049.24	89.98	85.96	n/a	85.51	81.87	n/a
5	230CS.00X1	1049.24	80.38	76.45	n/a	76.01	72.29	n/a
6	230CS.00X1	1049.24	88.53	84.52	n/a	84.07	80.34	n/a
7	230CS.00X1	1049.24	88.53	84.52	n/a	84.07	80.34	n/a
8	230CS.00X1	1049.24	89.99	85.97	n/a	85.52	81.87	n/a
9	230CS.00X1	1049.24	80.39	76.45	n/a	76.01	72.29	n/a
10	230CS.00X1	1049.24	78.26	74.34	n/a	73.90	70.17	n/a
11	230CS.00X1	1049.24	85.92	81.93	n/a	81.48	77.74	n/a
12	230CS.00X1	1049.24	87.44	83.44	n/a	83.00	79.33	n/a

Electrical Resistances

Cable	Cable ID	R_{dc} [Ω/mile]	y_s	y_p	R [Ω/mile]	R's [Ω/mile]	R'w [Ω/mile]	R'a [Ω/mile]
Cable Index Number	Cable Equipment ID	DC Resistance of the conductor at 20°C	Skin Effect Factor	Proximity Effect Factor	AC Resistance of Conductor at Operating Temperature	DC Resistance of Sheath at Operating Temperature	DC Resistance of Concentric Wires at Operating Temperature	DC Resistance of Armor at Operating Temperature
1	230CS.00X1	0.01	0.17	0.00	0.02	0.49	0.37	n/a
2	230CS.00X1	0.01	0.17	0.00	0.02	0.50	0.38	n/a
3	230CS.00X1	0.01	0.16	0.00	0.02	0.50	0.38	n/a
4	230CS.00X1	0.01	0.16	0.00	0.02	0.51	0.38	n/a
5	230CS.00X1	0.01	0.17	0.00	0.02	0.49	0.37	n/a
6	230CS.00X1	0.01	0.16	0.00	0.02	0.51	0.38	n/a
7	230CS.00X1	0.01	0.16	0.00	0.02	0.51	0.38	n/a
8	230CS.00X1	0.01	0.16	0.00	0.02	0.51	0.38	n/a
9	230CS.00X1	0.01	0.17	0.00	0.02	0.49	0.37	n/a
10	230CS.00X1	0.01	0.17	0.00	0.02	0.49	0.37	n/a
11	230CS.00X1	0.01	0.17	0.00	0.02	0.50	0.38	n/a
12	230CS.00X1	0.01	0.16	0.00	0.02	0.50	0.38	n/a

Thermal Resistances

Cable	Cable ID	T_1 [K.m/W]	T_2 [K.m/W]	T_3 [K.m/W]	T_4' [K.m/W]	T_4'' [K.m/W]	T_4''' [K.m/W]	T_4 [K.m/W]
Cable Index Number	Cable Equipment ID	Thermal resistance of insulation	Thermal resistance of bedding	Thermal resistance of outer covering	Thermal resistance inside the duct	Thermal resistance of the duct	Thermal resistance of the external medium	Total external thermal resistance
1	230CS.00X1	0.33	0.00	0.03	0.22	0.07	3.88	4.17
2	230CS.00X1	0.33	0.00	0.03	0.21	0.07	4.32	4.60
3	230CS.00X1	0.33	0.00	0.03	0.20	0.07	4.51	4.79
4	230CS.00X1	0.33	0.00	0.03	0.20	0.07	4.68	4.96
5	230CS.00X1	0.33	0.00	0.03	0.21	0.07	4.03	4.32
6	230CS.00X1	0.33	0.00	0.03	0.20	0.07	4.50	4.78
7	230CS.00X1	0.33	0.00	0.03	0.20	0.07	4.50	4.78
8	230CS.00X1	0.33	0.00	0.03	0.20	0.07	4.68	4.96
9	230CS.00X1	0.33	0.00	0.03	0.21	0.07	4.03	4.32
10	230CS.00X1	0.33	0.00	0.03	0.22	0.07	3.88	4.17
11	230CS.00X1	0.33	0.00	0.03	0.21	0.07	4.32	4.60
12	230CS.00X1	0.33	0.00	0.03	0.20	0.07	4.51	4.79

Losses

Cable	Cable ID	Wc [W/ft]	Wd [W/ft]	Ws [W/ft]	Wa [W/ft]	Wt [W/ft]	λ_1	λ_2
Cable Index Number	Cable Equipment ID	Conductor Losses	Dielectric Losses	Metallic Screen Losses	Armor/Pipe Losses	Total Losses	Screen Loss Factor	Armour Loss Factor + Pipe Loss Factor
1	230CS.00X1	3.36	0.55	0.02	0.00	3.94	0.01	0.00
2	230CS.00X1	3.42	0.55	0.09	0.00	4.07	0.03	0.00
3	230CS.00X1	3.43	0.55	0.02	0.00	4.01	0.01	0.00
4	230CS.00X1	3.45	0.55	0.02	0.00	4.03	0.01	0.00
5	230CS.00X1	3.38	0.55	0.02	0.00	3.95	0.01	0.00
6	230CS.00X1	3.44	0.55	0.09	0.00	4.09	0.03	0.00
7	230CS.00X1	3.44	0.55	0.09	0.00	4.09	0.03	0.00
8	230CS.00X1	3.45	0.55	0.02	0.00	4.03	0.01	0.00
9	230CS.00X1	3.38	0.55	0.02	0.00	3.96	0.01	0.00
10	230CS.00X1	3.36	0.55	0.02	0.00	3.94	0.01	0.00
11	230CS.00X1	3.42	0.55	0.09	0.00	4.07	0.03	0.00
12	230CS.00X1	3.43	0.55	0.02	0.00	4.01	0.01	0.00

Complementary Information

Cable	Cable ID	Δθint [°C]	[A]	[μF/mile]	[Ω]	[Ω/mile]	[Ω/mile]	[V/A/mile]
Cable Index Number	Cable Equipment ID	Temperature rise due to surrounding heat sources	Induced current on Metallic Screen	Cable Capacitance	Surge Impedance	Reactance of Conductor	Reactance of Metallic Sheath	Voltage drop for Three Phase System
1	230CS.00X1	43.03	0.00	0.44	48.28	0.39	0.28	0.03
2	230CS.00X1	49.66	0.00	0.44	48.28	0.39	0.28	0.03
3	230CS.00X1	50.73	0.00	0.44	48.28	0.39	0.28	0.03
4	230CS.00X1	53.69	0.00	0.44	48.28	0.39	0.28	0.03
5	230CS.00X1	45.59	0.00	0.44	48.28	0.39	0.28	0.03
6	230CS.00X1	52.71	0.00	0.44	48.28	0.39	0.28	0.03
7	230CS.00X1	52.71	0.00	0.44	48.28	0.39	0.28	0.03
8	230CS.00X1	53.69	0.00	0.44	48.28	0.39	0.28	0.03
9	230CS.00X1	45.59	0.00	0.44	48.28	0.39	0.28	0.03
10	230CS.00X1	43.03	0.00	0.44	48.28	0.39	0.28	0.03
11	230CS.00X1	49.66	0.00	0.44	48.28	0.39	0.28	0.03
12	230CS.00X1	50.73	0.00	0.44	48.28	0.39	0.28	0.03

Study Summary

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T1.1a-230kV, 8_ DOC, 5000kcmil Cu, 100 DLF
Date:	4/10/2024 8:46:44 AM

General Simulation Data

Steady State Option	Equally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.00
Conductor Resistances Computation Option:	IEC-228

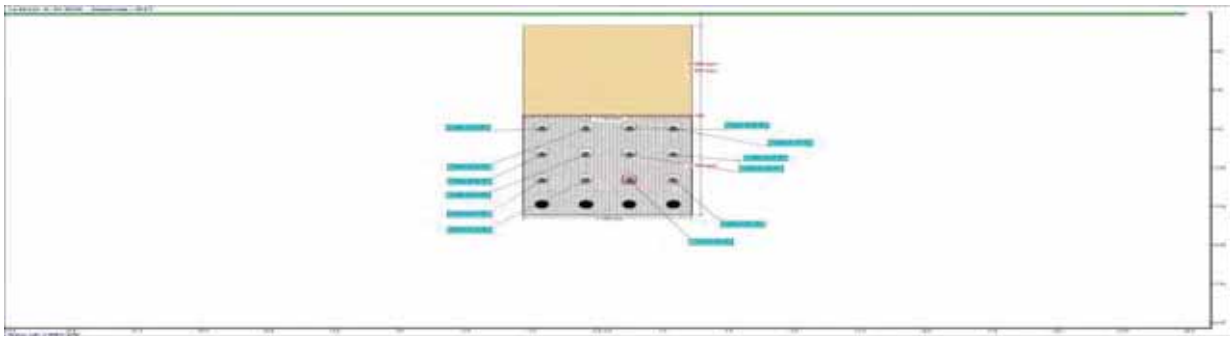
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.50
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
DB 4X4	0.00	11.88	7.75	7.75	0.60
Backfill	0.00	4.50	7.75	7.00	0.60



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	230C5.00X1	1		A	60.00	1.00	-3.00	8.99	78.25	1049.24
2	230C5.00X1	1		B	60.00	1.00	-3.00	10.99	85.91	1049.24
3	230C5.00X1	1		C	60.00	1.00	-3.00	12.99	87.43	1049.24
4	230C5.00X1	2		A	60.00	1.00	-1.00	12.99	89.98	1049.24
5	230C5.00X1	2		B	60.00	1.00	-1.00	8.99	80.38	1049.24
6	230C5.00X1	2		C	60.00	1.00	-1.00	10.99	88.53	1049.24
7	230C5.00X1	3		A	60.00	1.00	1.00	10.99	88.53	1049.24
8	230C5.00X1	3		B	60.00	1.00	1.00	12.99	89.99	1049.24
9	230C5.00X1	3		C	60.00	1.00	1.00	8.99	80.39	1049.24
10	230C5.00X1	4		A	60.00	1.00	3.00	8.99	78.26	1049.24
11	230C5.00X1	4		B	60.00	1.00	3.00	10.99	85.92	1049.24
12	230C5.00X1	4		C	60.00	1.00	3.00	12.99	87.44	1049.24

Cables Report

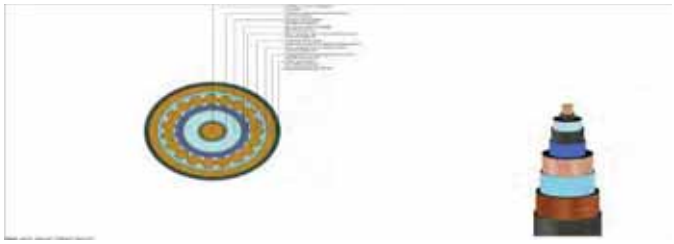
CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T1.1a-230kV, 8_ DOC, 5000kcmil Cu, 100 DLF
Date:	4/10/2024 8:46:44 AM

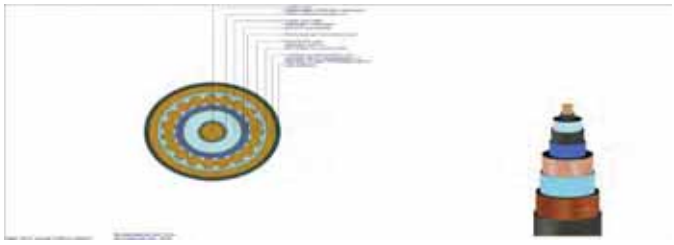
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230.00
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90.00
7	Maximum Emergency Conductor Temperature	[°C]	105.00
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.72
10	Temperature Coefficient at 20°C	[1/K]	0.00
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.45
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.20
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.10
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.50
23	Dielectric Loss Factor - (tan delta)		0.00
24	Relative Permittivity - (epsilon)		2.50
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858.06
26	Thickness	[in]	0.91
27	Diameter	[in]	4.55
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.65
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	3.50
33	Thickness	[in]	0.02
34	Diameter	[in]	4.69
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.72
38	Temperature Coefficient at 20°C	[1/K]	0.00
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.50
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.56
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.06
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.72
50	Temperature Coefficient at 20°C	[1/K]	0.00
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.50
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.01
55	Tape overlap	[in]	0.50
56	Tape width	[in]	15.91
57	Tape thickness	[in]	0.01
58	Accumulaton factor		1.20
59	Thickness	[in]	0.01
60	Diameter	[in]	4.91
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.50
63	Thickness	[in]	0.15
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60.00
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Flat
68	Loss Factor Constant (ALOS)		0.30
69	Conduit construction		PVC Duct in Concrete
70	Conduit material thermal resistivity	[K.m/W]	6.00
71	Conduit filling material		Air
72	Inner diameter of the conduit	[in]	7.98
73	Outer diameter of the conduit	[in]	8.62

Cable ID : 230C5.00X1

Cable Title	230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





General Summary Report

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T1.1- 20lkV_ _8D-DCS_ ckkkVma ll SL_ 1kk OF4
Date:	/:1k:2k2/ 6A/:Ac pM

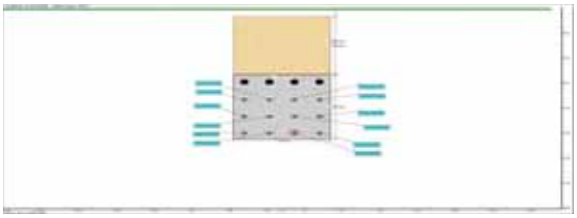
Simulation Data

Installation type:	MLttble Ck:ek-:anVk
Steady State Option	EqLally Foaded
Ambient temperature [°C]	2k.kk
Native Soil Thermal Rasistivity [K.m/W]	1.1c
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits) [A]	k.kk

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	2k.kk
Native Soil Thermal Rasistivity [K.m/W]	1.1c
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Rasistivity [K.m/W]
OB /X/	k.kk	11.88	7.7c	7.7c	k.f k
BarkSil	k.kk	/.ck	7.7c	7.kk	k.f k



General Cable Information

Cable ID	Number of Cores	Conductor Construction	Voltage [kV]	Conductor Area [mm²]	Cable Overall Diameter [in]	Maximum Steady-State Conductor Temperature [°C]	Maximum Emergency Conductor Temperature [°C]
20kSc.kkX1	girtlle Sore	f .gelu ents	20k.kk	2c0c.62	c.22	6k.kk	1kc.kk

Detailed Cable Information

Cable ID	Conductor	Insulation	Sheath / Tape	Concentric Wires	Filler	Armour	Jacket / Armour Serving
20kSc.kkX1	Sobber	XPPE UrdRad	Sobber	Sobber	n:a	n:a	Polyethylene

General Input Data

Cable	Cable ID	Circuit No.	Phase	Fq [Hz]	X [ft]	Y [ft]	DLF [p.u.]	Sheath / Shield Bonding
Cable Index Number	Cable Equipment ID	Circuit No.	Cable Phase	Operating Frequency	X coordinate	Y coordinate	Daily Load Factor	Bonding Type
1	20kSc.kkX1	1	p	f k.kk	3D.kk	1k.66	1.kk	1 SondLittor 1 Point Bonded 4lat
2	20kSc.kkX1	1	B	f k.kk	3D.kk	12.66	1.kk	1 SondLittor 1 Point Bonded 4lat
0	20kSc.kkX1	1	S	f k.kk	3D.kk	1/.66	1.kk	1 SondLittor 1 Point Bonded 4lat
/	20kSc.kkX1	2	p	f k.kk	3t.kk	1/.66	1.kk	1 SondLittor 1 Point Bonded 4lat
c	20kSc.kkX1	2	B	f k.kk	3t.kk	1k.66	1.kk	1 SondLittor 1 Point Bonded 4lat
f	20kSc.kkX1	2	S	f k.kk	3t.kk	12.66	1.kk	1 SondLittor 1 Point Bonded 4lat
7	20kSc.kkX1	0	p	f k.kk	1.kk	12.66	1.kk	1 SondLittor 1 Point Bonded 4lat
8	20kSc.kkX1	0	B	f k.kk	1.kk	1/.66	1.kk	1 SondLittor 1 Point Bonded 4lat
6	20kSc.kkX1	0	S	f k.kk	1.kk	1k.66	1.kk	1 SondLittor 1 Point Bonded 4lat
1k	20kSc.kkX1	/	p	f k.kk	0.kk	1k.66	1.kk	1 SondLittor 1 Point Bonded 4lat
11	20kSc.kkX1	/	B	f k.kk	0.kk	12.66	1.kk	1 SondLittor 1 Point Bonded 4lat
12	20kSc.kkX1	/	S	f k.kk	0.kk	1/.66	1.kk	1 SondLittor 1 Point Bonded 4lat

Ampacity and Temperatures

Cable	Cable ID	I [A]	θc [°C]	θs [°C]	θa [°C]	θsurf [°C]	θduct [°C]	θair / θcasing [°C]
Cable Index Number	Cable Equipment ID	Steady State Ampacity	Conductor temperature	Sheath/Shield temperature	Armour temperature	Cable surface temperature	Duct surface temperature	Mean air temperature in the tunnel / Casing surface temperature
1	20kSc.kkX1	1k7/ .2k	7B.c6	7/ ./6	n:a	7/ .k/	7k.1/	n:a
2	20kSc.kkX1	1k7/ .2k	8c./ /	81.2B	n:a	8k.81	7f .6k	n:a
0	20kSc.kkX1	1k7/ .2k	8f ./ /	82.27	n:a	81.81	77.68	n:a
/	20kSc.kkX1	1k7/ .2k	8c.6B	8c.7B	n:a	8c.02	81.c1	n:a
c	20kSc.kkX1	1k7/ .2k	81.22	77.1k	n:a	7f./ /	72.77	n:a
f	20kSc.kkX1	1k7/ .2k	8B.7B	8/ .c6	n:a	8/ .12	8k.2/	n:a
7	20kSc.kkX1	1k7/ .2k	8B.7B	8/ .c6	n:a	8/ .12	8k.2/	n:a
8	20kSc.kkX1	1k7/ .2k	8B.66	8c.7B	n:a	8c.02	81.c2	n:a
6	20kSc.kkX1	1k7/ .2k	81.22	77.1k	n:a	7f ./ /	72.77	n:a
1k	20kSc.kkX1	1k7/ .2k	7B.f k	7/ .ck	n:a	7/ .kc	7k.1c	n:a
11	20kSc.kkX1	1k7/ .2k	8c./ c	81.26	n:a	8k.82	7f .61	n:a
12	20kSc.kkX1	1k7/ .2k	8f ./ c	82.2B	n:a	81.82	77.66	n:a

Electrical Resistances

Cable	Cable ID	Rs [Ω/mile]	ys	yp	R [Ω/mile]	R's [Ω/mile]	R'w [Ω/mile]	R'a [Ω/mile]
Cable Index Number	Cable Equipment ID	DC Resistance of the conductor at 20°C	Skin Effect Factor	Proximity Effect Factor	AC Resistance of Conductor at Operating Temperature	DC Resistance of Sheath at Operating Temperature	DC Resistance of Concentric Wires at Operating Temperature	DC Resistance of Armor at Operating Temperature
1	20kSc.kkX1	k.k1	k.17	k.kk	k.k2	k./ 6	k.07	n:a
2	20kSc.kkX1	k.k1	k.17	k.kk	k.k2	k.ck	k.08	n:a
0	20kSc.kkX1	k.k1	k.1f	k.kk	k.k2	k.ck	k.08	n:a
/	20kSc.kkX1	k.k1	k.1f	k.kk	k.k2	k.c1	k.08	n:a
c	20kSc.kkX1	k.k1	k.17	k.kk	k.k2	k./ 6	k.07	n:a
f	20kSc.kkX1	k.k1	k.1f	k.kk	k.k2	k.c1	k.08	n:a
7	20kSc.kkX1	k.k1	k.1f	k.kk	k.k2	k.c1	k.08	n:a
8	20kSc.kkX1	k.k1	k.1f	k.kk	k.k2	k.c1	k.08	n:a
6	20kSc.kkX1	k.k1	k.17	k.kk	k.k2	k./ 6	k.07	n:a
1k	20kSc.kkX1	k.k1	k.17	k.kk	k.k2	k./ 6	k.07	n:a
11	20kSc.kkX1	k.k1	k.17	k.kk	k.k2	k.ck	k.08	n:a
12	20kSc.kkX1	k.k1	k.1f	k.kk	k.k2	k.ck	k.08	n:a

Thermal Resistances

Cable	Cable ID	T1 [K.m/W]	T2 [K.m/W]	T3 [K.m/W]	T4' [K.m/W]	T4'' [K.m/W]	T4''' [K.m/W]	Tt [K.m/W]
Cable Index Number	Cable Equipment ID	Thermal resistance of insulation	Thermal resistance of bedding	Thermal resistance of outer covering	Thermal resistance inside the duct	Thermal resistance of the duct	Thermal resistance of the external medium	Total external thermal resistance
1	20kSc.kkX1	k.00	k.kk	k.k0	k.21	k.k7	0.70	/.k1
2	20kSc.kkX1	k.00	k.kk	k.k0	k.21	k.k7	/.1k	/.08
0	20kSc.kkX1	k.00	k.kk	k.k0	k.21	k.k7	/.2/	/.c2
/	20kSc.kkX1	k.00	k.kk	k.k0	k.2k	k.k7	/./7	/.7/
c	20kSc.kkX1	k.00	k.kk	k.k0	k.21	k.k7	0.6k	/.18
f	20kSc.kkX1	k.00	k.kk	k.k0	k.2k	k.k7	/.01	/.c6
7	20kSc.kkX1	k.00	k.kk	k.k0	k.2k	k.k7	/.01	/.c6
8	20kSc.kkX1	k.00	k.kk	k.k0	k.2k	k.k7	/./7	/.7/
6	20kSc.kkX1	k.00	k.kk	k.k0	k.21	k.k7	0.6k	/.18
1k	20kSc.kkX1	k.00	k.kk	k.k0	k.21	k.k7	0.70	/.k1
11	20kSc.kkX1	k.00	k.kk	k.k0	k.21	k.k7	/.1k	/.08
12	20kSc.kkX1	k.00	k.kk	k.k0	k.21	k.k7	/.2/	/.c2

Losses

Cable	Cable ID	Wc [W/ft]	Wd [W/ft]	Ws [W/ft]	Wa [W/ft]	Wt [W/ft]	λ1	λ2
Cable Index Number	Cable Equipment ID	Conductor Losses	Dielectric Losses	Metallic Screen Losses	Armor/Pipe Losses	Total Losses	Screen Loss Factor	Armour Loss Factor + Pipe Loss Factor
1	20kSc.kkX1	0.c2	k.cc	k.k0	k.kk	/.1k	k.k1	k.kk
2	20kSc.kkX1	0.c8	k.cc	k.1k	k.kk	/.20	k.k0	k.kk
0	20kSc.kkX1	0.c6	k.cc	k.k2	k.kk	/.17	k.k1	k.kk
/	20kSc.kkX1	0.f 2	k.cc	k.k2	k.kk	/.2k	k.k1	k.kk
c	20kSc.kkX1	0.cc	k.cc	k.k0	k.kk	/.10	k.k1	k.kk
f	20kSc.kkX1	0.f 1	k.cc	k.1k	k.kk	/.2f	k.k0	k.kk
7	20kSc.kkX1	0.f 1	k.cc	k.1k	k.kk	/.2f	k.k0	k.kk
8	20kSc.kkX1	0.f 2	k.cc	k.k2	k.kk	/.2k	k.k1	k.kk
6	20kSc.kkX1	0.cc	k.cc	k.k0	k.kk	/.10	k.k1	k.kk
1k	20kSc.kkX1	0.c2	k.cc	k.k0	k.kk	/.1k	k.k1	k.kk
11	20kSc.kkX1	0.c8	k.cc	k.1k	k.kk	/.20	k.k0	k.kk
12	20kSc.kkX1	0.c6	k.cc	k.k2	k.kk	/.17	k.k1	k.kk

Complementary Information

Cable	Cable ID	ΔBist [°C]	[A]	[μF/mile]	[Ω]	[Ω/mile]	[Ω/mile]	[V/A/mile]
Cable Index Number	Cable Equipment ID	Temperature rise due to surrounding heat sources	Induced current on Metallic Screen	Cable Capacitance	Surge Impedance	Reactance of Conductor	Reactance of Metallic Sheath	Voltage drop for Three Phase System
1	20kSc.kkX1	/.2.6c	k.kk	k.//	/8.2B	k.06	k.2B	k.k0
2	20kSc.kkX1	/8.8f	k.kk	k.//	/8.2B	k.06	k.2B	k.k0
0	20kSc.kkX1	/6.02	k.kk	k.//	/8.2B	k.06	k.2B	k.k0
/	20kSc.kkX1	c0.11	k.kk	k.//	/8.2B	k.06	k.2B	k.k0
c	20kSc.kkX1	/c.87	k.kk	k.//	/8.2B	k.06	k.2B	k.k0
f	20kSc.kkX1	c2./6	k.kk	k.//	/8.2B	k.06	k.2B	k.k0
7	20kSc.kkX1	c2./6	k.kk	k.//	/8.2B	k.06	k.2B	k.k0
8	20kSc.kkX1	c0.11	k.kk	k.//	/8.2B	k.06	k.2B	k.k0
6	20kSc.kkX1	/c.87	k.kk	k.//	/8.2B	k.06	k.2B	k.k0
1k	20kSc.kkX1	/.2.6c	k.kk	k.//	/8.2B	k.06	k.2B	k.k0
11	20kSc.kkX1	/8.8f	k.kk	k.//	/8.2B	k.06	k.2B	k.k0
12	20kSc.kkX1	/6.02	k.kk	k.//	/8.2B	k.06	k.2B	k.k0

Study Summary

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T1.1-320kV, _8D OC5_ckkkVmu il 5L_1kk OF4
Date:	/ :1k:2k2/ 6A2/ Acc pM

General Simulation Data

Steady State Option	EqLally Foaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	k.kk
Conductor Resistances Computation Option:	IE53228

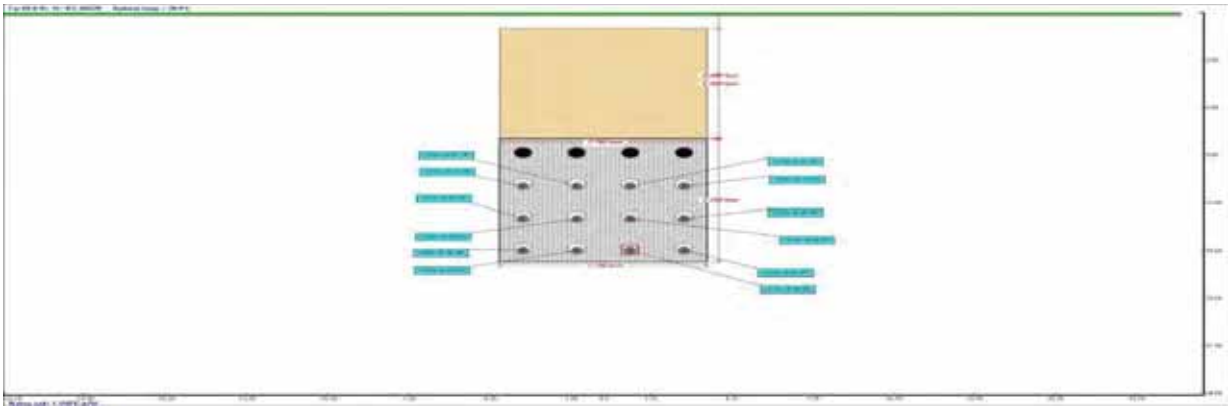
Standard Settings Options

General guidance	5Lstou
Factor on RAC due to magnetic armour	5IGREGLidanne
Factor on RAC due to magnetic duct	5IGREGLidanne
Factor on λ₁ due to magnetic armour	5YM5pPGLidanne
Factor on λ₁ due to magnetic duct	5IGREGLidanne
Factor on λ₂ due to λ'₁	5YM5pPGLidanne
λ''₁ computation	5IGREGLidanne
λ₂pipe computation	5YM5pPGLidanne
Wd computation	5IGREGLidanne
T₂ computation	5IGREGLidanne
T₄ computation	5YM5pPGLidanne

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	2k.kk
Native Soil Thermal Resistivity [K.m/W]	1.1c
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
OB / X/	k.kk	11.88	7.7c	7.7c	k.f k
BanWSil	k.kk	/ .ck	7.7c	7.kk	k.f k



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	20k5c.kkX1	1		p	f k.kk	1.kk	30.kk	1k.66	78.c6	1k7/.2k
2	20k5c.kkX1	1		B	f k.kk	1.kk	30.kk	12.66	8c.//	1k7/.2k
0	20k5c.kkX1	1		5	f k.kk	1.kk	30.kk	1/.66	8f .//	1k7/.2k
/	20k5c.kkX1	2		p	f k.kk	1.kk	31.kk	1/.66	86.68	1k7/.2k
c	20k5c.kkX1	2		B	f k.kk	1.kk	31.kk	1k.66	81.22	1k7/.2k
f	20k5c.kkX1	2		5	f k.kk	1.kk	31.kk	12.66	88.78	1k7/.2k
7	20k5c.kkX1	0		p	f k.kk	1.kk	1.kk	12.66	88.78	1k7/.2k
8	20k5c.kkX1	0		B	f k.kk	1.kk	1.kk	1/.66	86.66	1k7/.2k
6	20k5c.kkX1	0		5	f k.kk	1.kk	1.kk	1k.66	81.22	1k7/.2k
1k	20k5c.kkX1	/		p	f k.kk	1.kk	0.kk	1k.66	78.f k	1k7/.2k
11	20k5c.kkX1	/		B	f k.kk	1.kk	0.kk	12.66	8c./c	1k7/.2k
12	20k5c.kkX1	/		5	f k.kk	1.kk	0.kk	1/.66	8f ./c	1k7/.2k

Cables Report

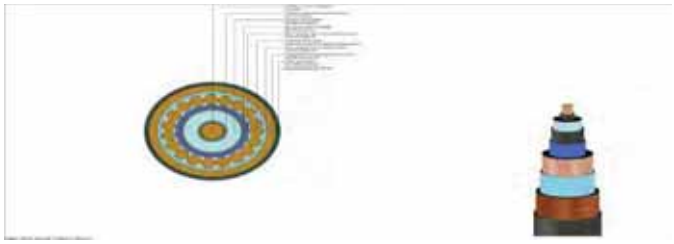
CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T1.1- 320kV, _8DOC5_ckkkVmu il 5L_1kk OF4
Date:	/:1k:2k2/ 6R/Acc pM

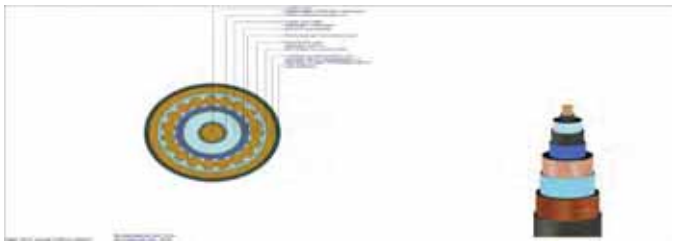
No.	Description	Unit	1
General Cable Information			
1	Sa- le EqLibu ent ID		20kSc.kkX1
2	NLu - er oSSores		qin9le Sore
0	, oIta9e	[V,]	20k.kk
/	SondLnttor prea	[in²]	0.60
c	Sa- le Cverall Olau eter	[in]	c.22
f	Maxiu Lu gteady3gtate SondLnttor Teu beratLre	[°S]	6k.kk
7	Maxiu Lu Eu erSenny SondLnttor Teu beratLre	[°S]	1kc.kk
Conductor			
8	Material		Sobber
6	Elentrinal Resistivity at 2k°S	[µΩ.nu]	1.72
1k	Teu beratLre SoetSinlent at 2k°S	[1:K]	k.kk
11	Remlbronal oSTeu beratLre SoetSinlent oSResistanne (BETp)	[K]	20/ ./ c
12	, oILu etrimgbentSinHeat (gH)	[J:(K°nu °)]	0,/ c
10	SonstrLntion		f ge9u ents
1/	SondLnttor InsLation gysteu		ExtrLded
1c	MilHVen Wires SonstrLntion		InsLated Wires
1f	Ks (gVin ETSinl SoetSinlent)		k.0c
17	Kb (Prosiu ity ETSinl SoetSinlent)		k.2k
18	Olau eter	[in]	2.c/
Conductor Shield			
16	Thinhess	[in]	k.1k
2k	Olau eter	[in]	2.7/
Insulation			
21	Material		XFPE UnSlled
22	Theru al Resistivity	[K.u :W]	0.ck
20	DielentrimFoss 4antor 3(tan delta)		k.kk
2/	Relative Peru ittivity 3(ebsilon)		2.ck
2c	gbentSinSnsLation Resistanne Sonstant at f k°4 3(K)	[M0.1000ft]	18c8.kf
2f	Thinhess	[in]	k.61
27	Olau eter	[in]	/.cc
Insulation Screen			
28	Material		geu l SondLnttin9 gmeen
26	Thinhess	[in]	k.kc
0k	Olau eter	[in]	/.f c
Non Metallic Layer - Water Swellable Tape 1			
01	Material		EXTRUDED gEMISCNOUSTL E gSREEN
02	Theru al Resistivity	[K.u :W]	2.ck
00	Thinhess	[in]	k.k2
0/	Olau eter	[in]	/.f 6
Concentric neutral/Skid wires			
0c	pre SonmentrimNeLtral Wires proLnd Earth Sore?		n:a
0f	Material		Sobber
07	Elentrinal Resistivity at 2k°S	[µΩ.nu]	1.72
08	Teu beratLre SoetSinlent at 2k°S	[1:K]	k.kk
06	Remlbronal oSTeu beratLre SoetSinlent oSResistanne (BETp)	[K]	20/ .ck
/ k	, oILu etrimgbentSinHeat (gH)	[J:(K°nu °)]	0,/ c
/ 1	Wire Tybe		RoLnd Wires
/2	Fen9th oSFay	[in]	/ c.cf
/0	NLu - er oSWires		/ f
//	Wire GaL9e		1/
/c	Thinhess	[in]	k.kf
/f	Olau eter	[in]	/.82
Sheath			
/7	Is gheath proLnd Earth Sore?		n:a
/8	Material		Sobber
/6	Elentrinal Resistivity at 2k°S	[µΩ.nu]	1.72
ck	Teu beratLre SoetSinlent at 2k°S	[1:K]	k.kk
c1	Remlbronal oSTeu beratLre SoetSinlent oSResistanne (BETp)	[K]	20/ .ck
c2	, oILu etrimgbentSinHeat (gH)	[J:(K°nu °)]	0,/ c
c0	SonrLStation Tybe		FonSttLdinally SonrLSated
c/	SonrLStation heiht	[in]	k.k1
cc	Tabe overlab	[in]	k.ck
cf	Tabe width	[in]	1c.61
c7	Tabe thinhess	[in]	k.k1
c8	pretLu LIaton Sintor		1.2k
c6	Thinhess	[in]	k.k1
f k	Olau eter	[in]	/.61
Jacket			
f 1	Material		Polyethylene
f 2	Theru al Resistivity	[K.u :W]	0.ck
f 0	Thinhess	[in]	k.1c
f/	Olau eter	[in]	c.22

No.	Description	Unit	1
Specific Installation Data			
f c	Sa- le EqLibu ent ID		20kSc.kkX1
f f	Sa- le 4reqLenny	[Hz]	f k.kk
f 7	gheath : ghield Bondin9		1 SondLnttor 1 Point Bonded 4lat
f 8	Foss 4antor Sonstant (pFCg)		k.0k
f 6	SondLit nenstrLntion		P, 5 OLnt in Sonmete
7k	SondLit u aterial theru al resistivity	[K.u :W]	f .kk
71	SondLit SlinS u aterial		pir
72	Inner diau eter oSthe nendLit	[in]	7.68
70	CLter diau eter oSthe nendLit	[in]	8.f 2

Cable ID : 230C5.00X1

Sa- le Title	20kV, _ckkk Vmu il 5L 3f ge9_6kf XFPE_5L nm_Prysu ian





General Summary Report

CYMCAP Version	8.2 Revision 2
Study:	Goldon to Mars
Execution:	T1.1-`20kV_ _8D OCS_ ckkk\V-mil Su_Bc OLF
Date:	4/1k/2k:24 ; 621801 AM

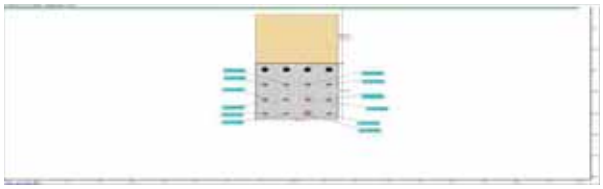
Simulation Data

Installation type:	Multiple Our-tbanlk
Steady State Option	Equally Loaded
Ambient temperature [°C]	2k.kk
Native Soil Thermal Resistivity [K.m/W]	1.ck
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits) [A]	k.kk

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	2k.kk
Native Soil Thermal Resistivity [K.m/W]	1.ck
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
OB 4X4	k.kk	11.88	7.7c	7.7c	k.f k
Ba-VSil	k.kk	4.ck	7.7c	7.kk	k.f k



General Cable Information

Cable ID	Number of Cores	Conductor Construction	Voltage [kV]	Conductor Area [mm²]	Cable Overall Diameter [in]	Maximum Steady-State Conductor Temperature [°C]	Maximum Emergency Conductor Temperature [°C]
20kSc.kkX1	gin9le Sore	f ge9ments	20k.kk	2c0c.: 2	c.22	: k.kk	1kc.kk

Detailed Cable Information

Cable ID	Conductor	Insulation	Sheath / Tape	Concentric Wires	Filler	Armour	Jacket / Armour Serving
20kSc.kkX1	5opper	XLPE Un9lked	5opper	5opper	n/a	n/a	Polyethylene

General Input Data

Cable	Cable ID	Circuit No.	Phase	Fq [Hz]	X [ft]	Y [ft]	DLF [p.u.]	Sheath / Shield Bonding
Cable Index Number	Cable Equipment ID	Circuit No.	Cable Phase	Operating Frequency	X coordinate	Y coordinate	Daily Load Factor	Bonding Type
1	20kSc.kkX1	1	A	f k.kk	30.kk	1k.: :	k.8c	1 Sondu-tor 1 Point Bonded Flat
2	20kSc.kkX1	1	B	f k.kk	30.kk	12.: :	k.8c	1 Sondu-tor 1 Point Bonded Flat
0	20kSc.kkX1	1	S	f k.kk	30.kk	14.: :	k.8c	1 Sondu-tor 1 Point Bonded Flat
4	20kSc.kkX1	2	A	f k.kk	3l.kk	14.: :	k.8c	1 Sondu-tor 1 Point Bonded Flat
c	20kSc.kkX1	2	B	f k.kk	3l.kk	1k.: :	k.8c	1 Sondu-tor 1 Point Bonded Flat
f	20kSc.kkX1	2	S	f k.kk	3l.kk	12.: :	k.8c	1 Sondu-tor 1 Point Bonded Flat
7	20kSc.kkX1	0	A	f k.kk	1.kk	12.: :	k.8c	1 Sondu-tor 1 Point Bonded Flat
8	20kSc.kkX1	0	B	f k.kk	1.kk	14.: :	k.8c	1 Sondu-tor 1 Point Bonded Flat
:	20kSc.kkX1	0	S	f k.kk	1.kk	1k.: :	k.8c	1 Sondu-tor 1 Point Bonded Flat
1k	20kSc.kkX1	4	A	f k.kk	0.kk	1k.: :	k.8c	1 Sondu-tor 1 Point Bonded Flat
11	20kSc.kkX1	4	B	f k.kk	0.kk	12.: :	k.8c	1 Sondu-tor 1 Point Bonded Flat
12	20kSc.kkX1	4	S	f k.kk	0.kk	14.: :	k.8c	1 Sondu-tor 1 Point Bonded Flat

Ampacity and Temperatures

Cable	Cable ID	I [A]	θc [°C]	θs [°C]	θa [°C]	θsurf [°C]	θduct [°C]	θair / θcasing [°C]
Cable Index Number	Cable Equipment ID	Steady State Ampacity	Conductor temperature	Sheath/Shield temperature	Armour temperature	Cable surface temperature	Duct surface temperature	Mean air temperature in the tunnel / Casing surface temperature
1	20kSc.kkX1	1111.07	7: .k4	74.f 7	n/a	74.1:	7k.kc	n/a
2	20kSc.kkX1	1111.07	8c.74	81.01	n/a	8k.81	7f.f f	n/a
0	20kSc.kkX1	1111.07	87.1k	82.f f	n/a	82.17	78.1k	n/a
4	20kSc.kkX1	1111.07	8: .: :	8c.c2	n/a	8c.k2	8k.: 8	n/a
c	20kSc.kkX1	1111.07	81.k0	7f.f 4	n/a	7f .1f	72.k4	n/a
f	20kSc.kkX1	1111.07	88.0k	80.84	n/a	80.04	7: .21	n/a
7	20kSc.kkX1	1111.07	88.0k	80.84	n/a	80.04	7: .21	n/a
8	20kSc.kkX1	1111.07	8: .: :	8c.c2	n/a	8c.k2	8k.: 8	n/a
:	20kSc.kkX1	1111.07	81.k0	7f.f 4	n/a	7f .1f	72.k4	n/a
1k	20kSc.kkX1	1111.07	7: .k4	74.f 7	n/a	74.1:	7k.kf	n/a
11	20kSc.kkX1	1111.07	8c.74	81.01	n/a	8k.81	7f.f f	n/a
12	20kSc.kkX1	1111.07	87.1k	82.f f	n/a	82.17	78.1k	n/a

Electrical Resistances

Cable	Cable ID	Re [Ω/mile]	ys	yp	R [Ω/mile]	R's [Ω/mile]	R'w [Ω/mile]	R'a [Ω/mile]
Cable Index Number	Cable Equipment ID	DC Resistance of the conductor at 20°C	Skin Effect Factor	Proximity Effect Factor	AC Resistance of Conductor at Operating Temperature	DC Resistance of Sheath at Operating Temperature	DC Resistance of Concentric Wires at Operating Temperature	DC Resistance of Armor at Operating Temperature
1	20kSc.kkX1	k.k1	k.17	k.kk	k.k2	k.4:	k.07	n/a
2	20kSc.kkX1	k.k1	k.17	k.kk	k.k2	k.ck	k.08	n/a
0	20kSc.kkX1	k.k1	k.1f	k.kk	k.k2	k.ck	k.08	n/a
4	20kSc.kkX1	k.k1	k.1f	k.kk	k.k2	k.c1	k.08	n/a
c	20kSc.kkX1	k.k1	k.17	k.kk	k.k2	k.4:	k.07	n/a
f	20kSc.kkX1	k.k1	k.1f	k.kk	k.k2	k.c1	k.08	n/a
7	20kSc.kkX1	k.k1	k.1f	k.kk	k.k2	k.c1	k.08	n/a
8	20kSc.kkX1	k.k1	k.1f	k.kk	k.k2	k.c1	k.08	n/a
:	20kSc.kkX1	k.k1	k.17	k.kk	k.k2	k.4:	k.07	n/a
1k	20kSc.kkX1	k.k1	k.17	k.kk	k.k2	k.4:	k.07	n/a
11	20kSc.kkX1	k.k1	k.17	k.kk	k.k2	k.ck	k.08	n/a
12	20kSc.kkX1	k.k1	k.1f	k.kk	k.k2	k.ck	k.08	n/a

Thermal Resistances

Cable	Cable ID	T1 [K.m/W]	T2 [K.m/W]	T3 [K.m/W]	Ta' [K.m/W]	Ta'' [K.m/W]	Ta''' [K.m/W]	T4 [K.m/W]
Cable Index Number	Cable Equipment ID	Thermal resistance of insulation	Thermal resistance of bedding	Thermal resistance of outer covering	Thermal resistance inside the duct	Thermal resistance of the duct	Thermal resistance of the external medium	Total external thermal resistance
1	20kSc.kkX1	k.00	k.kk	k.k0	k.21	k.k7	0.ck	0.7:
2	20kSc.kkX1	k.00	k.kk	k.k0	k.21	k.k7	0.84	4.12
0	20kSc.kkX1	k.00	k.kk	k.k0	k.21	k.k7	4.kk	4.28
4	20kSc.kkX1	k.00	k.kk	k.k0	k.2k	k.k7	4.17	4.4c
c	20kSc.kkX1	k.00	k.kk	k.k0	k.21	k.k7	0.f 0	0.: 1
f	20kSc.kkX1	k.00	k.kk	k.k0	k.2k	k.k7	0.: :	4.27
7	20kSc.kkX1	k.00	k.kk	k.k0	k.2k	k.k7	0.: :	4.27
8	20kSc.kkX1	k.00	k.kk	k.k0	k.2k	k.k7	4.17	4.4c
:	20kSc.kkX1	k.00	k.kk	k.k0	k.21	k.k7	0.f 0	0.: 1
1k	20kSc.kkX1	k.00	k.kk	k.k0	k.21	k.k7	0.ck	0.7:
11	20kSc.kkX1	k.00	k.kk	k.k0	k.21	k.k7	0.84	4.12
12	20kSc.kkX1	k.00	k.kk	k.k0	k.21	k.k7	4.kk	4.28

Losses

Cable	Cable ID	Wc [W/ft]	Wd [W/ft]	Ws [W/ft]	Wa [W/ft]	Wt [W/ft]	λ1	λ2
Cable Index Number	Cable Equipment ID	Conductor Losses	Dielectric Losses	Metallic Screen Losses	Armor/Pipe Losses	Total Losses	Screen Loss Factor	Armour Loss Factor + Pipe Loss Factor
1	20kSc.kkX1	0.78	k.cc	k.k0	k.kk	4.0f	k.k1	k.kk
2	20kSc.kkX1	0.84	k.cc	k.11	k.kk	4.ck	k.k0	k.kk
0	20kSc.kkX1	0.8c	k.cc	k.k0	k.kk	4.40	k.k1	k.kk
4	20kSc.kkX1	0.87	k.cc	k.k0	k.kk	4.4c	k.k1	k.kk
c	20kSc.kkX1	0.7:	k.cc	k.k0	k.kk	4.08	k.k1	k.kk
f	20kSc.kkX1	0.8f	k.cc	k.11	k.kk	4.c2	k.k0	k.kk
7	20kSc.kkX1	0.8f	k.cc	k.11	k.kk	4.c2	k.k0	k.kk
8	20kSc.kkX1	0.87	k.cc	k.k0	k.kk	4.4c	k.k1	k.kk
:	20kSc.kkX1	0.7:	k.cc	k.k0	k.kk	4.08	k.k1	k.kk
1k	20kSc.kkX1	0.78	k.cc	k.k0	k.kk	4.0f	k.k1	k.kk
11	20kSc.kkX1	0.84	k.cc	k.11	k.kk	4.ck	k.k0	k.kk
12	20kSc.kkX1	0.8c	k.cc	k.k0	k.kk	4.40	k.k1	k.kk

Complementary Information

Cable	Cable ID	ΔθInt [°C]	[A]	[μF/mile]	[Ω]	[Ω/mile]	[Ω/mile]	[V/A/mile]
Cable Index Number	Cable Equipment ID	Temperature rise due to surrounding heat sources	Induced current on Metallic Screen	Cable Capacitance	Surge Impedance	Reactance of Conductor	Reactance of Metallic Sheath	Voltage drop for Three Phase System
1	20kSc.kkX1	40.28	k.kk	k.44	48.28	k.0:	k.28	k.k0
2	20kSc.kkX1	4: .k0	k.kk	k.44	48.28	k.0:	k.28	k.k0
0	20kSc.kkX1	4: .70	k.kk	k.44	48.28	k.0:	k.28	k.k0
4	20kSc.kkX1	c0.kk	k.kk	k.44	48.28	k.0:	k.28	k.k0
c	20kSc.kkX1	4c.f.c	k.kk	k.44	48.28	k.0:	k.28	k.k0
f	20kSc.kkX1	c1.: 7	k.kk	k.44	48.28	k.0:	k.28	k.k0
7	20kSc.kkX1	c1.: 7	k.kk	k.44	48.28	k.0:	k.28	k.k0
8	20kSc.kkX1	c0.kk	k.kk	k.44	48.28	k.0:	k.28	k.k0
:	20kSc.kkX1	4c.f.c	k.kk	k.44	48.28	k.0:	k.28	k.k0
1k	20kSc.kkX1	40.28	k.kk	k.44	48.28	k.0:	k.28	k.k0
11	20kSc.kkX1	4: .k0	k.kk	k.44	48.28	k.0:	k.28	k.k0
12	20kSc.kkX1	4: .70	k.kk	k.44	48.28	k.0:	k.28	k.k0

Study Summary

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T1.1-320kV, _8D OC5_ckkkV-mil 5u_8c OLF
Date:	4/1k/2k24 : 621601 AM

General Simulation Data

Steady State Option	Equally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	k.kk
Conductor Resistances Computation Option:	IE53228

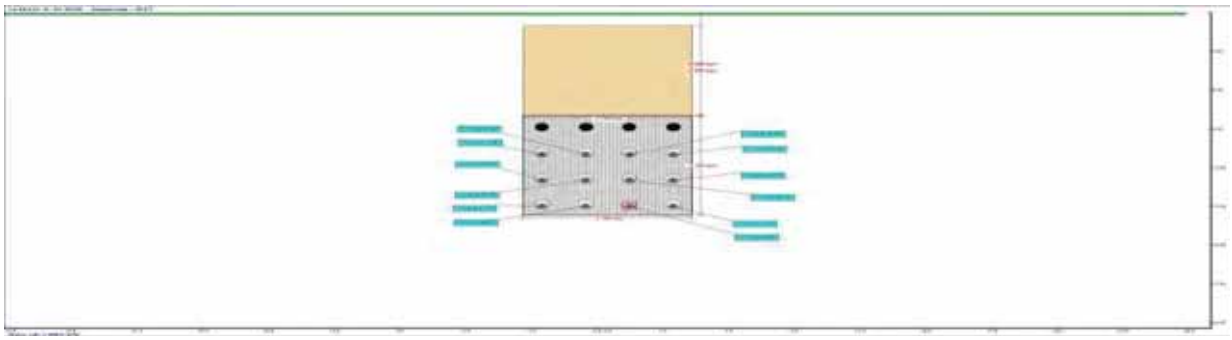
Standard Settings Options

General guidance	5ustom
Factor on RAC due to magnetic armour	5IGREGuidan-e
Factor on RAC due to magnetic duct	5IGREGuidan-e
Factor on λ_1 due to magnetic armour	5YM5APGuidan-e
Factor on λ_1 due to magnetic duct	5IGREGuidan-e
Factor on λ_2 due to λ'_1	5YM5APGuidan-e
λ''_1 computation	5IGREGuidan-e
$\lambda_2$pipe computation	5YM5APGuidan-e
Wd computation	5IGREGuidan-e
T_2 computation	5IGREGuidan-e
T_4 computation	5YM5APGuidan-e

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	2k.kk
Native Soil Thermal Resistivity [K.m/W]	1.ck
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
OB 4X4	k.kk	11.88	7.7c	7.7c	k.f k
Ba-V5il	k.kk	4.ck	7.7c	7.kk	k.f k



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	20k5c.kkX1	1		A	f k.kk	k.8c	30.kk	1k.::	7: .k4	1111.07
2	20k5c.kkX1	1		B	f k.kk	k.8c	30.kk	12.::	8c.74	1111.07
0	20k5c.kkX1	1		5	f k.kk	k.8c	30.kk	14.::	87.1k	1111.07
4	20k5c.kkX1	2		A	f k.kk	k.8c	31.kk	14.::	8: .::	1111.07
c	20k5c.kkX1	2		B	f k.kk	k.8c	31.kk	1k.::	81.k0	1111.07
f	20k5c.kkX1	2		5	f k.kk	k.8c	31.kk	12.::	88.0k	1111.07
7	20k5c.kkX1	0		A	f k.kk	k.8c	1.kk	12.::	88.0k	1111.07
8	20k5c.kkX1	0		B	f k.kk	k.8c	1.kk	14.::	8: .::	1111.07
:	20k5c.kkX1	0		5	f k.kk	k.8c	1.kk	1k.::	81.k0	1111.07
1k	20k5c.kkX1	4		A	f k.kk	k.8c	0.kk	1k.::	7: .k4	1111.07
11	20k5c.kkX1	4		B	f k.kk	k.8c	0.kk	12.::	8c.74	1111.07
12	20k5c.kkX1	4		5	f k.kk	k.8c	0.kk	14.::	87.1k	1111.07

Cables Report

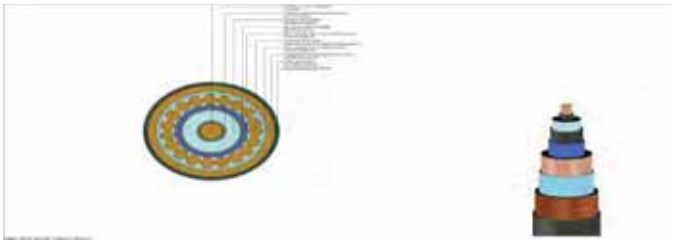
CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T1.1-320kV, _8D OC5_ckkkV-mil 5u_8c OLF
Date:	4/1k/2k24 : 621601 AM

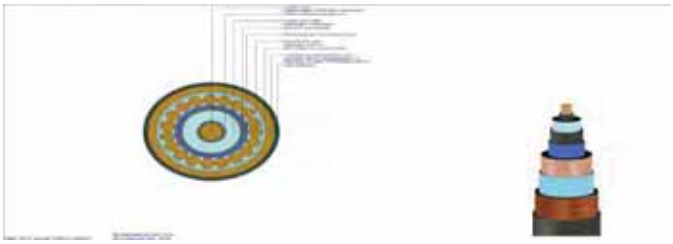
No.	Description	Unit	1
General Cable Information			
1	Sable Equipment ID		20kSc.kkX1
2	Number oSSores		qin9le Sore
0	, olta9e	[V_]	20k.kk
4	Sondu-tor Area	[in²]	0.:0
c	Sable Cverall Diameter	[in]	c.22
f	Maximum gteady3tate Sondu-tor Temperature	[°S]	: k.kk
7	Maximum Emer9en-y Sondu-tor Temperature	[°S]	1kc.kk
Conductor			
8	Material		5opper
:	Ele-tri-al Resistivity at 2k°S	[µΩ.-m]	1.72
1k	Temperature Soet9i-ient at 2k°S	[1/K]	k.kk
11	Re-ipro-al oSTemperature Soet9i-ient oSResistan-e (BETA)	[K]	204.4c
12	, olumetri- gpe-i9- Heat (gH)	[J/(K°-m³)]	0.4c
10	Sonstru-tion		f_ge9ments
14	Sondu-tor Insulation gystem		Extruded
1c	Milliwen Wires Sonstru-tion		Insulated Wires
1f	Ks (gWn Et9e-t 5oet9i-ient)		k.0c
17	Kp (Proximity Et9e-t 5oet9i-ient)		k.2k
18	Diameter	[in]	2.c4
Conductor Shield			
1:	Thi-Vness	[in]	k.1k
2k	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Un9lled
22	Thermal Resistivity	[K.m/W]	0.ck
20	Olele-tri- Loss Fa-tor 3(tan delta)		k.kk
24	Relative Permittivity 3(epsilon)		2.ck
2c	gpe-i9- Insulation Resistan-e Sonstant at f k°F 3(K)	[M0.1000ft]	18c8.kf
2f	Thi-Vness	[in]	k.:1
27	Diameter	[in]	4.cc
Insulation Screen			
28	Material		gemi Sondu-tin9 g-reen
2:	Thi-Vness	[in]	k.kc
0k	Diameter	[in]	4.f c
Non Metallic Layer - Water Swellable Tape 1			
01	Material		EXTRUOEO gEMISCNOUSTI, E gSREEN
02	Thermal Resistivity	[K.m/W]	2.ck
00	Thi-Vness	[in]	k.k2
04	Diameter	[in]	4.f :
Concentric neutral/Skid wires			
0c	Are Son-entri- Neutral Wires Around Ea-h Sore?		n/a
0f	Material		5opper
07	Ele-tri-al Resistivity at 2k°S	[µΩ.-m]	1.72
08	Temperature Soet9i-ient at 2k°S	[1/K]	k.kk
0:	Re-ipro-al oSTemperature Soet9i-ient oSResistan-e (BETA)	[K]	204.ck
4k	, olumetri- gpe-i9- Heat (gH)	[J/(K°-m³)]	0.4c
41	Wire Type		Round Wires
42	Len9th oSLay	[in]	4c.cf
40	Number oSWires		4f
44	Wire Gau9e		14
4c	Thi-Vness	[in]	k.kf
4f	Diameter	[in]	4.82
Sheath			
47	Is gheath Around Ea-h Sore?		n/a
48	Material		5opper
4:	Ele-tri-al Resistivity at 2k°S	[µΩ.-m]	1.72
ck	Temperature Soet9i-ient at 2k°S	[1/K]	k.kk
c1	Re-ipro-al oSTemperature Soet9i-ient oSResistan-e (BETA)	[K]	204.ck
c2	, olumetri- gpe-i9- Heat (gH)	[J/(K°-m³)]	0.4c
c0	Sonru9lation Type		LonSitudinally Sorru9lated
c4	Sonru9lation helfht	[in]	k.k1
cc	Tape overlap	[in]	k.ck
cf	Tape width	[in]	1c.:1
c7	Tape thi-Vness	[in]	k.k1
c8	A--umulaton 9a-tor		1.2k
c:	Thi-Vness	[in]	k.k1
f k	Diameter	[in]	4.:1
Jacket			
f 1	Material		Polyethylene
f 2	Thermal Resistivity	[K.m/W]	0.ck
f 0	Thi-Vness	[in]	k.1c
f 4	Diameter	[in]	c.22

No.	Description	Unit	1
Specific Installation Data			
f c	Sable Equipment ID		20kSc.kkX1
f f	Sable Frequen-y	[Hz]	f k.kk
f 7	gheath / ghield Bondin9		1 Sondu-tor 1 Point Bonded Flat
f 8	Loss Fa-tor Sonstant (ALCg)		k.0k
f :	Sonduit -onstru-tion		P, 5 Ou-t in Son-rete
7k	Sonduit material thermal resistivity	[K.m/W]	f .kk
71	Sonduit 9ll in9 material		Air
72	Inner diameter oSthe -onduit	[in]	7.:8
70	Cuter diameter oSthe -onduit	[in]	8.f 2

Cable ID : 230C5.00X1

Sable Title: 20kV, _ckkk V-mil 5u 3f ge9_: kf XLPE_5u -n_Prysmian





General Summary Report

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T2.1a-500kV, 8_ DOC, 5000kcmil Cu, 100 DLF
Date:	4/9/2024 1:29:15 PM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Equally Loaded
Ambient temperature [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.50
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits) [A]	0.00

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.50
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
DB 4X5	-1.64E-07	11.13	17.75	6.25	0.60
Backfill	0.00	4.50	17.75	7.00	0.60

General Cable Information

Cable ID	Number of Cores	Conductor Construction	Voltage [kV]	Conductor Area [mm²]	Cable Overall Diameter [in]	Maximum Steady-State Conductor Temperature [°C]	Maximum Emergency Conductor Temperature [°C]
500CS.00X	Single Core	6 Segments	500.00	2535.64	5.99	90.00	105.00

Detailed Cable Information

Cable ID	Conductor	Insulation	Sheath / Tape	Concentric Wires	Filler	Armour	Jacket / Armour Serving
500CS.00X	Copper	XLPE Unfilled	Copper	Copper	n/a	n/a	Polyethylene

General Input Data

Cable Index Number	Cable ID / Cable Equipment ID	Circuit No.	Phase	Fq [Hz] / Operating Frequency	X [ft] / X coordinate	Y [ft] / Y coordinate	DLF [p.u.] / Daily Load Factor	Sheath / Shield Bonding / Bonding Type
1	500CS.00X	1	A	60.00	-8.00	8.95	1.00	1 Conductor 1 Point Bonded Flat
2	500CS.00X	1	B	60.00	-8.00	10.45	1.00	1 Conductor 1 Point Bonded Flat
3	500CS.00X	1	C	60.00	-8.00	11.95	1.00	1 Conductor 1 Point Bonded Flat
4	500CS.00X	2	A	60.00	-4.00	11.95	1.00	1 Conductor 1 Point Bonded Flat
5	500CS.00X	2	B	60.00	-4.00	8.95	1.00	1 Conductor 1 Point Bonded Flat
6	500CS.00X	2	C	60.00	-4.00	10.45	1.00	1 Conductor 1 Point Bonded Flat
7	500CS.00X	3	A	60.00	0.00	10.45	1.00	1 Conductor 1 Point Bonded Flat
8	500CS.00X	3	B	60.00	0.00	11.95	1.00	1 Conductor 1 Point Bonded Flat
9	500CS.00X	3	C	60.00	0.00	8.95	1.00	1 Conductor 1 Point Bonded Flat
10	500CS.00X	4	A	60.00	4.00	8.95	1.00	1 Conductor 1 Point Bonded Flat
11	500CS.00X	4	B	60.00	4.00	10.45	1.00	1 Conductor 1 Point Bonded Flat
12	500CS.00X	4	C	60.00	4.00	11.95	1.00	1 Conductor 1 Point Bonded Flat
13	500CS.00X	5	A	60.00	8.00	11.95	1.00	1 Conductor 1 Point Bonded Flat
14	500CS.00X	5	B	60.00	8.00	8.95	1.00	1 Conductor 1 Point Bonded Flat
15	500CS.00X	5	C	60.00	8.00	10.45	1.00	1 Conductor 1 Point Bonded Flat

Ampacity and Temperatures

Cable Index Number	Cable ID / Cable Equipment ID	I [A] / Steady State Ampacity	θc [°C] / Conductor temperature	θs [°C] / Sheath/Shield temperature	θa [°C] / Armour temperature	θsurf [°C] / Cable surface temperature	θduct [°C] / Duct surface temperature	θair / θcasing [°C] / Mean air temperature in the tunnel / Casing surface temperature
1	500CS.00X	916.18	78.27	73.53	n/a	72.70	68.65	n/a
2	500CS.00X	916.18	84.22	79.43	n/a	78.56	74.40	n/a
3	500CS.00X	916.18	85.48	80.68	n/a	79.85	75.88	n/a
4	500CS.00X	916.18	88.87	84.04	n/a	83.21	79.27	n/a
5	500CS.00X	916.18	81.17	76.40	n/a	75.57	71.55	n/a
6	500CS.00X	916.18	87.26	82.45	n/a	81.58	77.45	n/a
7	500CS.00X	916.18	86.32	81.50	n/a	82.63	78.52	n/a
8	500CS.00X	916.18	90.01	85.17	n/a	84.34	80.41	n/a
9	500CS.00X	916.18	82.14	77.36	n/a	76.53	72.52	n/a
10	500CS.00X	916.18	81.16	76.39	n/a	75.56	71.54	n/a
11	500CS.00X	916.18	87.26	82.44	n/a	81.57	77.45	n/a
12	500CS.00X	916.18	88.87	84.03	n/a	83.20	79.27	n/a
13	500CS.00X	916.18	85.47	80.67	n/a	79.84	75.87	n/a
14	500CS.00X	916.18	78.26	73.51	n/a	72.69	68.63	n/a
15	500CS.00X	916.18	84.21	79.41	n/a	78.55	74.39	n/a

Electrical Resistances

Cable Index Number	Cable ID / Cable Equipment ID	Rs [Ω/mile] / DC Resistance of the conductor at 20°C	ys / Skin Effect Factor	yp / Proximity Effect Factor	R [Ω/mile] / AC Resistance of Conductor at Operating Temperature	R's [Ω/mile] / DC Resistance of Sheath at Operating Temperature	R'sw [Ω/mile] / DC Resistance of Concentric Wires at Operating Temperature	R'a [Ω/mile] / DC Resistance of Armor at Operating Temperature
1	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.26	n/a
2	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.27	n/a
3	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.27	n/a
4	500CS.00X	0.01	0.16	0.00	0.02	0.29	0.27	n/a
5	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.26	n/a
6	500CS.00X	0.01	0.16	0.00	0.02	0.29	0.27	n/a
7	500CS.00X	0.01	0.16	0.00	0.02	0.29	0.27	n/a
8	500CS.00X	0.01	0.16	0.00	0.02	0.29	0.27	n/a
9	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.26	n/a
10	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.26	n/a
11	500CS.00X	0.01	0.16	0.00	0.02	0.29	0.27	n/a
12	500CS.00X	0.01	0.16	0.00	0.02	0.29	0.27	n/a
13	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.27	n/a
14	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.26	n/a
15	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.27	n/a

Thermal Resistances

Cable Index Number	Cable ID / Cable Equipment ID	T1 [K.m/W] / Thermal resistance of insulation	T2 [K.m/W] / Thermal resistance of bedding	T3 [K.m/W] / Thermal resistance of outer covering	Ta' [K.m/W] / Thermal resistance inside the duct	Td'' [K.m/W] / Thermal resistance of the duct	Te''' [K.m/W] / Thermal resistance of the external medium	Te [K.m/W] / Total external thermal resistance
1	500CS.00X	0.40	0.00	0.05	0.19	0.07	3.19	3.45
2	500CS.00X	0.40	0.00	0.05	0.19	0.07	3.39	3.65
3	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.63	3.89
4	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.84	4.09
5	500CS.00X	0.40	0.00	0.05	0.19	0.07	3.37	3.63
6	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.57	3.83
7	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.63	3.89
8	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.91	4.16
9	500CS.00X	0.40	0.00	0.05	0.19	0.07	3.43	3.69
10	500CS.00X	0.40	0.00	0.05	0.19	0.07	3.37	3.63
11	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.57	3.83
12	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.84	4.09
13	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.63	3.89
14	500CS.00X	0.40	0.00	0.05	0.19	0.07	3.19	3.45
15	500CS.00X	0.40	0.00	0.05	0.19	0.07	3.39	3.65

Losses

Cable Index Number	Cable ID / Cable Equipment ID	Wc [W/ft] / Conductor Losses	Wd [W/ft] / Dielectric Losses	Ws [W/ft] / Metallic Screen Losses	Wa [W/ft] / Armor/Pipe Losses	Wt [W/ft] / Total Losses	λ1 / Screen Loss Factor	λ2 / Armour Loss Factor + Pipe Loss Factor
1	500CS.00X	2.57	2.01	0.07	0.00	4.65	0.03	0.00
2	500CS.00X	2.60	2.01	0.27	0.00	4.88	0.10	0.00
3	500CS.00X	2.61	2.01	0.06	0.00	4.69	0.02	0.00
4	500CS.00X	2.63	2.01	0.06	0.00	4.71	0.02	0.00
5	500CS.00X	2.58	2.01	0.07	0.00	4.67	0.03	0.00
6	500CS.00X	2.62	2.01	0.27	0.00	4.90	0.10	0.00
7	500CS.00X	2.63	2.01	0.27	0.00	4.91	0.10	0.00
8	500CS.00X	2.64	2.01	0.06	0.00	4.71	0.02	0.00
9	500CS.00X	2.59	2.01	0.07	0.00	4.67	0.03	0.00
10	500CS.00X	2.58	2.01	0.07	0.00	4.67	0.03	0.00
11	500CS.00X	2.62	2.01	0.27	0.00	4.90	0.10	0.00
12	500CS.00X	2.63	2.01	0.06	0.00	4.71	0.02	0.00
13	500CS.00X	2.61	2.01	0.06	0.00	4.69	0.02	0.00
14	500CS.00X	2.57	2.01	0.07	0.00	4.65	0.03	0.00
15	500CS.00X	2.60	2.01	0.27	0.00	4.88	0.10	0.00

Complementary Information

Cable Index Number	Cable ID / Cable Equipment ID	ΔDist [°C] / Temperature rise due to surrounding heat sources	[A] / Induced current on Metallic Screen	[μF/mile] / Cable Capacitance	[Ω] / Surge Impedance	[Ω/mile] / Reactance of Conductor	[Ω/mile] / Reactance of Metallic Sheath	[V/A/mile] / Voltage drop for Three Phase System
1	500CS.00X	48.63	0.00	0.34	52.71	0.35	0.23	0.03
2	500CS.00X	45.36	0.00	0.34	52.71	0.35	0.23	0.03
3	500CS.00X	48.64	0.00	0.34	52.71	0.35	0.23	0.03
4	500CS.00X	51.04	0.00	0.34	52.71	0.35	0.23	0.03
5	500CS.00X	44.46	0.00	0.34	52.71	0.35	0.23	0.03
6	500CS.00X	49.44	0.00	0.34	52.71	0.35	0.23	0.03
7	500CS.00X	50.67	0.00	0.34	52.71	0.35	0.23	0.03
8	500CS.00X	52.36	0.00	0.34	52.71	0.35	0.23	0.03
9	500CS.00X	45.59	0.00	0.34	52.71	0.35	0.23	0.03
10	500CS.00X	44.46	0.00	0.34	52.71	0.35	0.23	0.03
11	500CS.00X	49.44	0.00	0.34	52.71	0.35	0.23	0.03
12	500CS.00X	51.04	0.00	0.34	52.71	0.35	0.23	0.03
13	500CS.00X	46.64	0.00	0.34	52.71	0.35	0.23	0.03
14	500CS.00X	40.62	0.00	0.34	52.71	0.35	0.23	0.03
15	500CS.00X	45.35	0.00	0.34	52.71	0.35	0.23	0.03

Study Summary

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T2.1a-500kV, 8_ DOC, 5000kcmil Cu, 100 DLF
Date:	4/9/2024 3:29:15 PM

General Simulation Data

Steady State Option	Equally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.00
Conductor Resistances Computation Option:	IEC-228

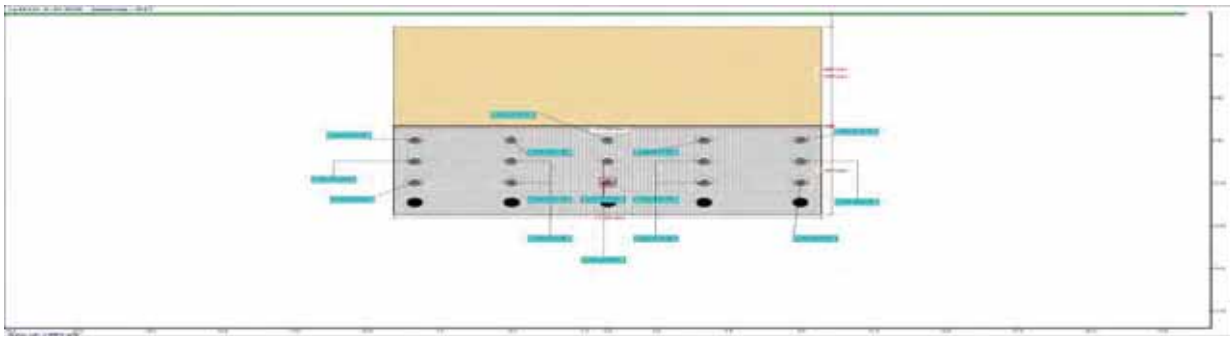
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.50
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
DB 4X5	-1.64E-07	11.13	17.75	6.25	0.60
Backfill	0.00	4.50	17.75	7.00	0.60



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	500C5.00X	1		A	60.00	1.00	-8.00	8.95	78.27	916.18
2	500C5.00X	1		B	60.00	1.00	-8.00	10.45	84.22	916.18
3	500C5.00X	1		C	60.00	1.00	-8.00	11.95	85.48	916.18
4	500C5.00X	2		A	60.00	1.00	-4.00	11.95	88.87	916.18
5	500C5.00X	2		B	60.00	1.00	-4.00	8.95	81.17	916.18
6	500C5.00X	2		C	60.00	1.00	-4.00	10.45	87.26	916.18
7	500C5.00X	3		A	60.00	1.00	0.00	10.45	88.32	916.18
8	500C5.00X	3		B	60.00	1.00	0.00	11.95	90.01	916.18
9	500C5.00X	3		C	60.00	1.00	0.00	8.95	82.14	916.18
10	500C5.00X	4		A	60.00	1.00	4.00	8.95	81.16	916.18
11	500C5.00X	4		B	60.00	1.00	4.00	10.45	87.26	916.18
12	500C5.00X	4		C	60.00	1.00	4.00	11.95	88.87	916.18
13	500C5.00X	5		A	60.00	1.00	8.00	11.95	85.47	916.18
14	500C5.00X	5		B	60.00	1.00	8.00	8.95	78.26	916.18
15	500C5.00X	5		C	60.00	1.00	8.00	10.45	84.21	916.18

Cables Report

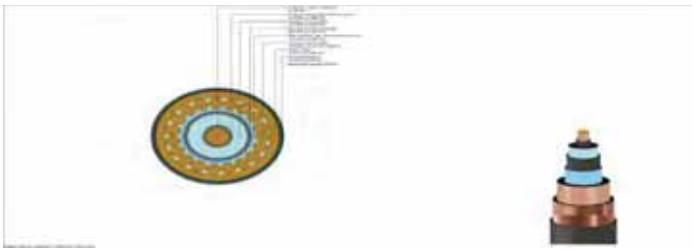
CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T2.1a-500kV, 8_ DOC, 5000kcmil Cu, 100 DLF
Date:	4/9/2024 3:29:15 PM

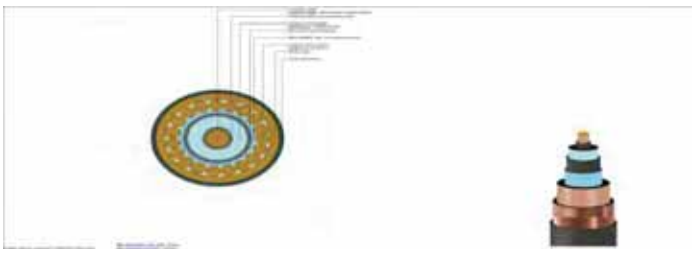
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500.00
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90.00
7	Maximum Emergency Conductor Temperature	[°C]	105.00
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[μΩ.cm]	1.72
10	Temperature Coefficient at 20°C	[1/K]	0.00
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.45
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.20
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.06
20	Diameter	[in]	2.61
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.50
23	Dielectric Loss Factor - (tan delta)		0.00
24	Relative Permittivity - (epsilon)		2.50
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858.06
26	Thickness	[in]	1.22
27	Diameter	[in]	5.05
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.06
30	Diameter	[in]	5.17
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.50
33	Thickness	[in]	0.04
34	Diameter	[in]	5.24
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[μΩ.cm]	1.72
38	Temperature Coefficient at 20°C	[1/K]	0.00
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.50
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.56
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.09
46	Diameter	[in]	5.41
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[μΩ.cm]	1.72
50	Temperature Coefficient at 20°C	[1/K]	0.00
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.50
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.01
55	Diameter	[in]	5.44
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.50
58	Thickness	[in]	0.28
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60.00
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Flat
63	Loss Factor Constant (ALOS)		0.30
64	Conduit construction		PVC Duct in Concrete
65	Conduit material thermal resistivity	[K.m/W]	6.00
66	Conduit filling material		Air
67	Inner diameter of the conduit	[in]	7.98
68	Outer diameter of the conduit	[in]	8.62

Cable ID : 500C5.00X

Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





General Summary Report

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T2.1- 50kkV, _8D OCc_0kkkVmu il cL_1kk OF4
Date:	/ 9392k2/ : P. : P2p bM

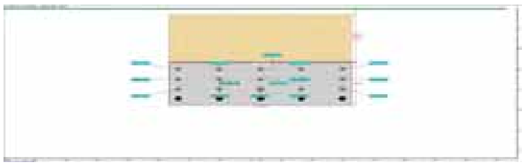
Simulation Data

Installation type:	MLltiEle OLmt- anVs
Steady State Option	qyLallN Foaded
Ambient temperature [°C]	2k.kk
Native Soil Thermal Resistivity [K.m/W]	1.: k
Consider Non-Isothermal Earth Surface	Bo
Consider effect of soil dry out	Bo
Consider Electrical interaction between circuits	Bo
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits) [A]	k.kk

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	2k.kk
Native Soil Thermal Resistivity [K.m/W]	1.: k
Consider Non-Isothermal Earth Surface	Bo

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
OX / 60	51.7/ q5kp	11.1:	1p.p0	7.20	k.7k
XanVfill	k.kk	/ .0k	1p.p0	p.kk	k.7k



General Cable Information

Cable ID	Number of Cores	Conductor Construction	Voltage [kV]	Conductor Area [mm²]	Cable Overall Diameter [in]	Maximum Steady-State Conductor Temperature [°C]	Maximum Emergency Conductor Temperature [°C]
0kkc0.kk6	Single core	7 Segu ents	0kk.kk	20: 0.7/	0.33	3k.kk	1k0.kk

Detailed Cable Information

Cable ID	Conductor	Insulation	Sheath / Tape	Concentric Wires	Filler	Armour	Jacket / Armour Serving
0kkc0.kk6	coEEer	6Fbq Unfilled	coEEer	coEEer	n9a	n9a	bolNethNene

General Input Data

Cable	Cable ID	Circuit No.	Phase	Fq [Hz]	X [ft]	Y [ft]	DLF [p.u.]	Sheath / Shield Bonding
Cable Index Number	**Cable Equipment ID**	**Circuit No.**	**Cable Phase**	**Operating Frequency**	**X coordinate**	**Y coordinate**	**Daily Load Factor**	**Bonding Type**
1	0kkc0.kk6	1	A	7k.kk	5B.kk	8.30	1.kk	1 condLmtor 1 boint Xonded 4lat
2	0kkc0.kk6	1	X	7k.kk	5B.kk	1k./ 0	1.kk	1 condLmtor 1 boint Xonded 4lat
:	0kkc0.kk6	1	c	7k.kk	5B.kk	11.30	1.kk	1 condLmtor 1 boint Xonded 4lat
/	0kkc0.kk6	2	A	7k.kk	5/.kk	11.30	1.kk	1 condLmtor 1 boint Xonded 4lat
0	0kkc0.kk6	2	X	7k.kk	5/.kk	8.30	1.kk	1 condLmtor 1 boint Xonded 4lat
7	0kkc0.kk6	2	c	7k.kk	5/.kk	1k./ 0	1.kk	1 condLmtor 1 boint Xonded 4lat
p	0kkc0.kk6	:	A	7k.kk	k.kk	1k./ 0	1.kk	1 condLmtor 1 boint Xonded 4lat
8	0kkc0.kk6	:	X	7k.kk	k.kk	11.30	1.kk	1 condLmtor 1 boint Xonded 4lat
3	0kkc0.kk6	:	c	7k.kk	k.kk	8.30	1.kk	1 condLmtor 1 boint Xonded 4lat
1k	0kkc0.kk6	/	A	7k.kk	/ .kk	8.30	1.kk	1 condLmtor 1 boint Xonded 4lat
11	0kkc0.kk6	/	X	7k.kk	/ .kk	1k./ 0	1.kk	1 condLmtor 1 boint Xonded 4lat
12	0kkc0.kk6	/	c	7k.kk	/ .kk	11.30	1.kk	1 condLmtor 1 boint Xonded 4lat
1:	0kkc0.kk6	0	A	7k.kk	8.kk	11.30	1.kk	1 condLmtor 1 boint Xonded 4lat
1/	0kkc0.kk6	0	X	7k.kk	8.kk	8.30	1.kk	1 condLmtor 1 boint Xonded 4lat
10	0kkc0.kk6	0	c	7k.kk	8.kk	1k./ 0	1.kk	1 condLmtor 1 boint Xonded 4lat

Ampacity and Temperatures

Cable	Cable ID	I [A]	θc [°C]	θs [°C]	θa [°C]	θsurf [°C]	θduct [°C]	θair / θcasing [°C]
Cable Index Number	**Cable Equipment ID**	**Steady State Ampacity**	**Conductor temperature**	**Sheath/Shield temperature**	**Armour temperature**	**Cable surface temperature**	**Duct surface temperature**	**Mean air temperature in the tunnel / Casing surface temperature**
1	0kkc0.kk6	308.kk	pp.73	p2.7/	n9a	p1.pp	7p./ 8	n9a
2	0kkc0.kk6	308.kk	8: .77	p8.0/	n9a	pp.7:	p: .2:	n9a
:	0kkc0.kk6	308.kk	8/ .p3	p3.7p	n9a	p8.8k	p/ .7k	n9a
/	0kkc0.kk6	308.kk	88.p:	8: .0p	n9a	82.73	p8.0/	n9a
0	0kkc0.kk6	308.kk	81.kp	p0.38	n9a	p0.11	pk.8p	n9a
7	0kkc0.kk6	308.kk	8p.27	82.12	n9a	81.2k	p7.8/	n9a
p	0kkc0.kk6	308.kk	88./ p	8: .: 1	n9a	82.: 3	p8.k0	n9a
8	0kkc0.kk6	308.kk	3k.k1	8/ .8/	n9a	8: .37	p3.82	n9a
3	0kkc0.kk6	308.kk	82.18	pp.k8	n9a	p7.21	p1.38	n9a
1k	0kkc0.kk6	308.kk	81.kp	p0.38	n9a	p0.11	pk.8p	n9a
11	0kkc0.kk6	308.kk	8p.20	82.11	n9a	81.13	p7.8/	n9a
12	0kkc0.kk6	308.kk	88.p2	8: .07	n9a	82.78	p8.0:	n9a
1:	0kkc0.kk6	308.kk	8/ .p8	p3.77	n9a	p8.p3	p/ .03	n9a
1/	0kkc0.kk6	308.kk	pp.78	p2.72	n9a	p1.p7	7p./ p	n9a
10	0kkc0.kk6	308.kk	8: .7/	p8.0:	n9a	pp.72	p: .21	n9a

Electrical Resistances

Cable	Cable ID	R_0 [Ω/mile]	ys	yp	R [Ω/mile]	R's [Ω/mile]	R'w [Ω/mile]	R'a [Ω/mile]
Cable Index Number	**Cable Equipment ID**	**DC Resistance of the conductor at 20°C**	**Skin Effect Factor**	**Proximity Effect Factor**	**AC Resistance of Conductor at Operating Temperature**	**DC Resistance of Sheath at Operating Temperature**	**DC Resistance of Concentric Wires at Operating Temperature**	**DC Resistance of Armor at Operating Temperature**
1	0kkc0.kk6	k.k1	k.1p	k.kk	k.k2	k.28	k.27	n9a
2	0kkc0.kk6	k.k1	k.1p	k.kk	k.k2	k.28	k.2p	n9a
:	0kkc0.kk6	k.k1	k.1p	k.kk	k.k2	k.28	k.2p	n9a
/	0kkc0.kk6	k.k1	k.17	k.kk	k.k2	k.23	k.2p	n9a
0	0kkc0.kk6	k.k1	k.1p	k.kk	k.k2	k.28	k.27	n9a
7	0kkc0.kk6	k.k1	k.17	k.kk	k.k2	k.23	k.2p	n9a
p	0kkc0.kk6	k.k1	k.17	k.kk	k.k2	k.23	k.2p	n9a
8	0kkc0.kk6	k.k1	k.17	k.kk	k.k2	k.23	k.2p	n9a
3	0kkc0.kk6	k.k1	k.1p	k.kk	k.k2	k.28	k.27	n9a
1k	0kkc0.kk6	k.k1	k.1p	k.kk	k.k2	k.28	k.27	n9a
11	0kkc0.kk6	k.k1	k.17	k.kk	k.k2	k.23	k.2p	n9a
12	0kkc0.kk6	k.k1	k.17	k.kk	k.k2	k.23	k.2p	n9a
1:	0kkc0.kk6	k.k1	k.1p	k.kk	k.k2	k.28	k.2p	n9a
1/	0kkc0.kk6	k.k1	k.1p	k.kk	k.k2	k.28	k.27	n9a
10	0kkc0.kk6	k.k1	k.1p	k.kk	k.k2	k.28	k.2p	n9a

Thermal Resistances

Cable	Cable ID	T_1 [K.m/W]	T_2 [K.m/W]	T_3 [K.m/W]	T_4' [K.m/W]	T_4'' [K.m/W]	T_4''' [K.m/W]	T_4 [K.m/W]
Cable Index Number	**Cable Equipment ID**	**Thermal resistance of insulation**	**Thermal resistance of bedding**	**Thermal resistance of outer covering**	**Thermal resistance inside the duct**	**Thermal resistance of the duct**	**Thermal resistance of the external medium**	**Total external thermal resistance**
1	0kkc0.kk6	k./ k	k.kk	k.k0	k.13	k.kp	2.37	: .22
2	0kkc0.kk6	k./ k	k.kk	k.k0	k.13	k.kp	: .10	: ./ 1
:	0kkc0.kk6	k./ k	k.kk	k.k0	k.13	k.kp	: .: p	: .7:
/	0kkc0.kk6	k./ k	k.kk	k.k0	k.18	k.kp	: .7k	: .80
0	0kkc0.kk6	k./ k	k.kk	k.k0	k.13	k.kp	: .10	: ./ 2
7	0kkc0.kk6	k./ k	k.kk	k.k0	k.18	k.kp	: .: 0	: .71
p	0kkc0.kk6	k./ k	k.kk	k.k0	k.18	k.kp	: ./ 2	: .7p
8	0kkc0.kk6	k./ k	k.kk	k.k0	k.18	k.kp	: .7p	: .3:
3	0kkc0.kk6	k./ k	k.kk	k.k0	k.13	k.kp	: .22	: ./ 8
1k	0kkc0.kk6	k./ k	k.kk	k.k0	k.13	k.kp	: .10	: ./ 2
11	0kkc0.kk6	k./ k	k.kk	k.k0	k.18	k.kp	: .: 0	: .71
12	0kkc0.kk6	k./ k	k.kk	k.k0	k.18	k.kp	: .7k	: .80
1:	0kkc0.kk6	k./ k	k.kk	k.k0	k.13	k.kp	: .: p	: .7:
1/	0kkc0.kk6	k./ k	k.kk	k.k0	k.13	k.kp	2.37	: .22
10	0kkc0.kk6	k./ k	k.kk	k.k0	k.13	k.kp	: .10	: ./ 1

Losses

Cable	Cable ID	Wc [W/ft]	Wd [W/ft]	Ws [W/ft]	Wa [W/ft]	Wt [W/ft]	λ_1	λ_2
Cable Index Number	**Cable Equipment ID**	**Conductor Losses**	**Dielectric Losses**	**Metallic Screen Losses**	**Armor/Pipe Losses**	**Total Losses**	**Screen Loss Factor**	**Armour Loss Factor + Pipe Loss Factor**
1	0kkc0.kk6	2.8k	2.k1	k.k8	k.kk	/ .83	k.k:	k.kk
2	0kkc0.kk6	2.8/	2.k1	k.: k	k.kk	0.10	k.1k	k.kk
:	0kkc0.kk6	2.80	2.k1	k.kp	k.kk	/ .3:	k.k2	k.kk
/	0kkc0.kk6	2.8p	2.k1	k.kp	k.kk	/ .37	k.k2	k.kk
0	0kkc0.kk6	2.82	2.k1	k.k8	k.kk	/ .31	k.k:	k.kk
7	0kkc0.kk6	2.87	2.k1	k.23	k.kk	0.1p	k.1k	k.kk
p	0kkc0.kk6	2.8p	2.k1	k.23	k.kk	0.18	k.1k	k.kk
8	0kkc0.kk6	2.88	2.k1	k.kp	k.kk	/ .3p	k.k2	k.kk
3	0kkc0.kk6	2.8:	2.k1	k.k8	k.kk	/ .32	k.k:	k.kk
1k	0kkc0.kk6	2.82	2.k1	k.k8	k.kk	/ .31	k.k:	k.kk
11	0kkc0.kk6	2.87	2.k1	k.23	k.kk	0.1p	k.1k	k.kk
12	0kkc0.kk6	2.8p	2.k1	k.kp	k.kk	/ .37	k.k2	k.kk
1:	0kkc0.kk6	2.80	2.k1	k.kp	k.kk	/ .3:	k.k2	k.kk
1/	0kkc0.kk6	2.8k	2.k1	k.k8	k.kk	/ .83	k.k:	k.kk
10	0kkc0.kk6	2.8/	2.k1	k.: k	k.kk	0.10	k.1k	k.kk

Complementary Information

Cable	Cable ID	Δθint [°C]	[A]	[μF/mile]	[Ω]	[Ω/mile]	[Ω/mile]	[V/A/mile]
Cable Index Number	**Cable Equipment ID**	**Temperature rise due to surrounding heat sources**	**Induced current on Metallic Screen**	**Cable Capacitance**	**Surge Impedance**	**Reactance of Conductor**	**Reactance of Metallic Sheath**	**Voltage drop for Three Phase System**
1	0kkc0.kk6	: 3./ :	k.kk	k.: /	02.p1	k.: 0	k.2:	k.k:
2	0kkc0.kk6	/ / .10	k.kk	k.: /	02.p1	k.: 0	k.2:	k.k:
:	0kkc0.kk6	/ 0.: 3	k.kk	k.: /	02.p1	k.: 0	k.2:	k.k:
/	0kkc0.kk6	0k.13	k.kk	k.: /	02.p1	k.: 0	k.2:	k.k:
0	0kkc0.kk6	/ : .7/	k.kk	k.: /	02.p1	k.: 0	k.2:	k.k:
7	0kkc0.kk6	/ 8.7p	k.kk	k.: /	02.p1	k.: 0	k.2:	k.k:
p	0kkc0.kk6	0k.k2	k.kk	k.: /	02.p1	k.: 0	k.2:	k.k:
8	0kkc0.kk6	01.72	k.kk	k.: /	02.p1	k.: 0	k.2:	k.k:
3	0kkc0.kk6	/ / .88	k.kk	k.: /	02.p1	k.: 0	k.2:	k.k:
1k	0kkc0.kk6	/ : .7/	k.kk	k.: /	02.p1	k.: 0	k.2:	k.k:
11	0kkc0.kk6	/ 8.7p	k.kk	k.: /	02.p1	k.: 0	k.2:	k.k:
12	0kkc0.kk6	0k.13	k.kk	k.: /	02.p1	k.: 0	k.2:	k.k:
1:	0kkc0.kk6	/ 0.: 3	k.kk	k.: /	02.p1	k.: 0	k.2:	k.k:
1/	0kkc0.kk6	: 3./ :	k.kk	k.: /	02.p1	k.: 0	k.2:	k.k:
10	0kkc0.kk6	/ / .10	k.kk	k.: /	02.p1	k.: 0	k.2:	k.k:

Study Summary

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T2.1- 50kkV, _8D OCc_0kkkVmu il cL_1kk OF4
Date:	/ 9392k2/ : P. : P2p bM

General Simulation Data

Steady State Option	qyLallN Foaded
Consider Electrical interaction between circuits	Bo
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	k.kk
Conductor Resistances Computation Option:	Iqc 5228

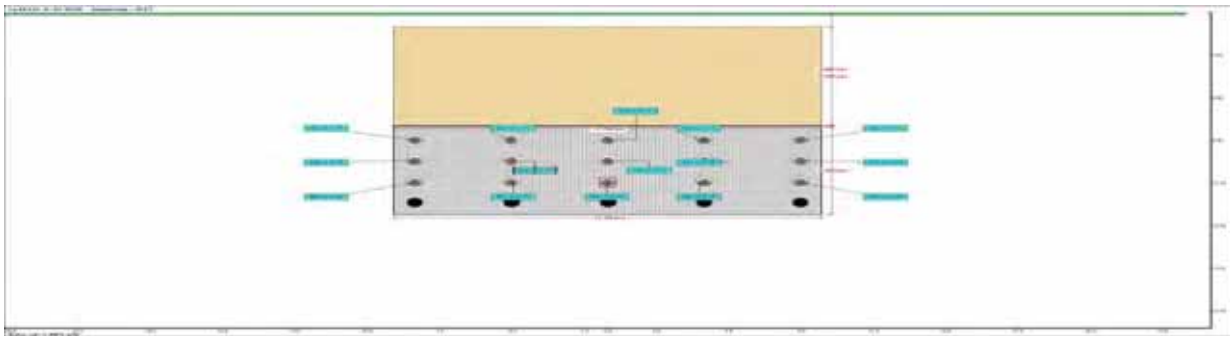
Standard Settings Options

General guidance	c Lstou
Factor on RAC due to magnetic armour	c IGRqGLidanne
Factor on RAC due to magnetic duct	c IGRqGLidanne
Factor on λ₁ due to magnetic armour	c YMc AbGLidanne
Factor on λ₁ due to magnetic duct	c IGRqGLidanne
Factor on λ₂ due to λ'₁	c YMc AbGLidanne
λ''₁ computation	c IGRqGLidanne
λ₂pipe computation	c YMc AbGLidanne
Wd computation	c IGRqGLidanne
T₂ computation	c IGRqGLidanne
T₄ computation	c YMc AbGLidanne

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	2k.kk
Native Soil Thermal Resistivity [K.m/W]	1.: k
Consider Non-Isothermal Earth Surface	Bo

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
OX / 60	5l.7/ q5kp	11.1:	1p.p0	7.20	k.7k
XanVfill	k.kk	/ .0k	1p.p0	p.kk	k.7k



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	0kkc0.kk6	1		A	7k.kk	1.kk	5B.kk	8.30	pp.73	308.kk
2	0kkc0.kk6	1		X	7k.kk	1.kk	5B.kk	1k./ 0	8: .77	308.kk
:	0kkc0.kk6	1		c	7k.kk	1.kk	5B.kk	11.30	8/ .p3	308.kk
/	0kkc0.kk6	2		A	7k.kk	1.kk	5/ .kk	11.30	88.p:	308.kk
0	0kkc0.kk6	2		X	7k.kk	1.kk	5/ .kk	8.30	81.kp	308.kk
7	0kkc0.kk6	2		c	7k.kk	1.kk	5/ .kk	1k./ 0	8p.27	308.kk
p	0kkc0.kk6	:		A	7k.kk	1.kk	k.kk	1k./ 0	88./ p	308.kk
8	0kkc0.kk6	:		X	7k.kk	1.kk	k.kk	11.30	3k.k1	308.kk
3	0kkc0.kk6	:		c	7k.kk	1.kk	k.kk	8.30	82.18	308.kk
1k	0kkc0.kk6	/		A	7k.kk	1.kk	/ .kk	8.30	81.kp	308.kk
11	0kkc0.kk6	/		X	7k.kk	1.kk	/ .kk	1k./ 0	8p.20	308.kk
12	0kkc0.kk6	/		c	7k.kk	1.kk	/ .kk	11.30	88.p2	308.kk
1:	0kkc0.kk6	0		A	7k.kk	1.kk	8.kk	11.30	8/ .p8	308.kk
1/	0kkc0.kk6	0		X	7k.kk	1.kk	8.kk	8.30	pp.78	308.kk
10	0kkc0.kk6	0		c	7k.kk	1.kk	8.kk	1k./ 0	8: .7/	308.kk

Cables Report

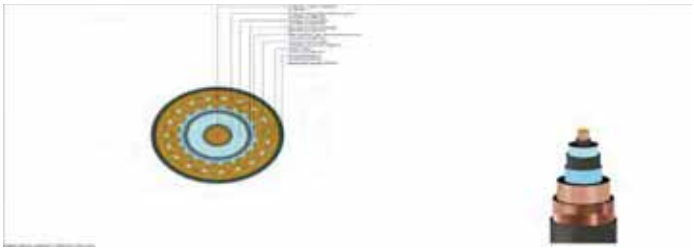
CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T2.1- 5lkkV, _8D OCc_ 0kkkVmm il cL_1kk OF4
Date:	/ 9$92k2/ : P. : P2p bM

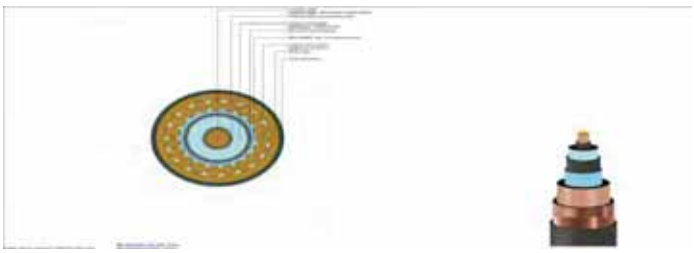
No.	Description	Unit	1
General Cable Information			
1	ca- le qyLiEu ent IO		0kkc0.kk6
2	BLu - er of cores		Single core
:	, oltage	[V,]	0kk.kk
/	condLittor Area	[in²]	: .3:
0	ca- le Cverall Clau eter	[in]	0.33
7	Maxiu Lu SteadNBtate condLittor Teu EeratLre	[°c]	3k.kk
p	Maxiu Lu qu ergemNi condLittor Teu EeratLre	[°c]	1k0.kk
Conductor			
8	Material		coEEer
3	qlentrinal ResistivitNat 2k°c	[µΩ.m]	1.p2
1k	Teu EeratLre coefflntent at 2k°c	[1¶K]	k.kk
11	RemEronal of Teu EeratLre coefflntent of Resistanme (XqTA)	[K]	2: / ./ 0
12	, olLu etrimSEentfimHeat (SH)	[J¶K°m ³)]	: ./ 0
1:	constrLmtion		7 Segu ents
1/	condLittor InsLlation SNteu		qxtrLded
10	MilliVen Wires constrLmtion		InsLlated Wires
17	Ks (SVln qffertt coefflntent)		k. : 0
1p	KE (broxiu itN qffertt coefflntent)		k.2k
18	Clau eter	[in]	2. / 3
Conductor Shield			
13	ThinNess	[in]	k.k7
2k	Clau eter	[in]	2.71
Insulation			
21	Material		6FbQ Unfilled
22	Theru al ResistivitN	[K.u 9W]	: .0k
2:	OielentrimFoss 4antor 5(tan delta)		k.kk
2/	Relative beru ittivitN 5(eEsilon)		2.0k
20	SEentfimInsLlation Resistanme constant at 7k°4 5(K)	[¶0.1000ft]	1808.k7
27	ThinNess	[in]	1.22
2p	Clau eter	[in]	0.k0
Insulation Screen			
28	Material		Seu i condLmting Smeen
23	ThinNess	[in]	k.k7
:k	Clau eter	[in]	0.1p
Non Metallic Layer - Water Swellable Tape			
:1	Material		q6TRUOqO SqMlcCBOUcTl, q ScRqqB
:2	Theru al ResistivitN	[K.u 9W]	2.0k
::	ThinNess	[in]	k.k/
:/	Clau eter	[in]	0.2/
Concentric neutral/Skid wires			
:0	Are conmentrimBeLtral Wires AroLnd qamk core?		n9e
:7	Material		coEEer
:p	qlentrinal ResistivitNat 2k°c	[µΩ.m]	1.p2
:8	Teu EeratLre coefflntent at 2k°c	[1¶K]	k.kk
:3	RemEronal of Teu EeratLre coefflntent of Resistanme (XqTA)	[K]	2: / .0k
/k	, olLu etrimSEentfimHeat (SH)	[J¶K°m ³)]	: ./ 0
/ 1	Wire TNEe		RoLnd Wires
/ 2	Fength of FaN	[in]	/ 0.07
/:	BLu - er of Wires		: 7
//	Wire GaLge		Undefined
/0	ThinNess	[in]	k.k3
. /7	Clau eter	[in]	0. / 1
Sheath			
/p	Is Sheath AroLnd qamk core?		n9e
/8	Material		coEEer
/3	qlentrinal ResistivitNat 2k°c	[µΩ.m]	1.p2
0k	Teu EeratLre coefflntent at 2k°c	[1¶K]	k.kk
01	RemEronal of Teu EeratLre coefflntent of Resistanme (XqTA)	[K]	2: / .0k
02	, olLu etrimSEentfimHeat (SH)	[J¶K°m ³)]	: ./ 0
0:	corrLgation TNEe		Bon corrLgated
0/	ThinNess	[in]	k.k1
00	Clau eter	[in]	0.//
Jacket			
07	Material		boiNethNene
0p	Theru al ResistivitN	[K.u 9W]	: .0k
08	ThinNess	[in]	k.28
03	Clau eter	[in]	0.33

No.	Description	Unit	1
Specific Installation Data			
7k	ca- le qyLiEu ent IO		0kkc0.kk6
71	ca- le 4reyLenmN	[Hz]	7k.kk
72	Sheath 9Shield Xonding		1 condLittor 1 boint Xonded 4lat
7:	Foss 4antor constant (AFCS)		k. : k
7/	condLit nonstrLmtion		b, c OLmtin conmete
70	condLit u aterial theru al resistivitN	[K.u 9W]	7.kk
77	condLit filling u aterial		Air
7p	Inner diau eter of the nondLit	[in]	p.38
78	CLter diau eter of the nondLit	[in]	8.72

Cable ID : 500C5.00X

ca- le Title: 0kkV, _0kkkVmm il cL 57 Seg_1221 6Fbq_cL conm Taihan





General Summary Report

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T2.1-50kkV, _8D OCc_0kkkV-mil cu_1kk OLF
Date:	4/9/2k24 3:43:21 PM

Simulation Data

Installation type:	Multiple Ou-tbanVs
Steady State Option	Equally Loaded
Ambient temperature [°C]	2k.kk
Native Soil Thermal Resistivity [K.m/W]	1.0k
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits) [A]	k.kk

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	2k.kk
Native Soil Thermal Resistivity [K.m/W]	1.0k
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
OB 4X0	51.64E5k7	11.88	17.70	7.70	k.6k
Ba-Vfill	k.kk	4.0k	17.70	7.kk	k.6k

General Cable Information

Cable ID	Number of Cores	Conductor Construction	Voltage [kV]	Conductor Area [mm²]	Cable Overall Diameter [in]	Maximum Steady-State Conductor Temperature [°C]	Maximum Emergency Conductor Temperature [°C]
0kkc0.kkX	Single core	6 Segments	0kk.kk	2030.64	0.99	9k.kk	1k0.kk

Detailed Cable Information

Cable ID	Conductor	Insulation	Sheath / Tape	Concentric Wires	Filler	Armour	Jacket / Armour Serving
0kkc0.kkX	copper	XLPE Unfilled	copper	copper	n/a	n/a	Polyethylene

General Input Data

Cable	Cable ID	Circuit No.	Phase	Fq [Hz]	X [ft]	Y [ft]	DLF [p.u.]	Sheath / Shield Bonding
Cable Index Number	**Cable Equipment ID**	**Circuit No.**	**Cable Phase**	**Operating Frequency**	**X coordinate**	**Y coordinate**	**Daily Load Factor**	**Bonding Type**
1	0kkc0.kkX	1	A	6k.kk	5B.kk	8.90	1.kk	1 condu-tor 1 Point Bonded Flat
2	0kkc0.kkX	1	B	6k.kk	5B.kk	1k.90	1.kk	1 condu-tor 1 Point Bonded Flat
3	0kkc0.kkX	1	c	6k.kk	5B.kk	12.90	1.kk	1 condu-tor 1 Point Bonded Flat
4	0kkc0.kkX	2	A	6k.kk	54.kk	12.90	1.kk	1 condu-tor 1 Point Bonded Flat
0	0kkc0.kkX	2	B	6k.kk	54.kk	8.90	1.kk	1 condu-tor 1 Point Bonded Flat
6	0kkc0.kkX	2	c	6k.kk	54.kk	1k.90	1.kk	1 condu-tor 1 Point Bonded Flat
7	0kkc0.kkX	3	A	6k.kk	k.kk	1k.90	1.kk	1 condu-tor 1 Point Bonded Flat
8	0kkc0.kkX	3	B	6k.kk	k.kk	12.90	1.kk	1 condu-tor 1 Point Bonded Flat
9	0kkc0.kkX	3	c	6k.kk	k.kk	8.90	1.kk	1 condu-tor 1 Point Bonded Flat
1k	0kkc0.kkX	4	A	6k.kk	4.kk	8.90	1.kk	1 condu-tor 1 Point Bonded Flat
11	0kkc0.kkX	4	B	6k.kk	4.kk	1k.90	1.kk	1 condu-tor 1 Point Bonded Flat
12	0kkc0.kkX	4	c	6k.kk	4.kk	12.90	1.kk	1 condu-tor 1 Point Bonded Flat
13	0kkc0.kkX	0	A	6k.kk	8.kk	12.90	1.kk	1 condu-tor 1 Point Bonded Flat
14	0kkc0.kkX	0	B	6k.kk	8.kk	8.90	1.kk	1 condu-tor 1 Point Bonded Flat
10	0kkc0.kkX	0	c	6k.kk	8.kk	1k.90	1.kk	1 condu-tor 1 Point Bonded Flat

Ampacity and Temperatures

Cable	Cable ID	I [A]	θc [°C]	θs [°C]	θa [°C]	θsurf [°C]	θduct [°C]	θair / θcasing [°C]
Cable Index Number	**Cable Equipment ID**	**Steady State Ampacity**	**Conductor temperature**	**Sheath/Shield temperature**	**Armour temperature**	**Cable surface temperature**	**Duct surface temperature**	**Mean air temperature in the tunnel / Casing surface temperature**
1	0kkc0.kkX	923.61	76.93	72.14	n/a	71.32	67.24	n/a
2	0kkc0.kkX	923.61	83.82	78.98	n/a	78.12	74.k2	n/a
3	0kkc0.kkX	923.61	80.63	8k.77	n/a	79.94	70.96	n/a
4	0kkc0.kkX	923.61	88.91	84.k3	n/a	83.19	79.20	n/a
0	0kkc0.kkX	923.61	79.67	74.86	n/a	74.k4	69.99	n/a
6	0kkc0.kkX	923.61	86.78	81.91	n/a	81.k6	76.99	n/a
7	0kkc0.kkX	923.61	87.79	82.92	n/a	82.k6	78.k1	n/a
8	0kkc0.kkX	923.61	9k.k1	80.12	n/a	84.28	8k.30	n/a
9	0kkc0.kkX	923.61	8k.09	70.77	n/a	74.94	7k.91	n/a
1k	0kkc0.kkX	923.61	79.67	74.86	n/a	74.k3	69.99	n/a
11	0kkc0.kkX	923.61	86.78	81.91	n/a	81.k6	76.99	n/a
12	0kkc0.kkX	923.61	88.91	84.k2	n/a	83.19	79.24	n/a
13	0kkc0.kkX	923.61	80.62	8k.77	n/a	79.93	70.90	n/a
14	0kkc0.kkX	923.61	76.92	72.13	n/a	71.31	67.23	n/a
10	0kkc0.kkX	923.61	83.8k	78.96	n/a	78.11	74.k1	n/a

Electrical Resistances

Cable	Cable ID	R₀ [Ω/mile]	ys	yp	R [Ω/mile]	R's [Ω/mile]	R'w [Ω/mile]	R'a [Ω/mile]
Cable Index Number	**Cable Equipment ID**	**DC Resistance of the conductor at 20°C**	**Skin Effect Factor**	**Proximity Effect Factor**	**AC Resistance of Conductor at Operating Temperature**	**DC Resistance of Sheath at Operating Temperature**	**DC Resistance of Concentric Wires at Operating Temperature**	**DC Resistance of Armor at Operating Temperature**
1	0kkc0.kkX	k.k1	k.17	k.kk	k.k2	k.28	k.26	n/a
2	0kkc0.kkX	k.k1	k.17	k.kk	k.k2	k.28	k.27	n/a
3	0kkc0.kkX	k.k1	k.17	k.kk	k.k2	k.28	k.27	n/a
4	0kkc0.kkX	k.k1	k.16	k.kk	k.k2	k.29	k.27	n/a
0	0kkc0.kkX	k.k1	k.17	k.kk	k.k2	k.28	k.26	n/a
6	0kkc0.kkX	k.k1	k.16	k.kk	k.k2	k.29	k.27	n/a
7	0kkc0.kkX	k.k1	k.16	k.kk	k.k2	k.29	k.27	n/a
8	0kkc0.kkX	k.k1	k.16	k.kk	k.k2	k.29	k.27	n/a
9	0kkc0.kkX	k.k1	k.17	k.kk	k.k2	k.28	k.26	n/a
1k	0kkc0.kkX	k.k1	k.17	k.kk	k.k2	k.28	k.26	n/a
11	0kkc0.kkX	k.k1	k.16	k.kk	k.k2	k.29	k.27	n/a
12	0kkc0.kkX	k.k1	k.16	k.kk	k.k2	k.29	k.27	n/a
13	0kkc0.kkX	k.k1	k.17	k.kk	k.k2	k.28	k.27	n/a
14	0kkc0.kkX	k.k1	k.17	k.kk	k.k2	k.28	k.26	n/a
10	0kkc0.kkX	k.k1	k.17	k.kk	k.k2	k.28	k.27	n/a

Thermal Resistances

Cable	Cable ID	T_1 [K.m/W]	T_2 [K.m/W]	T_3 [K.m/W]	T_4' [K.m/W]	T_4'' [K.m/W]	T_4''' [K.m/W]	T_4 [K.m/W]
Cable Index Number	**Cable Equipment ID**	**Thermal resistance of insulation**	**Thermal resistance of bedding**	**Thermal resistance of outer covering**	**Thermal resistance inside the duct**	**Thermal resistance of the duct**	**Thermal resistance of the external medium**	**Total external thermal resistance**
1	0kkc0.kkX	k.4k	k.kk	k.k0	k.19	k.k7	3.1k	3.36
2	0kkc0.kkX	k.4k	k.kk	k.k0	k.19	k.k7	3.43	3.69
3	0kkc0.kkX	k.4k	k.kk	k.k0	k.18	k.k7	3.63	3.89
4	0kkc0.kkX	k.4k	k.kk	k.k0	k.18	k.k7	3.83	4.k8
0	0kkc0.kkX	k.4k	k.kk	k.k0	k.19	k.k7	3.27	3.03
6	0kkc0.kkX	k.4k	k.kk	k.k0	k.18	k.k7	3.6k	3.86
7	0kkc0.kkX	k.4k	k.kk	k.k0	k.18	k.k7	3.66	3.92
8	0kkc0.kkX	k.4k	k.kk	k.k0	k.18	k.k7	3.89	4.10
9	0kkc0.kkX	k.4k	k.kk	k.k0	k.19	k.k7	3.32	3.09
1k	0kkc0.kkX	k.4k	k.kk	k.k0	k.19	k.k7	3.27	3.03
11	0kkc0.kkX	k.4k	k.kk	k.k0	k.18	k.k7	3.6k	3.86
12	0kkc0.kkX	k.4k	k.kk	k.k0	k.18	k.k7	3.83	4.k8
13	0kkc0.kkX	k.4k	k.kk	k.k0	k.18	k.k7	3.63	3.89
14	0kkc0.kkX	k.4k	k.kk	k.k0	k.19	k.k7	3.1k	3.36
10	0kkc0.kkX	k.4k	k.kk	k.k0	k.19	k.k7	3.43	3.69

Losses

Cable	Cable ID	Wc [W/ft]	Wd [W/ft]	Ws [W/ft]	Wa [W/ft]	Wt [W/ft]	λ_1	λ_2
Cable Index Number	**Cable Equipment ID**	**Conductor Losses**	**Dielectric Losses**	**Metallic Screen Losses**	**Armor/Pipe Losses**	**Total Losses**	**Screen Loss Factor**	**Armour Loss Factor + Pipe Loss Factor**
1	0kkc0.kkX	2.09	2.k1	k.k4	k.kk	4.60	k.k2	k.kk
2	0kkc0.kkX	2.64	2.k1	k.10	k.kk	4.81	k.k6	k.kk
3	0kkc0.kkX	2.60	2.k1	k.k4	k.kk	4.7k	k.k1	k.kk
4	0kkc0.kkX	2.67	2.k1	k.k4	k.kk	4.72	k.k1	k.kk
0	0kkc0.kkX	2.61	2.k1	k.k4	k.kk	4.66	k.k2	k.kk
6	0kkc0.kkX	2.66	2.k1	k.10	k.kk	4.82	k.k6	k.kk
7	0kkc0.kkX	2.66	2.k1	k.10	k.kk	4.83	k.k6	k.kk
8	0kkc0.kkX	2.68	2.k1	k.k4	k.kk	4.73	k.k1	k.kk
9	0kkc0.kkX	2.62	2.k1	k.k4	k.kk	4.67	k.k2	k.kk
1k	0kkc0.kkX	2.61	2.k1	k.k4	k.kk	4.66	k.k2	k.kk
11	0kkc0.kkX	2.66	2.k1	k.10	k.kk	4.82	k.k6	k.kk
12	0kkc0.kkX	2.67	2.k1	k.k4	k.kk	4.72	k.k1	k.kk
13	0kkc0.kkX	2.60	2.k1	k.k4	k.kk	4.7k	k.k1	k.kk
14	0kkc0.kkX	2.09	2.k1	k.k4	k.kk	4.60	k.k2	k.kk
10	0kkc0.kkX	2.64	2.k1	k.10	k.kk	4.81	k.k6	k.kk

Complementary Information

Cable	Cable ID	Δθint [°C]	[A]	[μF/mile]	[Ω]	[Ω/mile]	[Ω/mile]	[V/A/mile]
Cable Index Number	**Cable Equipment ID**	**Temperature rise due to surrounding heat sources**	**Induced current on Metallic Screen**	**Cable Capacitance**	**Surge Impedance**	**Reactance of Conductor**	**Reactance of Metallic Sheath**	**Voltage drop for Three Phase System**
1	0kkc0.kkX	39.34	k.kk	k.34	00.20	k.39	k.27	k.k3
2	0kkc0.kkX	40.16	k.kk	k.34	00.20	k.39	k.27	k.k3
3	0kkc0.kkX	46.62	k.kk	k.34	00.20	k.39	k.27	k.k3
4	0kkc0.kkX	0k.89	k.kk	k.34	00.20	k.39	k.27	k.k3
0	0kkc0.kkX	43.k1	k.kk	k.34	00.20	k.39	k.27	k.k3
6	0kkc0.kkX	49.12	k.kk	k.34	00.20	k.39	k.27	k.k3
7	0kkc0.kkX	0k.29	k.kk	k.34	00.20	k.39	k.27	k.k3
8	0kkc0.kkX	02.16	k.kk	k.34	00.20	k.39	k.27	k.k3
9	0kkc0.kkX	44.k7	k.kk	k.34	00.20	k.39	k.27	k.k3
1k	0kkc0.kkX	43.k1	k.kk	k.34	00.20	k.39	k.27	k.k3
11	0kkc0.kkX	49.12	k.kk	k.34	00.20	k.39	k.27	k.k3
12	0kkc0.kkX	0k.89	k.kk	k.34	00.20	k.39	k.27	k.k3
13	0kkc0.kkX	46.62	k.kk	k.34	00.20	k.39	k.27	k.k3
14	0kkc0.kkX	39.34	k.kk	k.34	00.20	k.39	k.27	k.k3
10	0kkc0.kkX	40.16	k.kk	k.34	00.20	k.39	k.27	k.k3

Study Summary

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T2.1-50kkV, _8D OCc_0kkkV-mil cu_1kk OLF
Date:	4/9/2k24 3:43:21 PM

General Simulation Data

Steady State Option	Equally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	k.kk
Conductor Resistances Computation Option:	IEc 5228

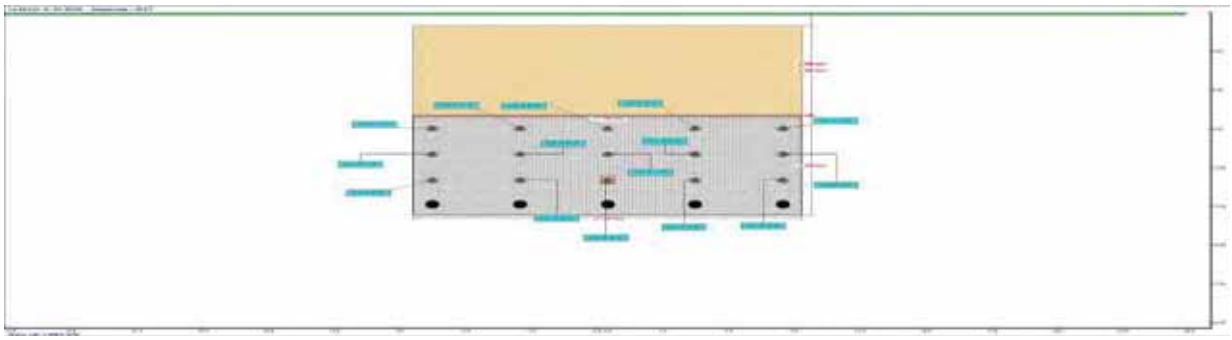
Standard Settings Options

General guidance	custom
Factor on RAC due to magnetic armour	cIGREGuidan-e
Factor on RAC due to magnetic duct	cIGREGuidan-e
Factor on λ_1 due to magnetic armour	cYMcAPGuidan-e
Factor on λ_1 due to magnetic duct	cIGREGuidan-e
Factor on λ_2 due to λ'_1	cYMcAPGuidan-e
λ''_1 computation	cIGREGuidan-e
$\lambda_2$pipe computation	cYMcAPGuidan-e
Wd computation	cIGREGuidan-e
T_2 computation	cIGREGuidan-e
T_4 computation	cYMcAPGuidan-e

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	2k.kk
Native Soil Thermal Resistivity [K.m/W]	1.0k
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
OB 4X0	5l.64E5k7	11.88	17.70	7.70	k.6k
Ba-Vfill	k.kk	4.0k	17.70	7.kk	k.6k



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	0kkc0.kkX	1		A	6k.kk	1.kk	5B.kk	8.90	76.93	923.61
2	0kkc0.kkX	1		B	6k.kk	1.kk	5B.kk	1k.90	83.82	923.61
3	0kkc0.kkX	1		c	6k.kk	1.kk	5B.kk	12.90	80.63	923.61
4	0kkc0.kkX	2		A	6k.kk	1.kk	54.kk	12.90	88.91	923.61
0	0kkc0.kkX	2		B	6k.kk	1.kk	54.kk	8.90	79.67	923.61
6	0kkc0.kkX	2		c	6k.kk	1.kk	54.kk	1k.90	86.78	923.61
7	0kkc0.kkX	3		A	6k.kk	1.kk	k.kk	1k.90	87.79	923.61
8	0kkc0.kkX	3		B	6k.kk	1.kk	k.kk	12.90	9k.k1	923.61
9	0kkc0.kkX	3		c	6k.kk	1.kk	k.kk	8.90	8k.09	923.61
1k	0kkc0.kkX	4		A	6k.kk	1.kk	4.kk	8.90	79.67	923.61
11	0kkc0.kkX	4		B	6k.kk	1.kk	4.kk	1k.90	86.78	923.61
12	0kkc0.kkX	4		c	6k.kk	1.kk	4.kk	12.90	88.91	923.61
13	0kkc0.kkX	0		A	6k.kk	1.kk	8.kk	12.90	80.62	923.61
14	0kkc0.kkX	0		B	6k.kk	1.kk	8.kk	8.90	76.92	923.61
10	0kkc0.kkX	0		c	6k.kk	1.kk	8.kk	1k.90	83.8k	923.61

Cables Report

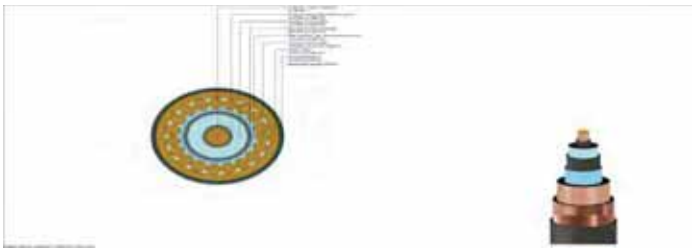
CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T2.1-5DkkV, _8D OCc_0kkkV-mil cu_1kk OLF
Date:	4/9/2k24 3:43:21 PM

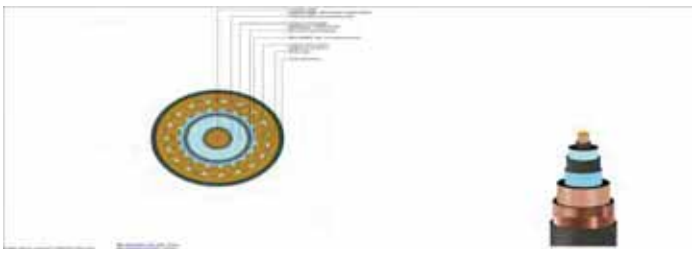
No.	Description	Unit	1
General Cable Information			
1	cable Equipment ID		0kkc0.kkX
2	Number of cores		Single c ore
3	, oltage	[V,]	0kk.kk
4	condu-tor Area	[in²]	3.93
0	cable Cverall Ciameter	[in]	0.99
6	Maximum Steady§State condu-tor Temperature	[°c]	9k.kk
7	Maximum Emergen-y condu-tor Temperature	[°c]	1k0.kk
Conductor			
8	Material		c opper
9	Ele-tri-al Resistivity at 2k°c	[µΩ.-m]	1.72
1k	Temperature coeffi-ient at 2k°c	[1/K]	k.kk
11	Re-ipro-al of Temperature coeffi-ient of Resistan-e (BETA)	[K]	234.40
12	, olumetri- Spe-ifi- Heat (SH)	[J/(K°-m³)]	3.40
13	constru-tion		6 Segments
14	condu-tor Insulation System		Extruded
10	MilliVen Wires constru-tion		Insulated Wires
16	Ks (SVin Effe-t coeffi-ient)		k.30
17	Kp (Proximity Effe-t coeffi-ient)		k.2k
18	Oiameter	[in]	2.49
Conductor Shield			
19	Thi-Vness	[in]	k.k6
2k	Oiameter	[in]	2.61
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.0k
23	Oiele-tri- Loss Fa-tor S(tan delta)		k.kk
24	Relative Permittivity S(epsilon)		2.0k
20	Spe-ifi- Insulation Resistan-e constant at 6k°F S(K)	[MΩ. 1000ft]	1808.k6
26	Thi-Vness	[in]	1.22
27	Oiameter	[in]	0.k0
Insulation Screen			
28	Material		Semi condu-ting S-reen
29	Thi-Vness	[in]	k.k6
3k	Oiameter	[in]	0.17
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUOEO SEMIcCNOUcTI, E ScREEN
32	Thermal Resistivity	[K.m/W]	2.0k
33	Thi-Vness	[in]	k.k4
34	Oiameter	[in]	0.24
Concentric neutral/Skid wires			
30	Are con-entri- Neutral Wires Around Ea-h core?		n/a
36	Material		c opper
37	Ele-tri-al Resistivity at 2k°c	[µΩ.-m]	1.72
38	Temperature coeffi-ient at 2k°c	[1/K]	k.kk
39	Re-ipro-al of Temperature coeffi-ient of Resistan-e (BETA)	[K]	234.0k
4k	, olumetri- Spe-ifi- Heat (SH)	[J/(K°-m³)]	3.40
41	Wire Type		Round Wires
42	Length of Lay	[in]	40.06
43	Number of Wires		36
44	Wire Gauge		Undefined
40	Thi-Vness	[in]	k.k9
46	Oiameter	[in]	0.41
Sheath			
47	Is Sheath Around Ea-h core?		n/a
48	Material		c opper
49	Ele-tri-al Resistivity at 2k°c	[µΩ.-m]	1.72
0k	Temperature coeffi-ient at 2k°c	[1/K]	k.kk
01	Re-ipro-al of Temperature coeffi-ient of Resistan-e (BETA)	[K]	234.0k
02	, olumetri- Spe-ifi- Heat (SH)	[J/(K°-m³)]	3.40
03	corrugation Type		Non corrugated
04	Thi-Vness	[in]	k.k1
00	Oiameter	[in]	0.44
Jacket			
06	Material		Polyethylene
07	Thermal Resistivity	[K.m/W]	3.0k
08	Thi-Vness	[in]	k.28
09	Oiameter	[in]	0.99

No.	Description	Unit	1
Specific Installation Data			
6k	cable Equipment ID		0kkc0.kkX
61	cable Frequen-y	[Hz]	6k.kk
62	Sheath / Shield Bonding		1 condu-tor 1 Point Bonded Flat
63	Loss Fa-tor constant (ALCS)		k.3k
64	conduit -onstru-tion		P, c Ou-t in con-rete
60	conduit material thermal resistivity	[K.m/W]	6.kk
66	conduit filling material		Air
67	Inner diameter of the -onduit	[in]	7.98
68	Cuter diameter of the -onduit	[in]	8.62

Cable ID : 500C5.00X

cable Title: 0kkV, _0kkkV-mil c u 56 Seg_1221 XLPE_cu con-_Taihan





General Summary Report

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T2.16-500kV, 6_ DOC_ 5000kcmil Cu, 100 DLF
Date:	4/9/2024 3:45:04 PM

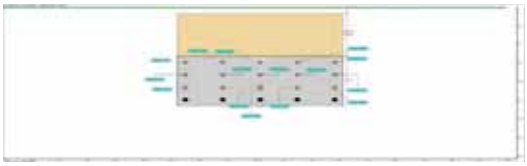
Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Equally Loaded
Ambient temperature [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits) [A]	0.00

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
DB 4X5	-1.64E-07	11.88	17.75	7.75	0.60
Backfill	0.00	4.50	17.75	7.00	0.60



General Cable Information

Cable ID	Number of Cores	Conductor Construction	Voltage [kV]	Conductor Area [mm²]	Cable Overall Diameter [in]	Maximum Steady-State Conductor Temperature [°C]	Maximum Emergency Conductor Temperature [°C]
500CS.00X	Single Core	6 Segments	500.00	2535.64	5.99	90.00	105.00

Detailed Cable Information

Cable ID	Conductor	Insulation	Sheath / Tape	Concentric Wires	Filler	Armour	Jacket / Armour Serving
500CS.00X	Copper	XLPE Unfilled	Copper	Copper	n/a	n/a	Polyethylene

General Input Data

Cable	Cable ID	Circuit No.	Phase	Fq [Hz]	X [ft]	Y [ft]	DLF [p.u.]	Sheath / Shield Bonding
Cable Index Number	Cable Equipment ID	Circuit No.	Cable Phase	Operating Frequency	X coordinate	Y coordinate	Daily Load Factor	Bonding Type
1	500CS.00X	1	A	60.00	-8.00	8.95	1.00	1 Conductor 1 Point Bonded Flat
2	500CS.00X	1	B	60.00	-8.00	10.95	1.00	1 Conductor 1 Point Bonded Flat
3	500CS.00X	1	C	60.00	-8.00	12.95	1.00	1 Conductor 1 Point Bonded Flat
4	500CS.00X	2	A	60.00	-4.00	12.95	1.00	1 Conductor 1 Point Bonded Flat
5	500CS.00X	2	B	60.00	-4.00	8.95	1.00	1 Conductor 1 Point Bonded Flat
6	500CS.00X	2	C	60.00	-4.00	10.95	1.00	1 Conductor 1 Point Bonded Flat
7	500CS.00X	3	A	60.00	0.00	10.95	1.00	1 Conductor 1 Point Bonded Flat
8	500CS.00X	3	B	60.00	0.00	12.95	1.00	1 Conductor 1 Point Bonded Flat
9	500CS.00X	3	C	60.00	0.00	8.95	1.00	1 Conductor 1 Point Bonded Flat
10	500CS.00X	4	A	60.00	4.00	8.95	1.00	1 Conductor 1 Point Bonded Flat
11	500CS.00X	4	B	60.00	4.00	10.95	1.00	1 Conductor 1 Point Bonded Flat
12	500CS.00X	4	C	60.00	4.00	12.95	1.00	1 Conductor 1 Point Bonded Flat
13	500CS.00X	5	A	60.00	8.00	12.95	1.00	1 Conductor 1 Point Bonded Flat
14	500CS.00X	5	B	60.00	8.00	8.95	1.00	1 Conductor 1 Point Bonded Flat
15	500CS.00X	5	C	60.00	8.00	10.95	1.00	1 Conductor 1 Point Bonded Flat

Ampacity and Temperatures

Cable	Cable ID	I [A]	θc [°C]	θs [°C]	θa [°C]	θsurf [°C]	θduct [°C]	θair / θcasing [°C]
Cable Index Number	Cable Equipment ID	Steady State Ampacity	Conductor temperature	Sheath/Shield temperature	Armour temperature	Cable surface temperature	Duct surface temperature	Mean air temperature in the tunnel / Casing surface temperature
1	500CS.00X	1004.55	75.98	70.58	n/a	69.87	65.14	n/a
2	500CS.00X	1004.55	82.81	77.34	n/a	76.40	71.83	n/a
3	500CS.00X	1004.55	84.36	78.88	n/a	77.96	73.53	n/a
4	500CS.00X	1004.55	80.64	83.11	n/a	82.18	77.80	n/a
5	500CS.00X	1004.55	79.61	74.17	n/a	73.26	68.77	n/a
6	500CS.00X	1004.55	86.83	81.32	n/a	80.37	75.86	n/a
7	500CS.00X	1004.55	88.13	82.60	n/a	81.65	77.16	n/a
8	500CS.00X	1004.55	90.01	84.47	n/a	83.54	79.18	n/a
9	500CS.00X	1004.55	80.77	75.32	n/a	74.40	69.94	n/a
10	500CS.00X	1004.55	79.61	74.17	n/a	73.26	68.77	n/a
11	500CS.00X	1004.55	86.83	81.32	n/a	80.37	75.86	n/a
12	500CS.00X	1004.55	88.63	83.10	n/a	82.18	77.80	n/a
13	500CS.00X	1004.55	84.36	78.87	n/a	77.95	73.53	n/a
14	500CS.00X	1004.55	75.97	70.57	n/a	69.66	65.13	n/a
15	500CS.00X	1004.55	82.80	77.33	n/a	76.39	71.82	n/a

Electrical Resistances

Cable	Cable ID	Rₐ [Ω/mile]	ys	yp	R [Ω/mile]	R's [Ω/mile]	R'w [Ω/mile]	R'a [Ω/mile]
Cable Index Number	Cable Equipment ID	DC Resistance of the conductor at 30°C	Skin Effect Factor	Proximity Effect Factor	AC Resistance of Conductor at Operating Temperature	DC Resistance of Sheath at Operating Temperature	DC Resistance of Concentric Wires at Operating Temperature	DC Resistance of Armor at Operating Temperature
1	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.26	n/a
2	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.26	n/a
3	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.27	n/a
4	500CS.00X	0.01	0.16	0.00	0.02	0.29	0.27	n/a
5	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.26	n/a
6	500CS.00X	0.01	0.16	0.00	0.02	0.28	0.27	n/a
7	500CS.00X	0.01	0.16	0.00	0.02	0.29	0.27	n/a
8	500CS.00X	0.01	0.16	0.00	0.02	0.29	0.27	n/a
9	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.26	n/a
10	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.26	n/a
11	500CS.00X	0.01	0.16	0.00	0.02	0.28	0.27	n/a
12	500CS.00X	0.01	0.16	0.00	0.02	0.29	0.27	n/a
13	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.27	n/a
14	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.26	n/a
15	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.26	n/a

Thermal Resistances

Cable	Cable ID	T₁ [K.m/W]	T₂ [K.m/W]	T₃ [K.m/W]	T₄' [K.m/W]	T₄'' [K.m/W]	T₄''' [K.m/W]	T₄ [K.m/W]
Cable Index Number	Cable Equipment ID	Thermal resistance of insulation	Thermal resistance of bedding	Thermal resistance of outer covering	Thermal resistance inside the duct	Thermal resistance of the duct	Thermal resistance of the external medium	Total external thermal resistance
1	500CS.00X	0.40	0.00	0.05	0.20	0.07	2.68	2.95
2	500CS.00X	0.40	0.00	0.05	0.19	0.07	2.97	3.24
3	500CS.00X	0.40	0.00	0.05	0.19	0.07	3.15	3.41
4	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.38	3.64
5	500CS.00X	0.40	0.00	0.05	0.19	0.07	2.89	3.15
6	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.19	3.45
7	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.26	3.51
8	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.45	3.71
9	500CS.00X	0.40	0.00	0.05	0.19	0.07	2.95	3.21
10	500CS.00X	0.40	0.00	0.05	0.19	0.07	2.89	3.15
11	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.19	3.45
12	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.38	3.64
13	500CS.00X	0.40	0.00	0.05	0.19	0.07	3.15	3.41
14	500CS.00X	0.40	0.00	0.05	0.20	0.07	2.68	2.95
15	500CS.00X	0.40	0.00	0.05	0.19	0.07	2.97	3.24

Losses

Cable	Cable ID	Wc [W/ft]	Wd [W/ft]	Ws [W/ft]	Wa [W/ft]	Wt [W/ft]	λ₁	λ₂
Cable Index Number	Cable Equipment ID	Conductor Losses	Dielectric Losses	Metallic Screen Losses	Armor/Pipe Losses	Total Losses	Screen Loss Factor	Armour Loss Factor + Pipe Loss Factor
1	500CS.00X	3.06	2.01	0.05	0.00	5.12	0.02	0.00
2	500CS.00X	3.11	2.01	0.18	0.00	5.31	0.06	0.00
3	500CS.00X	3.12	2.01	0.04	0.00	5.18	0.01	0.00
4	500CS.00X	3.16	2.01	0.04	0.00	5.21	0.01	0.00
5	500CS.00X	3.09	2.01	0.05	0.00	5.15	0.02	0.00
6	500CS.00X	3.14	2.01	0.18	0.00	5.34	0.06	0.00
7	500CS.00X	3.15	2.01	0.18	0.00	5.35	0.06	0.00
8	500CS.00X	3.17	2.01	0.04	0.00	5.22	0.01	0.00
9	500CS.00X	3.10	2.01	0.05	0.00	5.16	0.02	0.00
10	500CS.00X	3.09	2.01	0.05	0.00	5.15	0.02	0.00
11	500CS.00X	3.14	2.01	0.18	0.00	5.34	0.06	0.00
12	500CS.00X	3.16	2.01	0.04	0.00	5.21	0.01	0.00
13	500CS.00X	3.12	2.01	0.04	0.00	5.18	0.01	0.00
14	500CS.00X	3.06	2.01	0.05	0.00	5.12	0.02	0.00
15	500CS.00X	3.11	2.01	0.18	0.00	5.31	0.06	0.00

Complementary Information

Cable	Cable ID	ΔθInt [°C]	[A]	[μF/mile]	[Ω]	[Ω/mile]	[Ω/mile]	[V/A/mile]
Cable Index Number	Cable Equipment ID	Temperature rise due to surrounding heat sources	Induced current on Metallic Screen	Cable Capacitance	Surge Impedance	Reactance of Conductor	Reactance of Metallic Sheath	Voltage drop for Three Phase System
1	500CS.00X	37.14	0.00	0.34	55.25	0.39	0.27	0.03
2	500CS.00X	42.88	0.00	0.34	55.25	0.39	0.27	0.03
3	500CS.00X	44.20	0.00	0.34	55.25	0.39	0.27	0.03
4	500CS.00X	49.20	0.00	0.34	55.25	0.39	0.27	0.03
5	500CS.00X	41.49	0.00	0.34	55.25	0.39	0.27	0.03
6	500CS.00X	47.67	0.00	0.34	55.25	0.39	0.27	0.03
7	500CS.00X	49.08	0.00	0.34	55.25	0.39	0.27	0.03
8	500CS.00X	50.70	0.00	0.34	55.25	0.39	0.27	0.03
9	500CS.00X	42.76	0.00	0.34	55.25	0.39	0.27	0.03
10	500CS.00X	41.49	0.00	0.34	55.25	0.39	0.27	0.03
11	500CS.00X	47.67	0.00	0.34	55.25	0.39	0.27	0.03
12	500CS.00X	49.20	0.00	0.34	55.25	0.39	0.27	0.03
13	500CS.00X	44.20	0.00	0.34	55.25	0.39	0.27	0.03
14	500CS.00X	37.14	0.00	0.34	55.25	0.39	0.27	0.03
15	500CS.00X	42.88	0.00	0.34	55.25	0.39	0.27	0.03

Study Summary

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T2.1d-500kV, 8_ DOC, 5000kcmil Cu, 100 DLF
Date:	4/9/2024 3:45:04 PM

General Simulation Data

Steady State Option	Equally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.00
Conductor Resistances Computation Option:	IEC-228

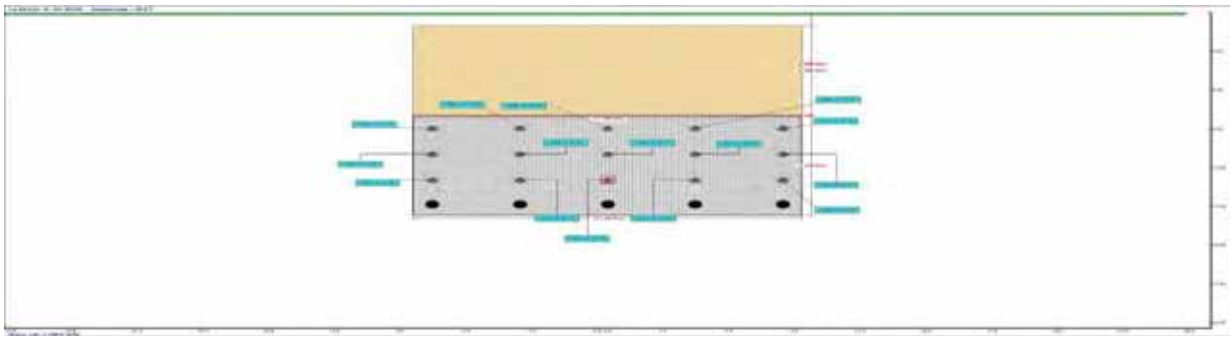
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
DB 4X5	-1.64E-07	11.88	17.75	7.75	0.60
Backfill	0.00	4.50	17.75	7.00	0.60



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	500C5.00X	1		A	60.00	1.00	-8.00	8.95	75.98	1004.55
2	500C5.00X	1		B	60.00	1.00	-8.00	10.95	82.81	1004.55
3	500C5.00X	1		C	60.00	1.00	-8.00	12.95	84.36	1004.55
4	500C5.00X	2		A	60.00	1.00	-4.00	12.95	88.64	1004.55
5	500C5.00X	2		B	60.00	1.00	-4.00	8.95	79.61	1004.55
6	500C5.00X	2		C	60.00	1.00	-4.00	10.95	86.83	1004.55
7	500C5.00X	3		A	60.00	1.00	0.00	10.95	88.13	1004.55
8	500C5.00X	3		B	60.00	1.00	0.00	12.95	90.01	1004.55
9	500C5.00X	3		C	60.00	1.00	0.00	8.95	80.77	1004.55
10	500C5.00X	4		A	60.00	1.00	4.00	8.95	79.61	1004.55
11	500C5.00X	4		B	60.00	1.00	4.00	10.95	86.83	1004.55
12	500C5.00X	4		C	60.00	1.00	4.00	12.95	88.63	1004.55
13	500C5.00X	5		A	60.00	1.00	8.00	12.95	84.36	1004.55
14	500C5.00X	5		B	60.00	1.00	8.00	8.95	75.97	1004.55
15	500C5.00X	5		C	60.00	1.00	8.00	10.95	82.80	1004.55

Cables Report

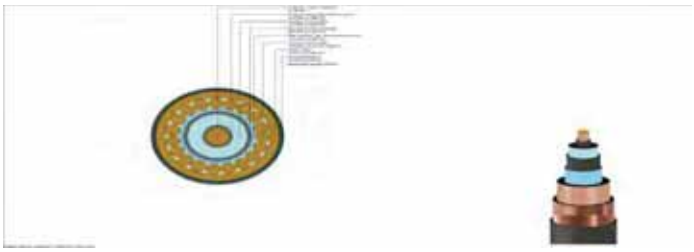
CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T2.1d-500kV, 8_ DOC, 5000kcmil Cu, 100 DLF
Date:	4/9/2024 3:45:04 PM

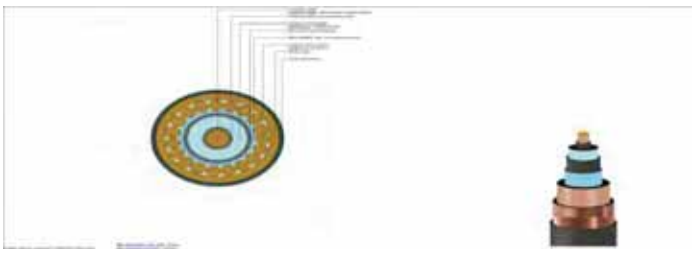
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500.00
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90.00
7	Maximum Emergency Conductor Temperature	[°C]	105.00
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[μΩ.cm]	1.72
10	Temperature Coefficient at 20°C	[1/K]	0.00
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.45
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.20
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.06
20	Diameter	[in]	2.61
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.50
23	Dielectric Loss Factor - (tan delta)		0.00
24	Relative Permittivity - (epsilon)		2.50
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858.06
26	Thickness	[in]	1.22
27	Diameter	[in]	5.05
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.06
30	Diameter	[in]	5.17
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.50
33	Thickness	[in]	0.04
34	Diameter	[in]	5.24
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[μΩ.cm]	1.72
38	Temperature Coefficient at 20°C	[1/K]	0.00
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.50
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.56
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.09
46	Diameter	[in]	5.41
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[μΩ.cm]	1.72
50	Temperature Coefficient at 20°C	[1/K]	0.00
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.50
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.01
55	Diameter	[in]	5.44
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.50
58	Thickness	[in]	0.28
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60.00
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Flat
63	Loss Factor Constant (ALOS)		0.30
64	Conduit construction		PVC Duct in Concrete
65	Conduit material thermal resistivity	[K.m/W]	6.00
66	Conduit filling material		Air
67	Inner diameter of the conduit	[in]	7.98
68	Outer diameter of the conduit	[in]	8.62

Cable ID : 500C5.00X

Cable Title: 500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





General Summary Report

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T2.1a-500kV, 8_ DOC, 5000kcmil Cu, 85 DLF
Date:	4/9/2024 1:48:40 PM

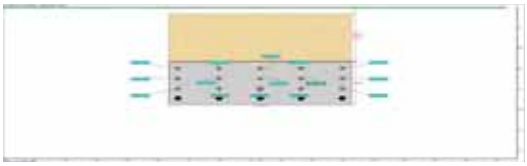
Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Equally Loaded
Ambient temperature [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.50
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits) [A]	0.00

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.50
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
DB 4X5	-1.64E-07	11.13	17.75	6.25	0.60
Backfill	0.00	4.50	17.75	7.00	0.60



General Cable Information

Cable ID	Number of Cores	Conductor Construction	Voltage [kV]	Conductor Area [mm²]	Cable Overall Diameter [in]	Maximum Steady-State Conductor Temperature [°C]	Maximum Emergency Conductor Temperature [°C]
500CS.00X	Single Core	6 Segments	500.00	2535.64	5.99	90.00	105.00

Detailed Cable Information

Cable ID	Conductor	Insulation	Sheath / Tape	Concentric Wires	Filler	Armour	Jacket / Armour Serving
500CS.00X	Copper	XLPE Unfilled	Copper	Copper	n/a	n/a	Polyethylene

General Input Data

Cable	Cable ID	Circuit No.	Phase	Fq [Hz]	X [ft]	Y [ft]	DLF [p.u.]	Sheath / Shield Bonding
Cable Index Number	Cable Equipment ID	Circuit No.	Cable Phase	Operating Frequency	X coordinate	Y coordinate	Daily Load Factor	Bonding Type
1	500CS.00X	1	A	60.00	-8.00	8.95	0.85	1 Conductor 1 Point Bonded Flat
2	500CS.00X	1	B	60.00	-8.00	10.45	0.85	1 Conductor 1 Point Bonded Flat
3	500CS.00X	1	C	60.00	-8.00	11.95	0.85	1 Conductor 1 Point Bonded Flat
4	500CS.00X	2	A	60.00	-4.00	11.95	0.85	1 Conductor 1 Point Bonded Flat
5	500CS.00X	2	B	60.00	-4.00	8.95	0.85	1 Conductor 1 Point Bonded Flat
6	500CS.00X	2	C	60.00	-4.00	10.45	0.85	1 Conductor 1 Point Bonded Flat
7	500CS.00X	3	A	60.00	0.00	10.45	0.85	1 Conductor 1 Point Bonded Flat
8	500CS.00X	3	B	60.00	0.00	11.95	0.85	1 Conductor 1 Point Bonded Flat
9	500CS.00X	3	C	60.00	0.00	8.95	0.85	1 Conductor 1 Point Bonded Flat
10	500CS.00X	4	A	60.00	4.00	8.95	0.85	1 Conductor 1 Point Bonded Flat
11	500CS.00X	4	B	60.00	4.00	10.45	0.85	1 Conductor 1 Point Bonded Flat
12	500CS.00X	4	C	60.00	4.00	11.95	0.85	1 Conductor 1 Point Bonded Flat
13	500CS.00X	5	A	60.00	8.00	11.95	0.85	1 Conductor 1 Point Bonded Flat
14	500CS.00X	5	B	60.00	8.00	8.95	0.85	1 Conductor 1 Point Bonded Flat
15	500CS.00X	5	C	60.00	8.00	10.45	0.85	1 Conductor 1 Point Bonded Flat

Ampacity and Temperatures

Cable	Cable ID	I [A]	θc [°C]	θs [°C]	θa [°C]	θsurf [°C]	θduct [°C]	θair / θcasing [°C]
Cable Index Number	Cable Equipment ID	Steady State Ampacity	Conductor temperature	Sheath/Shield temperature	Armour temperature	Cable surface temperature	Duct surface temperature	Mean air temperature in the tunnel / Casing surface temperature
1	500CS.00X	1025.78	78.57	72.96	n/a	72.01	67.36	n/a
2	500CS.00X	1025.78	84.43	78.76	n/a	77.76	72.96	n/a
3	500CS.00X	1025.78	85.59	79.91	n/a	78.96	74.39	n/a
4	500CS.00X	1025.78	88.90	83.18	n/a	82.23	77.70	n/a
5	500CS.00X	1025.78	81.39	75.75	n/a	74.80	70.18	n/a
6	500CS.00X	1025.78	87.39	81.69	n/a	80.69	75.93	n/a
7	500CS.00X	1025.78	88.42	82.71	n/a	81.71	76.96	n/a
8	500CS.00X	1025.78	90.01	84.28	n/a	83.32	78.81	n/a
9	500CS.00X	1025.78	82.34	76.69	n/a	75.74	71.13	n/a
10	500CS.00X	1025.78	81.39	75.75	n/a	74.80	70.18	n/a
11	500CS.00X	1025.78	87.39	81.69	n/a	80.69	75.92	n/a
12	500CS.00X	1025.78	88.89	83.18	n/a	82.22	77.69	n/a
13	500CS.00X	1025.78	85.59	79.90	n/a	78.95	74.39	n/a
14	500CS.00X	1025.78	78.56	72.95	n/a	72.01	67.35	n/a
15	500CS.00X	1025.78	84.42	78.74	n/a	77.75	72.95	n/a

Electrical Resistances

Cable	Cable ID	R₀ [Ω/mile]	ys	yp	R [Ω/mile]	R's [Ω/mile]	R'w [Ω/mile]	R'a [Ω/mile]
Cable Index Number	Cable Equipment ID	DC Resistance of the conductor at 20°C	Skin Effect Factor	Proximity Effect Factor	AC Resistance of Conductor at Operating Temperature	DC Resistance of Sheath at Operating Temperature	DC Resistance of Concentric Wires at Operating Temperature	DC Resistance of Armor at Operating Temperature
1	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.26	n/a
2	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.27	n/a
3	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.27	n/a
4	500CS.00X	0.01	0.16	0.00	0.02	0.29	0.27	n/a
5	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.26	n/a
6	500CS.00X	0.01	0.16	0.00	0.02	0.29	0.27	n/a
7	500CS.00X	0.01	0.16	0.00	0.02	0.29	0.27	n/a
8	500CS.00X	0.01	0.16	0.00	0.02	0.29	0.27	n/a
9	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.26	n/a
10	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.26	n/a
11	500CS.00X	0.01	0.16	0.00	0.02	0.29	0.27	n/a
12	500CS.00X	0.01	0.16	0.00	0.02	0.29	0.27	n/a
13	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.27	n/a
14	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.26	n/a
15	500CS.00X	0.01	0.17	0.00	0.02	0.28	0.27	n/a

Thermal Resistances

Cable	Cable ID	T₁ [K.m/W]	T₂ [K.m/W]	T₃ [K.m/W]	T₄' [K.m/W]	T₄'' [K.m/W]	T₄''' [K.m/W]	T₄ [K.m/W]
Cable Index Number	Cable Equipment ID	Thermal resistance of insulation	Thermal resistance of bedding	Thermal resistance of outer covering	Thermal resistance inside the duct	Thermal resistance of the duct	Thermal resistance of the external medium	Total external thermal resistance
1	500CS.00X	0.40	0.00	0.05	0.19	0.07	2.71	2.98
2	500CS.00X	0.40	0.00	0.05	0.19	0.07	2.87	3.13
3	500CS.00X	0.40	0.00	0.05	0.19	0.07	3.09	3.35
4	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.26	3.52
5	500CS.00X	0.40	0.00	0.05	0.19	0.07	2.86	3.13
6	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.02	3.28
7	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.08	3.33
8	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.32	3.57
9	500CS.00X	0.40	0.00	0.05	0.19	0.07	2.91	3.18
10	500CS.00X	0.40	0.00	0.05	0.19	0.07	2.86	3.13
11	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.02	3.28
12	500CS.00X	0.40	0.00	0.05	0.18	0.07	3.26	3.52
13	500CS.00X	0.40	0.00	0.05	0.19	0.07	3.09	3.35
14	500CS.00X	0.40	0.00	0.05	0.19	0.07	2.71	2.98
15	500CS.00X	0.40	0.00	0.05	0.19	0.07	2.87	3.13

Losses

Cable	Cable ID	Wc [W/ft]	Wd [W/ft]	Ws [W/ft]	Wa [W/ft]	Wt [W/ft]	λ₁	λ₂
Cable Index Number	Cable Equipment ID	Conductor Losses	Dielectric Losses	Metallic Screen Losses	Armor/Pipe Losses	Total Losses	Screen Loss Factor	Armour Loss Factor + Pipe Loss Factor
1	500CS.00X	3.22	2.01	0.09	0.00	5.32	0.03	0.00
2	500CS.00X	3.26	2.01	0.34	0.00	5.62	0.10	0.00
3	500CS.00X	3.27	2.01	0.08	0.00	5.37	0.02	0.00
4	500CS.00X	3.30	2.01	0.08	0.00	5.39	0.02	0.00
5	500CS.00X	3.24	2.01	0.09	0.00	5.34	0.03	0.00
6	500CS.00X	3.29	2.01	0.34	0.00	5.64	0.10	0.00
7	500CS.00X	3.29	2.01	0.33	0.00	5.64	0.10	0.00
8	500CS.00X	3.31	2.01	0.08	0.00	5.40	0.02	0.00
9	500CS.00X	3.25	2.01	0.09	0.00	5.35	0.03	0.00
10	500CS.00X	3.24	2.01	0.09	0.00	5.34	0.03	0.00
11	500CS.00X	3.29	2.01	0.34	0.00	5.63	0.10	0.00
12	500CS.00X	3.30	2.01	0.08	0.00	5.39	0.02	0.00
13	500CS.00X	3.27	2.01	0.08	0.00	5.37	0.02	0.00
14	500CS.00X	3.22	2.01	0.09	0.00	5.32	0.03	0.00
15	500CS.00X	3.26	2.01	0.34	0.00	5.62	0.10	0.00

Complementary Information

Cable	Cable ID	ΔθInt [°C]	[A]	[μF/mile]	[Ω]	[Ω/mile]	[Ω/mile]	[V/A/mile]
Cable Index Number	Cable Equipment ID	Temperature rise due to surrounding heat sources	Induced current on Metallic Screen	Cable Capacitance	Surge Impedance	Reactance of Conductor	Reactance of Metallic Sheath	Voltage Drop for Three Phase System
1	500CS.00X	39.55	0.00	0.34	52.71	0.35	0.23	0.03
2	500CS.00X	44.16	0.00	0.34	52.71	0.35	0.23	0.03
3	500CS.00X	45.41	0.00	0.34	52.71	0.35	0.23	0.03
4	500CS.00X	48.69	0.00	0.34	52.71	0.35	0.23	0.03
5	500CS.00X	43.28	0.00	0.34	52.71	0.35	0.23	0.03
6	500CS.00X	48.13	0.00	0.34	52.71	0.35	0.23	0.03
7	500CS.00X	49.33	0.00	0.34	52.71	0.35	0.23	0.03
8	500CS.00X	50.97	0.00	0.34	52.71	0.35	0.23	0.03
9	500CS.00X	44.38	0.00	0.34	52.71	0.35	0.23	0.03
10	500CS.00X	43.28	0.00	0.34	52.71	0.35	0.23	0.03
11	500CS.00X	48.13	0.00	0.34	52.71	0.35	0.23	0.03
12	500CS.00X	49.69	0.00	0.34	52.71	0.35	0.23	0.03
13	500CS.00X	45.40	0.00	0.34	52.71	0.35	0.23	0.03
14	500CS.00X	39.54	0.00	0.34	52.71	0.35	0.23	0.03
15	500CS.00X	44.16	0.00	0.34	52.71	0.35	0.23	0.03

Study Summary

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T2.1e-500kV, 8_ DOC, 5000kcmil Cu, 85 DLF
Date:	4/9/2024 3:48:45 PM

General Simulation Data

Steady State Option	Equally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.00
Conductor Resistances Computation Option:	IEC-228

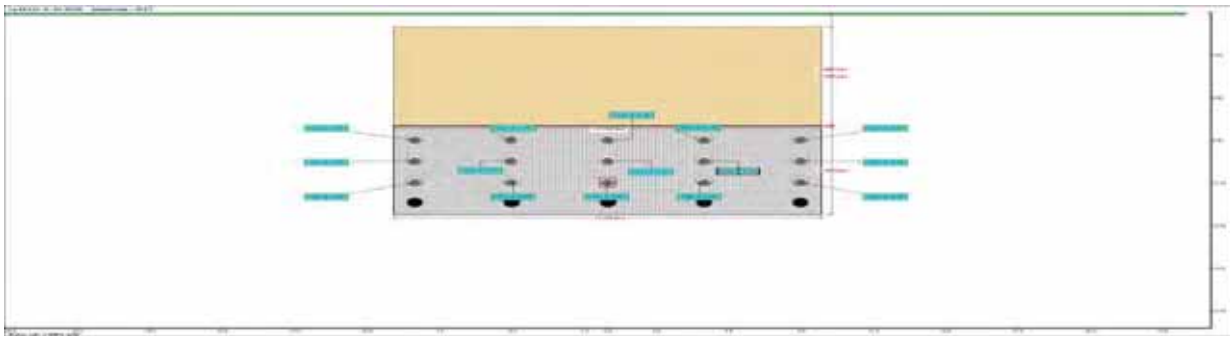
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.50
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
DB 4X5	-1.64E-07	11.13	17.75	6.25	0.60
Backfill	0.00	4.50	17.75	7.00	0.60



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	500C5.00X	1		A	60.00	0.85	-8.00	8.95	78.57	1025.78
2	500C5.00X	1		B	60.00	0.85	-8.00	10.45	84.43	1025.78
3	500C5.00X	1		C	60.00	0.85	-8.00	11.95	85.59	1025.78
4	500C5.00X	2		A	60.00	0.85	-4.00	11.95	88.90	1025.78
5	500C5.00X	2		B	60.00	0.85	-4.00	8.95	81.39	1025.78
6	500C5.00X	2		C	60.00	0.85	-4.00	10.45	87.39	1025.78
7	500C5.00X	3		A	60.00	0.85	0.00	10.45	88.42	1025.78
8	500C5.00X	3		B	60.00	0.85	0.00	11.95	90.01	1025.78
9	500C5.00X	3		C	60.00	0.85	0.00	8.95	82.34	1025.78
10	500C5.00X	4		A	60.00	0.85	4.00	8.95	81.39	1025.78
11	500C5.00X	4		B	60.00	0.85	4.00	10.45	87.39	1025.78
12	500C5.00X	4		C	60.00	0.85	4.00	11.95	88.89	1025.78
13	500C5.00X	5		A	60.00	0.85	8.00	11.95	85.59	1025.78
14	500C5.00X	5		B	60.00	0.85	8.00	8.95	78.56	1025.78
15	500C5.00X	5		C	60.00	0.85	8.00	10.45	84.42	1025.78

Cables Report

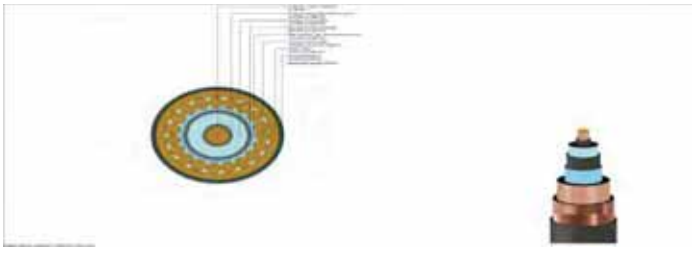
CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T2.1e-500kV, 8_ DOC, 5000kcmil Cu, 85 DLF
Date:	4/9/2024 3:48:45 PM

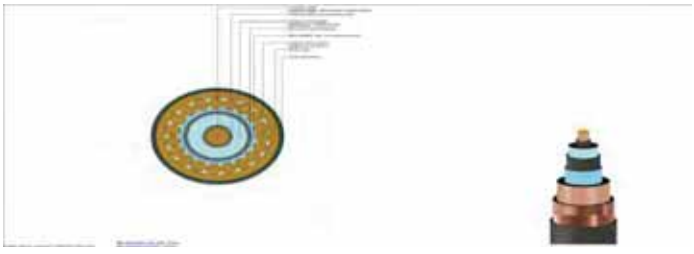
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500.00
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90.00
7	Maximum Emergency Conductor Temperature	[°C]	105.00
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[μΩ.cm]	1.72
10	Temperature Coefficient at 20°C	[1/K]	0.00
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.45
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.20
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.06
20	Diameter	[in]	2.61
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.50
23	Dielectric Loss Factor - (tan delta)		0.00
24	Relative Permittivity - (epsilon)		2.50
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858.06
26	Thickness	[in]	1.22
27	Diameter	[in]	5.05
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.06
30	Diameter	[in]	5.17
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.50
33	Thickness	[in]	0.04
34	Diameter	[in]	5.24
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[μΩ.cm]	1.72
38	Temperature Coefficient at 20°C	[1/K]	0.00
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.50
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.56
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.09
46	Diameter	[in]	5.41
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[μΩ.cm]	1.72
50	Temperature Coefficient at 20°C	[1/K]	0.00
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.50
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.01
55	Diameter	[in]	5.44
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.50
58	Thickness	[in]	0.28
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60.00
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Flat
63	Loss Factor Constant (ALOS)		0.30
64	Conduit construction		PVC Duct in Concrete
65	Conduit material thermal resistivity	[K.m/W]	6.00
66	Conduit filling material		Air
67	Inner diameter of the conduit	[in]	7.98
68	Outer diameter of the conduit	[in]	8.62

Cable ID : 500C5.00X

Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





General Summary Report

CYMCAP Version	8.2 Revision 2
Study:	Goldon to Mars
Execution:	T1-500kV, 8_ DOC_ 5000kcmil Cu, 100 DLF
Date:	5Q/4ΩΩ9 10ΣΘ3Ð: PM

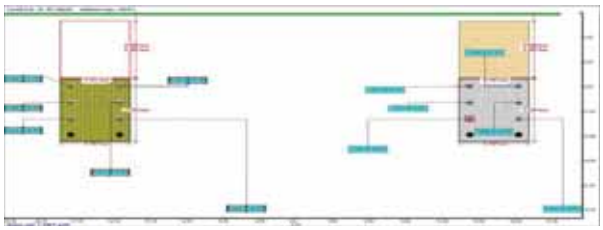
Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Enequally Loaded
Ambient temperature [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits) [A]	0.00

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
Tack∎∎9	1:.5/	9.9X	5.65	:.XX	0.:0
DT 972	1:.5/	11.86	5.65	6.6:	0.:0
Tack∎∎2	-1:.2/	9.9X	5.65	:.XX	0.:0
DT 972	-1:.2/	11.86	5.65	6.6:	0.:0



General Cable Information

Cable ID	Number of Cores	Conductor Construction	Voltage [kV]	Conductor Area [mm²]	Cable Overall Diameter [in]	Maximum Steady-State Conductor Temperature [°C]	Maximum Emergency Conductor Temperature [°C]
500CS.007	f inSle Core	: fESments	500.00	2S/5.: 9	5.XX	X0.00	105.00

Detailed Cable Information

Cable ID	Conductor	Insulation	Sheath / Tape	Concentric Wires	Filler	Armour	Jacket / Armour Serving
500CS.007	Copper	7LgU EnBled	Copper	Copper	n∎	n∎	golyethylene

General Input Data

Cable	Cable ID	Circuit No.	Phase	Fq [Hz]	X [ft]	Y [ft]	DLF [p.u.]	Sheath / Shield Bonding
Cable Index Number	Cable Equipment ID	Circuit No.	Cable Phase	Operating Frequency	X coordinate	Y coordinate	Daily Load Factor	Bonding Type
1	500CS.007	1	P	:0.00	19.5/	8.XS	1.00	Multicables 1 goint Tonded
2	500CS.007	1	T	:0.00	18.5/	10.XS	1.00	Multicables 1 goint Tonded
/	500CS.007	1	C	:0.00	19.5/	12.XS	1.00	Multicables 1 goint Tonded
9	500CS.007	1	P	:0.00	18.5/	8.XS	1.00	Multicables 1 goint Tonded
5	500CS.007	1	T	:0.00	19.5/	10.XS	1.00	Multicables 1 goint Tonded
:	500CS.007	1	C	:0.00	18.5/	12.XS	1.00	Multicables 1 goint Tonded
6	500CS.007	2	P	:0.00	-18.2/	8.XS	1.00	Multicables 1 goint Tonded
8	500CS.007	2	T	:0.00	-19.2/	10.XS	1.00	Multicables 1 goint Tonded
X	500CS.007	2	C	:0.00	-18.2/	12.XS	1.00	Multicables 1 goint Tonded
10	500CS.007	2	P	:0.00	-19.2/	8.XS	1.00	Multicables 1 goint Tonded
11	500CS.007	2	T	:0.00	-18.2/	10.XS	1.00	Multicables 1 goint Tonded
12	500CS.007	2	C	:0.00	-19.2/	12.XS	1.00	Multicables 1 goint Tonded

Ampacity and Temperatures

Cable	Cable ID	I [A]	θc [°C]	θs [°C]	θa [°C]	θsurf [°C]	θduct [°C]	θair / θcasing [°C]
Cable Index Number	Cable Equipment ID	Steady State Ampacity	Conductor temperature	Sheath/Shield temperature	Armour temperature	Cable surface temperature	Duct surface temperature	Mean air temperature in the tunnel / Casing surface temperature
1	500CS.007	1291.16	81.:8	69.0:	n∎	62.89	:.:89	n∎
2	500CS.007	125X.18	8X/.5	81.92	n∎	80.11	6/.82	n∎
/	500CS.007	12/8.:2	X0.02	82.2X	n∎	81.0:	65.20	n∎
9	500CS.007	1258.8:	81.61	6/.X0	n∎	62.::	:.:59	n∎
5	500CS.007	1290.85	8X:/	81.SX	n∎	80./0	69.15	n∎
:	500CS.007	12:.1.91	X0.01	82.05	n∎	80.68	69.66	n∎
6	500CS.007	1258.89	81.61	6/.X1	n∎	62.:6	:.:59	n∎
8	500CS.007	1290.82	8X:/	81.:0	n∎	80./1	69.1:	n∎
X	500CS.007	12:.1/6	X0.01	82.05	n∎	80.6X	69.66	n∎
10	500CS.007	1291.15	81.:6	69.05	n∎	62.8/	:.:89	n∎
11	500CS.007	125X.1:	8X./9	81.92	n∎	80.10	6/.81	n∎
12	500CS.007	12/8.:1	X0.01	82.28	n∎	81.05	65.20	n∎

Electrical Resistances

Cable	Cable ID	R₀ [Ω/mile]	ys	yp	R [Ω/mile]	R's [Ω/mile]	R'w [Ω/mile]	R'a [Ω/mile]
Cable Index Number	Cable Equipment ID	DC Resistance of the conductor at 20°C	Skin Effect Factor	Proximity Effect Factor	AC Resistance of Conductor at Operating Temperature	DC Resistance of Sheath at Operating Temperature	DC Resistance of Concentric Wires at Operating Temperature	DC Resistance of Armor at Operating Temperature
1	500CS.007	0.01	0.1:	0.00	0.02	0.28	0.2:	n∎
2	500CS.007	0.01	0.1:	0.00	0.02	0.28	0.26	n∎
/	500CS.007	0.01	0.1:	0.00	0.02	0.2X	0.26	n∎
9	500CS.007	0.01	0.16	0.00	0.02	0.28	0.2:	n∎
5	500CS.007	0.01	0.1:	0.00	0.02	0.28	0.26	n∎
:	500CS.007	0.01	0.1:	0.00	0.02	0.2X	0.26	n∎
6	500CS.007	0.01	0.16	0.00	0.02	0.28	0.2:	n∎
8	500CS.007	0.01	0.1:	0.00	0.02	0.28	0.26	n∎
X	500CS.007	0.01	0.1:	0.00	0.02	0.2X	0.26	n∎
10	500CS.007	0.01	0.16	0.00	0.02	0.28	0.2:	n∎
11	500CS.007	0.01	0.1:	0.00	0.02	0.28	0.26	n∎
12	500CS.007	0.01	0.1:	0.00	0.02	0.2X	0.26	n∎

Thermal Resistances

Cable	Cable ID	T₁ [K.m/W]	T₂ [K.m/W]	T₃ [K.m/W]	Tₐ' [K.m/W]	Tₐ'' [K.m/W]	Tₐ''' [K.m/W]	Tₑ [K.m/W]
Cable Index Number	Cable Equipment ID	Thermal resistance of insulation	Thermal resistance of bedding	Thermal resistance of outer covering	Thermal resistance inside the duct	Thermal resistance of the duct	Thermal resistance of the external medium	Total external thermal resistance
1	500CS.007	0.90	0.00	0.05	0.1X	0.06	2.08	2./5
2	500CS.007	0.90	0.00	0.05	0.18	0.06	2.21	2.96
/	500CS.007	0.90	0.00	0.05	0.18	0.06	2.9/	2.:8
9	500CS.007	0.90	0.00	0.05	0.1X	0.06	2.0/	2.2X
5	500CS.007	0.90	0.00	0.05	0.18	0.06	2.28	2.5/
:	500CS.007	0.90	0.00	0.05	0.18	0.06	2./5	2.:0
6	500CS.007	0.90	0.00	0.05	0.1X	0.06	2.0/	2.2X
8	500CS.007	0.90	0.00	0.05	0.18	0.06	2.28	2.5/
X	500CS.007	0.90	0.00	0.05	0.18	0.06	2./5	2.:0
10	500CS.007	0.90	0.00	0.05	0.1X	0.06	2.08	2./5
11	500CS.007	0.90	0.00	0.05	0.18	0.06	2.21	2.96
12	500CS.007	0.90	0.00	0.05	0.18	0.06	2.9/	2.:8

Losses

Cable	Cable ID	Wc [W/ft]	Wd [W/ft]	Ws [W/ft]	Wa [W/ft]	Wt [W/ft]	λ₁	λ₂
Cable Index Number	Cable Equipment ID	Conductor Losses	Dielectric Losses	Metallic Screen Losses	Armor/Pipe Losses	Total Losses	Screen Loss Factor	Armour Loss Factor + Pipe Loss Factor
1	500CS.007	9.6/	2.01	0.12	0.00	:.8:	0.02	0.00
2	500CS.007	9.X:	2.01	0.9/	0.00	6.91	0.0X	0.00
/	500CS.007	9.81	2.01	0.11	0.00	:.X/	0.02	0.00
9	500CS.007	9.86	2.01	0.12	0.00	6.00	0.02	0.00
5	500CS.007	9.82	2.01	0.92	0.00	6.25	0.0X	0.00
:	500CS.007	9.X8	2.01	0.12	0.00	6.11	0.02	0.00
6	500CS.007	9.86	2.01	0.12	0.00	6.00	0.02	0.00
8	500CS.007	9.82	2.01	0.92	0.00	6.25	0.0X	0.00
X	500CS.007	9.X8	2.01	0.12	0.00	6.11	0.02	0.00
10	500CS.007	9.6/	2.01	0.12	0.00	:.8:	0.02	0.00
11	500CS.007	9.X:	2.01	0.9/	0.00	6.91	0.0X	0.00
12	500CS.007	9.81	2.01	0.11	0.00	:.X/	0.02	0.00

Complementary Information

Cable	Cable ID	Δθint [°C]	[A]	[μF/mile]	[Ω]	[Ω/mile]	[Ω/mile]	[V/A/mile]
Cable Index Number	Cable Equipment ID	Temperature rise due to surrounding heat sources	Induced current on Metallic Screen	Cable Capacitance	Surge Impedance	Reactance of Conductor	Reactance of Metallic Sheath	Voltage drop for Three Phase System
1	500CS.007	/5.5:	0.00	0./9	:.02	0.9:	0.00	0.0/
2	500CS.007	90.:0	0.00	0./9	5X.16	0.95	0.00	0.0/
/	500CS.007	91.XX	0.00	0./9	:.02	0.9:	0.00	0.0/
9	500CS.007	/5.02	0.00	0./9	:.02	0.9:	0.00	0.0/
5	500CS.007	91.22	0.00	0./9	5X.16	0.95	0.00	0.0/
:	500CS.007	91.1X	0.00	0./9	:.02	0.9:	0.00	0.0/
6	500CS.007	/5.0/	0.00	0./9	:.02	0.9:	0.00	0.0/
8	500CS.007	91.2/	0.00	0./9	5X.16	0.95	0.00	0.0/
X	500CS.007	91.1X	0.00	0./9	:.02	0.9:	0.00	0.0/
10	500CS.007	/5.55	0.00	0./9	:.02	0.9:	0.00	0.0/
11	500CS.007	90.5X	0.00	0./9	5X.16	0.95	0.00	0.0/
12	500CS.007	91.XX	0.00	0./9	:.02	0.9:	0.00	0.0/

Study Summary

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T1-500kV, 8_ DOC, 5000kcmil Cu, 100 DLF
Date:	542/42029 1030839: PM

General Simulation Data

Steady State Option	Enequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.00
Conductor Resistances Computation Option:	AJC-228

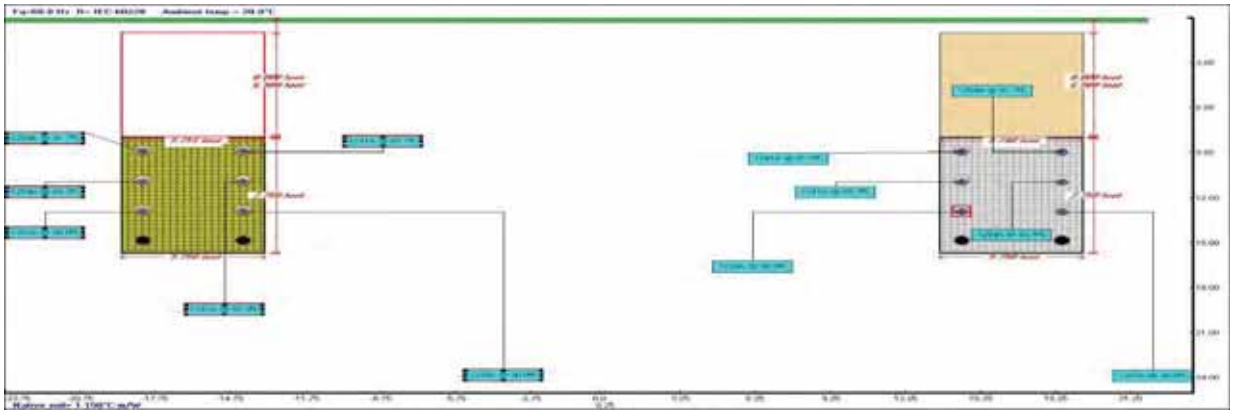
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CAGRUGuidance
Factor on RAC due to magnetic duct	CAGRUGuidance
Factor on λ_1 due to magnetic armour	CI MCPgGuidance
Factor on λ_1 due to magnetic duct	CAGRUGuidance
Factor on λ_2 due to λ'_1	CI MCPgGuidance
λ''_1 computation	CAGRUGuidance
$\lambda_2$pipe computation	CI MCPgGuidance
Wd computation	CAGRUGuidance
T_2 computation	CAGRUGuidance
T_4 computation	CI MCPgGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
TackBll9	1: .5/	9.9X	5.65	: .XX	0.: 0
DT 972	1: .5/	11.86	5.65	6.6:	0.: 0
TackBll2	-1: .2/	9.9X	5.65	: .XX	0.: 0
DT 972	-1: .2/	11.86	5.65	6.6:	0.: 0



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	500C5.007	1		P	: 0.00	1.00	19.5/	8.X5	81.: 8	1291.16
2	500C5.007	1		T	: 0.00	1.00	18.5/	10.X5	8X./ 5	125X.18
/	500C5.007	1		C	: 0.00	1.00	19.5/	12.X5	X0.02	12/ 8.: 2
9	500C5.007	1		P	: 0.00	1.00	18.5/	8.X5	81.61	1258.8:
5	500C5.007	1		T	: 0.00	1.00	19.5/	10.X5	8X.//	1290.85
:	500C5.007	1		C	: 0.00	1.00	18.5/	12.X5	X0.01	12: 1.91
6	500C5.007	2		P	: 0.00	1.00	-18.2/	8.X5	81.61	1258.89
8	500C5.007	2		T	: 0.00	1.00	-19.2/	10.X5	8X.//	1290.82
X	500C5.007	2		C	: 0.00	1.00	-18.2/	12.X5	X0.01	12: 1./ 6
10	500C5.007	2		P	: 0.00	1.00	-19.2/	8.X5	81.: 6	1291.15
11	500C5.007	2		T	: 0.00	1.00	-18.2/	10.X5	8X./ 9	125X.1:
12	500C5.007	2		C	: 0.00	1.00	-19.2/	12.X5	X0.01	12/ 8.: 1

Cables Report

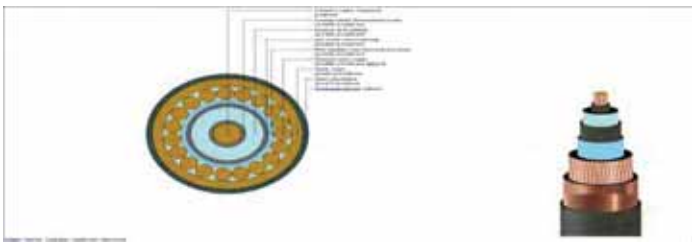
CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T1-500kV, 8_ DOC, 5000kcmil Cu, 100 DLF
Date:	5/2/2029 10:30:39: PM

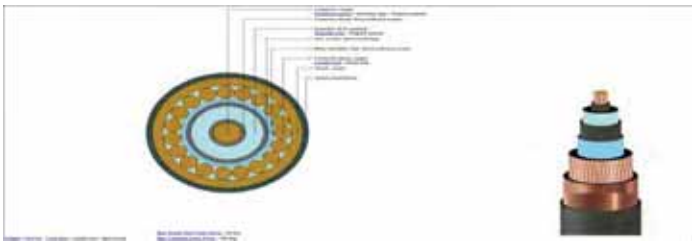
No.	Description	Unit	1
General Cable Information			
1	Cable Uquipment AD		500C5.007
2	Number oBCores		f inSle Core
/	VoltaSe	YkV[	500.00
9	Conductor Prea	Yin][	/ .X/
5	Cable Overall Diameter	Yin[	5.XX
:	Ma²imum f teady-f tate Conductor xemperature	Y°C[	X0.00
6	Ma²imum UmerSency Conductor xemperature	Y°C[	105.00
Conductor			
8	Material		Copper
X	Uectrical Resistivity at 20°C	Y¿Ω.cm[	1.62
10	xemperature Coe¥Bicient at 20°C	Y1·4K[	0.00
11	Reciprocal oBxemperature Coe¥Bicient oBResistance (TUxP)	YK[	2/9.95
12	Volumetric f pecil¥c Heat (f H)	Y3·4[K*cm³)[	/ .95
1/	Construction		: f eSments
19	Conductor Ansulation f ystem		UPtruded
15	Milliken Wires Construction		Ansulated Wires
1:	Ks (f kin U¥Bect Coe¥Bicient)		0./5
16	Kp (gro²imity U¥Bect Coe¥Bicient)		0.20
18	Diameter	Yin[	2.9X
Conductor Shield			
1X	xhickness	Yin[	0.0:
20	Diameter	Yin[	2.:1
Insulation			
21	Material		7LgU En¥Bled
22	xhermal Resistivity	YK.m4W[	/ .50
2/	Dielectric Loss Factor - (tan delta)		0.00
29	Relative germittivity - (epsilon)		2.50
25	f pecil¥c Ansulation Resistance Constant at : 0°F - (K)	[¥Ω.1000ft]	1858.0:
2:	xhickness	Yin[	1.22
26	Diameter	Yin[	5.05
Insulation Screen			
28	Material		f emi ConductinS f creen
2X	xhickness	Yin[	0.0:
/0	Diameter	Yin[	5.16
Non Metallic Layer - Water Swellable Tape			
/1	Material		U7xREDUD f UMACONDECxAVU f CRUUN
/2	xhermal Resistivity	YK.m4W[	2.50
//	xhickness	Yin[	0.09
/9	Diameter	Yin[	5.29
Concentric neutral/Skid wires			
/5	Pre Concentric Neutral Wires Pround Uach Core?		n¥e
/:	Material		Copper
/6	Uectrical Resistivity at 20°C	Y¿Ω.cm[	1.62
/8	xemperature Coe¥Bicient at 20°C	Y1·4K[	0.00
/X	Reciprocal oBxemperature Coe¥Bicient oBResistance (TUxP)	YK[	2/9.50
90	Volumetric f pecil¥c Heat (f H)	Y3·4[K*cm³)[	/ .95
91	Wire xype		Round Wires
92	LenSth oBLay	Yin[	95.5:
9/	Number oBWires		/:
99	Wire GauSe		Endel¥ned
95	xhickness	Yin[	0.0X
9:	Diameter	Yin[	5.91
Sheath			
96	As f heath Pround Uach Core?		n¥e
98	Material		Copper
9X	Uectrical Resistivity at 20°C	Y¿Ω.cm[	1.62
50	xemperature Coe¥Bicient at 20°C	Y1·4K[	0.00
51	Reciprocal oBxemperature Coe¥Bicient oBResistance (TUxP)	YK[	2/9.50
52	Volumetric f pecil¥c Heat (f H)	Y3·4[K*cm³)[	/ .95
5/	CorruSation xype		Non CorruSated
59	xhickness	Yin[	0.01
55	Diameter	Yin[	5.99
Jacket			
5:	Material		golyethylene
56	xhermal Resistivity	YK.m4W[	/ .50
58	xhickness	Yin[	0.28
5X	Diameter	Yin[	5.XX

No.	Description	Unit	1
Specific Installation Data			
:0	Cable Uquipment AD		500C5.007
:1	Cable Frequency	YHz[	: 0.00
:2	f heath 4 f hield TondinS		Multicables 1 goint Tonded
:/	Loss Factor Constant (PLOf)		0./0
:9	Conduit construction		gVC Duct in Concrete
:5	Conduit material thermal resistivity	YK.m4W[	: .00
::	Conduit B¥linS material		Pir
:6	Anner diameter oBthe conduit	Yin[	6.X8
:8	Outer diameter oBthe conduit	Yin[	8.:2

Cable ID : 500C5.00X

Cable xitle	500kV, 5000kcmil Cu - : f eS, 1221 7LgU, Cu Conc, xaihan





General Summary Report

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T21-550kV8_ _DOV- 55500: ll OnlvB- _.uL
Date:	-f24f252/ 953\353\9 : M

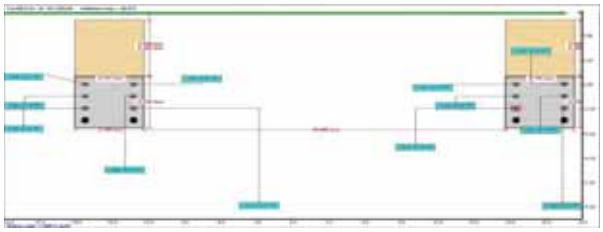
Simulation Data

Installation type:	HmtlPle _.m2pan0s
Steady State Option	bneEmallq uoadod
Ambient temperature [°C]	25.55
Native Soil Thermal Resistivity [K.m/W]	9.-5
Consider Non-Isothermal Earth Surface	y o
Consider effect of soil dry out	y o
Consider Electrical interaction between circuits	y o
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits) [A]	5.55

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	25.55
Native Soil Thermal Resistivity [K.m/W]	9.-5
Consider Non-Isothermal Earth Surface	y o

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
TaCDNl/	25.-4	/.;B	-.X-	6.BB	5.65
_T /72	25.-4	99.92	-.X-	6.26	5.65
TaCDNl2	I9-.24	/.;B	-.X-	6.BB	5.65
_T /72	I9-.24	99.92	-.X-	6.26	5.65



General Cable Information

Cable ID	Number of Cores	Conductor Construction	Voltage [kV]	Conductor Area [mm²]	Cable Overall Diameter [in]	Maximum Steady-State Conductor Temperature [°C]	Maximum Emergency Conductor Temperature [°C]
- SSO-.SS7	f inSle Oore	6 f eSc ents	-55.55	2-4-.&/	-.BB	B5.55	95-.55

Detailed Cable Information

Cable ID	Conductor	Insulation	Sheath / Tape	Concentric Wires	Filler	Armour	Jacket / Armour Serving
- SSO-.SS7	OzPPer	7ugU bnNlled	OzPPer	OzPPer	nRa	nRa	golapthdene

General Input Data

Cable	Cable ID	Circuit No.	Phase	Fq [Hz]	X [ft]	Y [ft]	DLF [p.u.]	Sheath / Shield Bonding
Cable Index Number	**Cable Equipment ID**	**Circuit No.**	**Cable Phase**	**Operating Frequency**	**X coordinate**	**Y coordinate**	**Daily Load Factor**	**Bonding Type**
9	- SSO-.SS7	9	:	65.55	9B.-4	8.B-	5.8-	MnltiCaples 9 goint Tonded
2	- SSO-.SS7	9	T	65.55	22.-4	95./-	5.8-	MnltiCaples 9 goint Tonded
4	- SSO-.SS7	9	O	65.55	9B.-4	99.B-	5.8-	MnltiCaples 9 goint Tonded
/	- SSO-.SS7	9	:	65.55	22.-4	8.B-	5.8-	MnltiCaples 9 goint Tonded
-	- SSO-.SS7	9	T	65.55	9B.-4	95./-	5.8-	MnltiCaples 9 goint Tonded
6	- SSO-.SS7	9	O	65.55	22.-4	99.B-	5.8-	MnltiCaples 9 goint Tonded
X	- SSO-.SS7	2	:	65.55	BX.24	8.B-	5.8-	MnltiCaples 9 goint Tonded
8	- SSO-.SS7	2	T	65.55	B4.24	95./-	5.8-	MnltiCaples 9 goint Tonded
B	- SSO-.SS7	2	O	65.55	BX.24	99.B-	5.8-	MnltiCaples 9 goint Tonded
95	- SSO-.SS7	2	:	65.55	B4.24	8.B-	5.8-	MnltiCaples 9 goint Tonded
99	- SSO-.SS7	2	T	65.55	BX.24	95./-	5.8-	MnltiCaples 9 goint Tonded
92	- SSO-.SS7	2	O	65.55	B4.24	99.B-	5.8-	MnltiCaples 9 goint Tonded

Ampacity and Temperatures

Cable	Cable ID	I [A]	θc [°C]	θs [°C]	θa [°C]	θsurf [°C]	θduct [°C]	θair / θcasing [°C]
Cable Index Number	**Cable Equipment ID**	**Steady State Ampacity**	**Conductor temperature**	**Sheath/Shield temperature**	**Armour temperature**	**Cable surface temperature**	**Duct surface temperature**	**Mean air temperature in the tunnel / Casing surface temperature**
9	- SSO-.SS7	92/./.69	82.B4	X-.2-	nRa	X/.59	6X.BB	nRa
2	- SSO-.SS7	92-.6.ZX	8B.-8	89.68	nRa	B5.42	X4.8B	nRa
4	- SSO-.SS7	92/2./.5	B5.59	82.2/	nRa	89.55	X-.5X	nRa
/	- SSO-.SS7	92-.-.B4	82.B4	X-.94	nRa	X4.8B	6X.X-	nRa
-	- SSO-.SS7	92/./.9X	8B.-X	89.XB	nRa	B5./6	X/.5B	nRa
6	- SSO-.SS7	92-.8.54	B5.55	82.58	nRa	B5.B9	X/.X6	nRa
X	- SSO-.SS7	92-.-.X9	82.B4	X-.94	nRa	X4.8B	6X.X-	nRa
8	- SSO-.SS7	92/./.48	8B.-8	89.85	nRa	B5./X	X/.5B	nRa
B	- SSO-.SS7	92-.8.55	B5.55	82.58	nRa	B5.B9	X/.X6	nRa
95	- SSO-.SS7	92/./-.X	82.B4	X-.2-	nRa	X/.59	6X.BB	nRa
99	- SSO-.SS7	92-.-.B5	8B.-X	89.6X	nRa	B5.42	X4.B-	nRa
92	- SSO-.SS7	92/.2.ZX	B5.55	82.2/	nRa	B5.BB	X-.56	nRa

Electrical Resistances

Cable	Cable ID	Rₑ [Ω/mile]	ys	yp	R [Ω/mile]	R's [Ω/mile]	R'w [Ω/mile]	R'a [Ω/mile]
Cable Index Number	**Cable Equipment ID**	**DC Resistance of the conductor at 20°C**	**Skin Effect Factor**	**Proximity Effect Factor**	**AC Resistance of Conductor at Operating Temperature**	**DC Resistance of Sheath at Operating Temperature**	**DC Resistance of Concentric Wires at Operating Temperature**	**DC Resistance of Armor at Operating Temperature**
9	- SSO-.SS7	5.59	5.9X	5.55	5.52	5.2B	5.26	nRa
2	- SSO-.SS7	5.59	5.96	5.55	5.52	5.2B	5.2X	nRa
4	- SSO-.SS7	5.59	5.96	5.55	5.52	5.2B	5.2X	nRa
/	- SSO-.SS7	5.59	5.9X	5.55	5.52	5.2B	5.26	nRa
-	- SSO-.SS7	5.59	5.96	5.55	5.52	5.2B	5.2X	nRa
6	- SSO-.SS7	5.59	5.96	5.55	5.52	5.2B	5.2X	nRa
X	- SSO-.SS7	5.59	5.9X	5.55	5.52	5.2B	5.26	nRa
8	- SSO-.SS7	5.59	5.96	5.55	5.52	5.2B	5.2X	nRa
B	- SSO-.SS7	5.59	5.96	5.55	5.52	5.2B	5.2X	nRa
95	- SSO-.SS7	5.59	5.9X	5.55	5.52	5.2B	5.26	nRa
99	- SSO-.SS7	5.59	5.96	5.55	5.52	5.2B	5.2X	nRa
92	- SSO-.SS7	5.59	5.96	5.55	5.52	5.2B	5.2X	nRa

Thermal Resistances

Cable	Cable ID	T₁ [K.m/W]	T₂ [K.m/W]	T₃ [K.m/W]	Tₐ' [K.m/W]	Tₐ'' [K.m/W]	Tₐ''' [K.m/W]	Tₐ [K.m/W]
Cable Index Number	**Cable Equipment ID**	**Thermal resistance of insulation**	**Thermal resistance of bedding**	**Thermal resistance of outer covering**	**Thermal resistance inside the duct**	**Thermal resistance of the duct**	**Thermal resistance of the external medium**	**Total external thermal resistance**
9	- SSO-.SS7	5./5	5.55	5.5-	5.9B	5.5X	2.95	2.4X
2	- SSO-.SS7	5./5	5.55	5.5-	5.9B	5.5X	2.9-	2./9
4	- SSO-.SS7	5./5	5.55	5.5-	5.9B	5.5X	2.4B	2.6-
/	- SSO-.SS7	5./5	5.55	5.5-	5.9B	5.5X	2.56	2.44
-	- SSO-.SS7	5./5	5.55	5.5-	5.9B	5.5X	2.9B	2./-
6	- SSO-.SS7	5./5	5.55	5.5-	5.9B	5.5X	2.4/	2.-B
X	- SSO-.SS7	5./5	5.55	5.5-	5.9B	5.5X	2.56	2.44
8	- SSO-.SS7	5./5	5.55	5.5-	5.9B	5.5X	2.9B	2./-
B	- SSO-.SS7	5./5	5.55	5.5-	5.9B	5.5X	2.4/	2.-B
95	- SSO-.SS7	5./5	5.55	5.5-	5.9B	5.5X	2.95	2.4X
99	- SSO-.SS7	5./5	5.55	5.5-	5.9B	5.5X	2.9-	2./9
92	- SSO-.SS7	5./5	5.55	5.5-	5.9B	5.5X	2.4B	2.6-

Losses

Cable	Cable ID	Wc [W/ft]	Wd [W/ft]	Ws [W/ft]	Wa [W/ft]	Wt [W/ft]	λ₁	λ₂
Cable Index Number	**Cable Equipment ID**	**Conductor Losses**	**Dielectric Losses**	**Metallic Screen Losses**	**Armor/Pipe Losses**	**Total Losses**	**Screen Loss Factor**	**Armour Loss Factor + Pipe Loss Factor**
9	- SSO-.SS7	/.XX	2.59	5.9X	5.55	6.B6	5.5/	5.55
2	- SSO-.SS7	/.8/	2.59	5.6X	5.55	X.62	5.9/	5.55
4	- SSO-.SS7	/.8/	2.59	5.9X	5.55	X.52	5.54	5.55
/	- SSO-.SS7	/.86	2.59	5.9B	5.55	X.5-	5.5/	5.55
-	- SSO-.SS7	/.8-	2.59	5.66	5.55	X.-2	5.9/	5.55
6	- SSO-.SS7	/.86	2.59	5.9X	5.55	X.9-	5.54	5.55
X	- SSO-.SS7	/.86	2.59	5.9B	5.55	X.5-	5.5/	5.55
8	- SSO-.SS7	/.8-	2.59	5.66	5.55	X.-2	5.9/	5.55
B	- SSO-.SS7	/.86	2.59	5.9X	5.55	X.9-	5.54	5.55
95	- SSO-.SS7	/.XX	2.59	5.9X	5.55	6.B6	5.5/	5.55
99	- SSO-.SS7	/.8/	2.59	5.6X	5.55	X.62	5.9/	5.55
92	- SSO-.SS7	/.8/	2.59	5.9X	5.55	X.52	5.54	5.55

Complementary Information

Cable	Cable ID	ΔθInt [°C]	[A]	[μF/mile]	[Ω]	[Ω/mile]	[Ω/mile]	[V/A/mile]
Cable Index Number	**Cable Equipment ID**	**Temperature rise due to surrounding heat sources**	**Induced current on Metallic Screen**	**Cable Capacitance**	**Surge Impedance**	**Reactance of Conductor**	**Reactance of Metallic Sheath**	**Voltage drop for Three Phase System**
9	- SSO-.SS7	4X.96	5.55	5.4/	-8.8B	5./	5.55	5.54
2	- SSO-.SS7	/.9.9B	5.55	5.4/	-8.5B	5./4	5.55	5.54
4	- SSO-.SS7	/.2-.8	5.55	5.4/	-8.8B	5./	5.55	5.54
/	- SSO-.SS7	46.89	5.55	5.4/	-8.8B	5./	5.55	5.54
-	- SSO-.SS7	/.9.65	5.55	5.4/	-8.5B	5./4	5.55	5.54
6	- SSO-.SS7	/.2.5-	5.55	5.4/	-8.8B	5./	5.55	5.54
X	- SSO-.SS7	46.89	5.55	5.4/	-8.8B	5./	5.55	5.54
8	- SSO-.SS7	/.9.65	5.55	5.4/	-8.5B	5./4	5.55	5.54
B	- SSO-.SS7	/.2.56	5.55	5.4/	-8.8B	5./	5.55	5.54
95	- SSO-.SS7	4X.96	5.55	5.4/	-8.8B	5./	5.55	5.54
99	- SSO-.SS7	/.9.9B	5.55	5.4/	-8.5B	5./4	5.55	5.54
92	- SSO-.SS7	/.2.-.8	5.55	5.4/	-8.8B	5./	5.55	5.54

Study Summary

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T21- 550kV8, _DOV- 5550Cc il OnV8- _uL
Date:	- F24F252/ 95395399 : M

General Simulation Data

Steady State Option	bneEmallq uoaded
Consider Electrical interaction between circuits	y o
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	5.55
Conductor Resistances Computation Option:	AUO1228

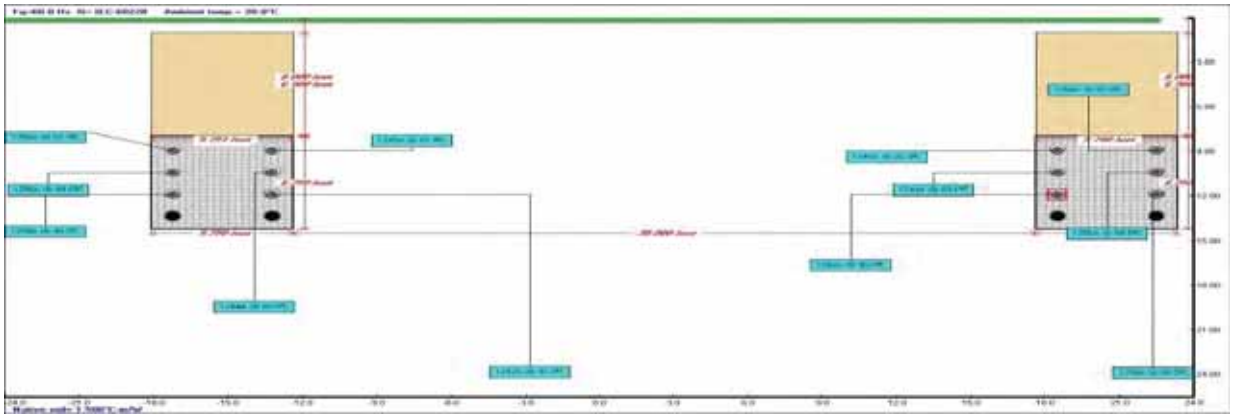
Standard Settings Options

General guidance	Onstoc
Factor on RAC due to magnetic armour	OAGRUGmidanCe
Factor on RAC due to magnetic duct	OAGRUGmidanCe
Factor on λ₁ due to magnetic armour	OI MO: gGmidanCe
Factor on λ₁ due to magnetic duct	OAGRUGmidanCe
Factor on λ₂ due to λ'₁	OI MO: gGmidanCe
λ''₁ computation	OAGRUGmidanCe
λ₂pipe computation	OI MO: gGmidanCe
Wd computation	OAGRUGmidanCe
T₂ computation	OAGRUGmidanCe
T₄ computation	OI MO: gGmidanCe

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	25.55
Native Soil Thermal Resistivity [K.m/W]	9.- 5
Consider Non-Isothermal Earth Surface	y o

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
TaCDNll/	25.- 4	/ ./ B	- .X-	6.BB	5.65
_T / 72	25.- 4	99.92	- .X-	6.26	5.65
TaCDNll2	19- .24	/ ./ B	- .X-	6.BB	5.65
_T / 72	19- .24	99.92	- .X-	6.26	5.65



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
9	- 55O- .557	9		:	65.55	5.8-	98.- 4	8.B-	82.B4	92/ / .69
2	- 55O- .557	9		T	65.55	5.8-	22.- 4	95./ -	8B.- 8	92- 6.2X
4	- 55O- .557	9		O	65.55	5.8-	98.- 4	99.B-	B5.59	92/ 2./ 5
/	- 55O- .557	9		:	65.55	5.8-	22.- 4	8.B-	82.B4	92- - .84
-	- 55O- .557	9		T	65.55	5.8-	98.- 4	95./ -	8B.- X	92/ / .9X
6	- 55O- .557	9		O	65.55	5.8-	22.- 4	99.B-	B5.55	92- 8.54
X	- 55O- .557	2		:	65.55	5.8-	19X.24	8.B-	82.B4	92- - .X9
8	- 55O- .557	2		T	65.55	5.8-	194.24	95./ -	8B.- 8	92/ / .48
B	- 55O- .557	2		O	65.55	5.8-	19X.24	99.B-	B5.55	92- 8.55
95	- 55O- .557	2		:	65.55	5.8-	194.24	8.B-	82.B4	92/ / .- X
99	- 55O- .557	2		T	65.55	5.8-	19X.24	95./ -	8B.- X	92- - .B5
92	- 55O- .557	2		O	65.55	5.8-	194.24	99.B-	B5.55	92/ 2.2X

Cables Report

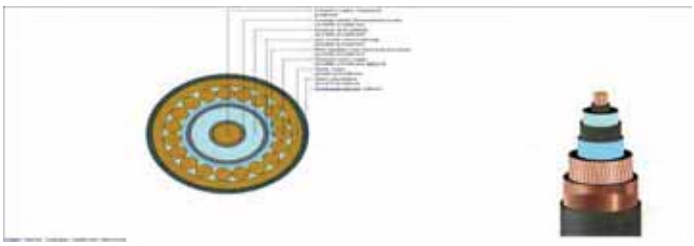
CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T21-550kV8, _DOV-5550Cc il OnV8-_uL
Date:	-F24F252/ 9539S399 : M

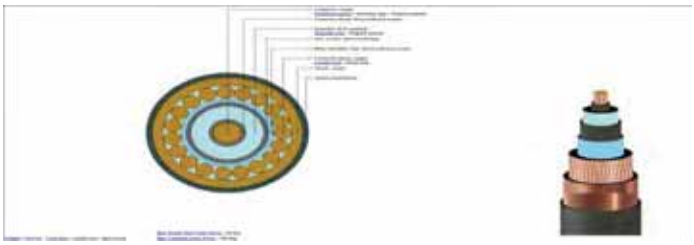
No.	Description	Unit	1
General Cable Information			
9	Oaple UEmPc ent A_		-55O-.557
2	y:nc per oNOores		FinSle Oore
4	koltaSe	Ydk[	-55.55
/	OondmDor : rea	Ym)[	4.B4
-	Oaple Dverall _ac eter	Ym[	-.BB
6	Ma²ic nc f teadq]Ftate OondmDor xec Peratrne	Y*Q[	B5.55
X	Ma²ic nc Uc erSenQ; OondmDor xec Peratrne	Y*Q[	95-.55
Conductor			
8	Material		OoPPer
B	UeDtriQal Resistivitq at 25°O	YµΩ.Cc [	9.X2
95	xec Peratrne OoeNKDent at 25°O	Y9fK[	5.55
99	ReDProQal oNxec Peratrne OoeNKDent oNResistanQr (TUx:)	Yk[	24/ ./ -
92	koInt etnC f PeDNC Heat (f H)	Y0f(K*Q: ²)[	4./-
94	OonstrnDtion		6 f eSc ents
9/	OondmDor Arsnlation f qstec		UTrrnded
9-	MilliDen Wires OonstrnDtion		Arsnlated Wires
96	Ks (f0in UNeQ: OoeNKDent)		5.4-
9X	KP (gro²ic ito UNeQ: OoeNKDent)		5.25
9B	_ac eter	Ym[	2./ B
Conductor Shield			
9B	xhiDness	Ym[	5.56
25	_ac eter	Ym[	2.69
Insulation			
29	Material		7ugU bnNlled
22	xherc al Resistivitq	Yk.c fW[	4.- 5
24	_ieleDriCuoss LaQor 1 (tan delta)		5.55
2/	Relative gerc ittivitq 1 (ePsilon)		2.- 5
2-	f PeDNC Arsnlation ResistanQr Oonstant at 65°L 1 (K)	[lK0.1000ft]	9B-8.56
26	xhiDness	Ym[	9.22
2X	_ac eter	Ym[	-.5-
Insulation Screen			
28	Material		f ec i OondmDinS f Green
2B	xhiDness	Ym[	5.56
45	_ac eter	Ym[	-.9X
Non Metallic Layer - Water Swellable Tape			
49	Material		U?xRb_.U_ f UMADDy_bOxAkU f CRUUy
42	xherc al Resistivitq	Yk.c fW[	2.- 5
44	xhiDness	Ym[	5.5/
4/	_ac eter	Ym[	-./
Concentric neutral/Skid wires			
4-	: re OonCentriC y entral Wires : romnd UaCh Oore?		nRe
46	Material		OoPPer
4X	UeDtriQal Resistivitq at 25°O	YµΩ.Cc [	9.X2
48	xec Peratrne OoeNKDent at 25°O	Y9fK[	5.55
4B	ReDProQal oNxec Peratrne OoeNKDent oNResistanQr (TUx:)	Yk[	24/ .- 5
/5	koInt etnC f PeDNC Heat (f H)	Y0f(K*Q: ²)[	4./-
/9	Wire xcPe		Romnd Wires
/2	uenSth oNuaq	Ym[	/ -.-6
/4	y:nc per oNWires		46
//	Wire GanSe		bndelNed
/-	xhiDness	Ym[	5.59
_/6	_ac eter	Ym[	-./9
Sheath			
/X	Ar f heath : romnd UaCh Oore?		nRe
/8	Material		OoPPer
/B	UeDtriQal Resistivitq at 25°O	YµΩ.Cc [	9.X2
-5	xec Peratrne OoeNKDent at 25°O	Y9fK[	5.55
-9	ReDProQal oNxec Peratrne OoeNKDent oNResistanQr (TUx:)	Yk[	24/ .- 5
-2	koInt etnC f PeDNC Heat (f H)	Y0f(K*Q: ²)[	4./-
-4	OorrnSation xcPe		y on OorrnSated
-/	xhiDness	Ym[	5.59
--	_ac eter	Ym[	-./ /
Jacket			
-6	Material		golqethqlene
-X	xherc al Resistivitq	Yk.c fW[	4.- 5
-8	xhiDness	Ym[	5.28
-B	_ac eter	Ym[	-.BB

No.	Description	Unit	1
Specific Installation Data			
65	Oaple UEmPc ent A_		-55O-.557
69	Oaple LreEmenQ;	Yfz[	65.55
62	f heath F f hield TondinS		MnltiOaples 9 goint Tonded
64	uoss LaQor Oonstant (: uDf)		5.45
6/	Oondnit ConstrnDtion		gkO _ntt in OonCrete
6-	Oondnit c aterial therc al resistivitq	Yk.c fW[	6.55
66	Oondnit NlinS c aterial		: ir
6X	Anner diac eter oNthe Oondnit	Ym[	X.BB
68	Dnter diac eter oNthe Oondnit	Ym[	8.62

Cable ID : 500C5.00X

Oaple xitle -550kV-5550Cc il Om16 f eSV9229 7ugUVOmOonCVxaihan





General Summary Report

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T1.-a320kV, and _kkV, D8OC5cD_kkkVmu il cLD-kk CF4
Date:	_/20/2k21 2:k6:2A pM

Simulation Data

Installation type:	MLltible CLrntEanVs
Steady State Option	qneyLalN Foaded
Ambient temperature [°C]	2k.kk
Native Soil Thermal Resistivity [K.m/W]	-.-_
Consider Non-Isothermal Earth Surface	Bo
Consider effect of soil dry out	Bo
Consider Electrical interaction between circuits	Bo
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits) [A]	k.kk

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	2k.kk
Native Soil Thermal Resistivity [K.m/W]	-.-_
Consider Non-Isothermal Earth Surface	Bo

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
XanVlll2	f.08	1.16	_.f_	A.66	k.Ak
CX 1S1	308.-0	--.8f	f.f_	f.fA	k.Ak
XanVlll	308.-0	1.16	f.f_	A.66	k.Ak
CX 1S2	f.08	--.8f	_.f_	f.fA	k.Ak
XanVlll0	1k.-0	1.16	_.f_	A.66	k.Ak
CX 1S2	1k.-0	--.8f	_.f_	f.fA	k.Ak

General Cable Information

Cable ID	Number of Cores	Conductor Construction	Voltage [kV]	Conductor Area [mm²]	Cable Overall Diameter [in]	Maximum Steady-State Conductor Temperature [°C]	Maximum Emergency Conductor Temperature [°C]
20kc_.kkS-	gin9le core	A ge9u ents	20k.kk	2_0_.62	_.22	6k.kk	-k_.kk
kkc.kkS	gin9le core	A ge9u ents	_kk.kk	2_0_.A1	_.66	6k.kk	-k_.kk

Detailed Cable Information

Cable ID	Conductor	Insulation	Sheath / Tape	Concentric Wires	Filler	Armour	Jacket / Armour Serving
20kc_.kkS-	cobber	SFpP qn7lled	cobber	cobber	n/a	n/a	polNetUNene
kkc.kkS	cobber	SFpP qn7lled	cobber	cobber	n/a	n/a	polNetUNene

General Input Data

Cable	Cable ID	Circuit No.	Phase	Fq [Hz]	X [ft]	Y [ft]	DLF [p.u.]	Sheath / Shield Bonding
Cable Index Number	Cable Equipment ID	Circuit No.	Cable Phase	Operating Frequency	X coordinate	Y coordinate	Daily Load Factor	Bonding Type
-	20kc_.kkS-	-	h	Ak.kk	31-.-0	-k.66	-.kk	- condLrtor - point Xonded 4lat
2	20kc_.kkS-	-	X	Ak.kk	31-.-0	-2.66	-.kk	- condLrtor - point Xonded 4lat
0	20kc_.kkS-	-	c	Ak.kk	31-.-0	-1.66	-.kk	- condLrtor - point Xonded 4lat
1	20kc_.kkS-	2	h	Ak.kk	306.-0	-2.66	-.kk	- condLrtor - point Xonded 4lat
_	20kc_.kkS-	2	X	Ak.kk	306.-0	-k.66	-.kk	- condLrtor - point Xonded 4lat
A	20kc_.kkS-	2	c	Ak.kk	306.-0	-1.66	-.kk	- condLrtor - point Xonded 4lat
f	20kc_.kkS-	0	h	Ak.kk	30f.-0	-2.66	-.kk	- condLrtor - point Xonded 4lat
8	20kc_.kkS-	0	X	Ak.kk	30f.-0	-1.66	-.kk	- condLrtor - point Xonded 4lat
6	20kc_.kkS-	0	c	Ak.kk	30f.-0	-k.66	-.kk	- condLrtor - point Xonded 4lat
-k	20kc_.kkS-	1	h	Ak.kk	30_.-0	-k.66	-.kk	- condLrtor - point Xonded 4lat
--	20kc_.kkS-	1	X	Ak.kk	30_.-0	-2.66	-.kk	- condLrtor - point Xonded 4lat
-2	20kc_.kkS-	1	c	Ak.kk	30_.-0	-1.66	-.kk	- condLrtor - point Xonded 4lat
-0	_kkc_.kkS	_	h	Ak.kk	_.08	8.6_	-.kk	MLltinaEles - point Xonded
-1	_kkc_.kkS	_	X	Ak.kk	6.08	-k.6_	-.kk	MLltinaEles - point Xonded
-_	_kkc_.kkS	_	c	Ak.kk	_.08	-2.6_	-.kk	MLltinaEles - point Xonded
-A	_kkc_.kkS	_	h	Ak.kk	6.08	8.6_	-.kk	MLltinaEles - point Xonded
-f	_kkc_.kkS	_	X	Ak.kk	_.08	-k.6_	-.kk	MLltinaEles - point Xonded
-8	_kkc_.kkS	_	c	Ak.kk	6.08	-2.6_	-.kk	MLltinaEles - point Xonded
-6	_kkc_.kkS	A	h	Ak.kk	08.-0	8.6_	-.kk	MLltinaEles - point Xonded
2k	_kkc_.kkS	A	X	Ak.kk	12.-0	-k.6_	-.kk	MLltinaEles - point Xonded
2-	_kkc_.kkS	A	c	Ak.kk	08.-0	-2.6_	-.kk	MLltinaEles - point Xonded
22	_kkc_.kkS	A	h	Ak.kk	12.-0	8.6_	-.kk	MLltinaEles - point Xonded
20	_kkc_.kkS	A	X	Ak.kk	08.-0	-k.6_	-.kk	MLltinaEles - point Xonded
21	_kkc_.kkS	A	c	Ak.kk	12.-0	-2.6_	-.kk	MLltinaEles - point Xonded

Ampacity and Temperatures

Cable	Cable ID	I [A]	θc [°C]	θs [°C]	θa [°C]	θsurf [°C]	θduct [°C]	θair / θcasing [°C]
Cable Index Number	Cable Equipment ID	Steady State Ampacity	Conductor temperature	Sheath/Shield temperature	Armour temperature	Cable surface temperature	Duct surface temperature	Mean air temperature in the tunnel / Casing surface temperature
-	20kc_.kkS-	688.kk	f2.ff	A6.0k	n/a	A8.6-	A_._k	n/a
2	20kc_.kkS-	688.kk	f6.k1	f_._2	n/a	f_.-2	f-.fk	n/a
0	20kc_.kkS-	688.kk	8k.2A	fA.f1	n/a	fA.01	f2.66	n/a
1	20kc_.kkS-	688.kk	82.k1	f8._k	n/a	f8.-k	f1.fk	n/a
_	20kc_.kkS-	688.kk	f_.-1	f-.A_	n/a	f-.2A	Af.8f	n/a
A	20kc_.kkS-	688.kk	80.1A	f6.6-	n/a	f6._-	fA.-6	n/a
f	20kc_.kkS-	688.kk	82.21	f8.fk	n/a	f8.0k	f1.6k	n/a
8	20kc_.kkS-	688.kk	80.fk	8k.-_	n/a	f6.f_	fA.12	n/a
6	20kc_.kkS-	688.kk	f_.0k	f-.82	n/a	f-.10	A8.k1	n/a
-k	20kc_.kkS-	688.kk	f0.2A	A6.f6	n/a	A6.1k	AA.kk	n/a
--	20kc_.kkS-	688.kk	f6.A0	fA.-2	n/a	f_.f-	f2.0k	n/a
-2	20kc_.kkS-	688.kk	8k.68	ff.1_	n/a	ff.k_	f0.f-	n/a
-0	_kkc_.kkS	-22k.-8	8-.26	f0.88	n/a	f2.A6	AA.81	n/a
-1	_kkc_.kkS	-2k1.0_	88.8_	8-.16	n/a	8k.2A	f1.0f	n/a
-_	_kkc_.kkS	-2-f.k_	6k.k-	82._-	n/a	8-.0-	f_.Ak	n/a
-A	_kkc_.kkS	-2k0.88	8-.kf	f0.80	n/a	f2.Af	AA.62	n/a
-f	_kkc_.kkS	-2-6.f-	86.k0	8-._-	n/a	8k.2_	f1.2A	n/a
-8	_kkc_.kkS	-2kf.k-	6k.k-	82.A-	n/a	8-.12	f_.f8	n/a
-6	_kkc_.kkS	-202.0f	8-._A	f1.k0	n/a	f2.82	AA.86	n/a
2k	_kkc_.kkS	-2_k.86	86.21	8-.1k	n/a	8k.-k	f0.8f	n/a
2-	_kkc_.kkS	-228.8f	6k.k-	82.06	n/a	8-.-f	f_.08	n/a
22	_kkc_.kkS	-2_k.1_	8-._f	f0.8_	n/a	f2.A2	AA._A	n/a
20	_kkc_.kkS	-20-.60	86.21	8-.Ak	n/a	8k.02	f1.21	n/a
21	_kkc_.kkS	-2_0.6_	6k.k-	82.-2	n/a	8k.8f	f1.6-	n/a

Electrical Resistances

Cable	Cable ID	R₀ [Ω/mile]	ys	yp	R [Ω/mile]	R's [Ω/mile]	R'w [Ω/mile]	R'a [Ω/mile]
Cable Index Number	Cable Equipment ID	DC Resistance of the conductor at 20°C	Skin Effect Factor	Proximity Effect Factor	AC Resistance of Conductor at Operating Temperature	DC Resistance of Sheath at Operating Temperature	DC Resistance of Concentric Wires at Operating Temperature	DC Resistance of Armor at Operating Temperature
-	20kc_.kkS-	k.k-	k.-8	k.kk	k.k2	k.18	k.0A	n/a
2	20kc_.kkS-	k.k-	k.-f	k.kk	k.k2	k.16	k.0f	n/a
0	20kc_.kkS-	k.k-	k.-f	k.kk	k.k2	k.16	k.0f	n/a
1	20kc_.kkS-	k.k-	k.-f	k.kk	k.k2	k._k	k.08	n/a
_	20kc_.kkS-	k.k-	k.-8	k.kk	k.k2	k.16	k.0f	n/a
A	20kc_.kkS-	k.k-	k.-f	k.kk	k.k2	k._k	k.08	n/a
f	20kc_.kkS-	k.k-	k.-f	k.kk	k.k2	k._k	k.08	n/a
8	20kc_.kkS-	k.k-	k.-f	k.kk	k.k2	k._k	k.08	n/a
6	20kc_.kkS-	k.k-	k.-8	k.kk	k.k2	k.16	k.0f	n/a
-k	20kc_.kkS-	k.k-	k.-8	k.kk	k.k2	k.18	k.0f	n/a
--	20kc_.kkS-	k.k-	k.-f	k.kk	k.k2	k.16	k.0f	n/a
-2	20kc_.kkS-	k.k-	k.-f	k.kk	k.k2	k._k	k.0f	n/a
-0	_kkc_.kkS	k.k-	k.-f	k.kk	k.k2	k.28	k.2A	n/a
-1	_kkc_.kkS	k.k-	k.-A	k.kk	k.k2	k.28	k.2f	n/a
-_	_kkc_.kkS	k.k-	k.-A	k.kk	k.k2	k.26	k.2f	n/a
-A	_kkc_.kkS	k.k-	k.-f	k.kk	k.k2	k.28	k.2A	n/a
-f	_kkc_.kkS	k.k-	k.-A	k.kk	k.k2	k.28	k.2f	n/a
-8	_kkc_.kkS	k.k-	k.-A	k.kk	k.k2	k.26	k.2f	n/a
-6	_kkc_.kkS	k.k-	k.-f	k.kk	k.k2	k.28	k.2A	n/a
2k	_kkc_.kkS	k.k-	k.-A	k.kk	k.k2	k.28	k.2f	n/a
2-	_kkc_.kkS	k.k-	k.-A	k.kk	k.k2	k.26	k.2f	n/a
22	_kkc_.kkS	k.k-	k.-f	k.kk	k.k2	k.28	k.2A	n/a
20	_kkc_.kkS	k.k-	k.-A	k.kk	k.k2	k.28	k.2f	n/a
21	_kkc_.kkS	k.k-	k.-A	k.kk	k.k2	k.26	k.2f	n/a

Thermal Resistances

Cable	Cable ID	T_1 [K.m/W]	T_2 [K.m/W]	T_3 [K.m/W]	T_4' [K.m/W]	T_4'' [K.m/W]	T_4''' [K.m/W]	T_4 [K.m/W]
Cable Index Number	Cable Equipment ID	Thermal resistance of insulation	Thermal resistance of bedding	Thermal resistance of outer covering	Thermal resistance inside the duct	Thermal resistance of the duct	Thermal resistance of the external medium	Total external thermal resistance
-	20kc_.kkS-	k.00	k.kk	k.k0	k.22	k.kf	0.61	1.21
2	20kc_.kkS-	k.00	k.kk	k.k0	k.2-	k.kf	1.0_	1.A1
0	20kc_.kkS-	k.00	k.kk	k.k0	k.2-	k.kf	1._0	1.8-
1	20kc_.kkS-	k.00	k.kk	k.k0	k.2-	k.kf	1._f	1.8A
_	20kc_.kkS-	k.00	k.kk	k.k0	k.22	k.kf	1.-0	1.12
A	20kc_.kkS-	k.00	k.kk	k.k0	k.2-	k.kf	1.ff	_.k_
f	20kc_.kkS-	k.00	k.kk	k.k0	k.2-	k.kf	1._6	1.8f
8	20kc_.kkS-	k.00	k.kk	k.k0	k.2-	k.kf	1.f6	_.kf
6	20kc_.kkS-	k.00	k.kk	k.k0	k.22	k.kf	1.-1	1.11
-k	20kc_.kkS-	k.00	k.kk	k.k0	k.22	k.kf	0.68	1.28
--	20kc_.kkS-	k.00	k.kk	k.k0	k.2-	k.kf	1.06	1.A8
-2	20kc_.kkS-	k.00	k.kk	k.k0	k.2-	k.kf	1._8	1.8f
-0	_kkc_.kkS	k.1k	k.kk	k.k_	k.-6	k.kf	2.-0	2.1k
-1	_kkc_.kkS	k.1k	k.kk	k.k_	k.-8	k.kf	2.06	2.A1
-_	_kkc_.kkS	k.1k	k.kk	k.k_	k.-8	k.kf	2._-	2.fA
-A	_kkc_.kkS	k.1k	k.kk	k.k_	k.-6	k.kf	2.-8	2.11
-f	_kkc_.kkS	k.1k	k.kk	k.k_	k.-8	k.kf	2.01	2.Ak
-8	_kkc_.kkS	k.1k	k.kk	k.k_	k.-8	k.kf	2._1	2.8k
-6	_kkc_.kkS	k.1k	k.kk	k.k_	k.-6	k.kf	2.-k	2.0f
2k	_kkc_.kkS	k.1k	k.kk	k.k_	k.-8	k.kf	2.21	2._k
2-	_kkc_.kkS	k.1k	k.kk	k.k_	k.-8	k.kf	2.1A	2.f2
22	_kkc_.kkS	k.1k	k.kk	k.k_	k.-6	k.kf	2.k_	2.0-
20	_kkc_.kkS	k.1k	k.kk	k.k_	k.-8	k.kf	2.0k	2._A
21	_kkc_.kkS	k.1k	k.kk	k.k_	k.-8	k.kf	2.0f	2.A0

Losses

Cable	Cable ID	Wc [W/ft]	Wd [W/ft]	Ws [W/ft]	Wa [W/ft]	Wt [W/ft]	λ_1	λ_2
Cable Index Number	Cable Equipment ID	Conductor Losses	Dielectric Losses	Metallic Screen Losses	Armor/Pipe Losses	Total Losses	Screen Loss Factor	Armour Loss Factor + Pipe Loss Factor
-	20kc_.kkS-	2.61	k.__	k.k2	k.kk	0._2	k.k-	k.kk
2	20kc_.kkS-	2.68	k.__	k.k6	k.kk	0.A2	k.k0	k.kk
0	20kc_.kkS-	2.66	k.__	k.k2	k.kk	0._f	k.k-	k.kk
1	20kc_.kkS-	0.k-	k.__	k.k8	k.kk	0.A1	k.k0	k.kk
_	20kc_.kkS-	2.6A	k.__	k.k2	k.kk	0._0	k.k-	k.kk
A	20kc_.kkS-	0.k2	k.__	k.k2	k.kk	0._6	k.k-	k.kk
f	20kc_.kkS-	0.k-	k.__	k.k8	k.kk	0.A_	k.k0	k.kk
8	20kc_.kkS-	0.k2	k.__	k.k2	k.kk	0._6	k.k-	k.kk
6	20kc_.kkS-	2.6A	k.__	k.k2	k.kk	0._0	k.k-	k.kk
-k	20kc_.kkS-	2.61	k.__	k.k2	k.kk	0._2	k.k-	k.kk
--	20kc_.kkS-	2.66	k.__	k.k6	k.kk	0.A0	k.k0	k.kk
-2	20kc_.kkS-	0.kk	k.__	k.k2	k.kk	0._f	k.k-	k.kk
-0	_kkc_.kkS	1._f	2.k-	k.--	k.kk	A.fk	k.k2	k.kk
-1	_kkc_.kkS	1._0	2.k-	k.1k	k.kk	A.6_	k.k6	k.kk
-_	_kkc_.kkS	1.A1	2.k-	k.--	k.kk	A.fA	k.k2	k.kk
-A	_kkc_.kkS	1.1_	2.k-	k.--	k.kk	A._f	k.k2	k.kk
-f	_kkc_.kkS	1.A_	2.k-	k.1-	k.kk	f.kf	k.k6	k.kk
-8	_kkc_.kkS	1._A	2.k-	k.--	k.kk	A.A8	k.k2	k.kk
-6	_kkc_.kkS	1.AA	2.k-	k.--	k.kk	A.f6	k.k2	k.kk
2k	_kkc_.kkS	1.86	2.k-	k.10	k.kk	f.01	k.k6	k.kk
2-	_kkc_.kkS	1.f0	2.k-	k.--	k.kk	A.8_	k.k2	k.kk
22	_kkc_.kkS	1.8k	2.k-	k.-2	k.kk	A.60	k.k2	k.kk
20	_kkc_.kkS	1.f_	2.k-	k.12	k.kk	f.-8	k.k6	k.kk
21	_kkc_.kkS	1.60	2.k-	k.--	k.kk	f.k_	k.k2	k.kk

Complementary Information

Cable	Cable ID	Δθint [°C]	[A]	[μF/mile]	[Ω]	[Ω/mile]	[Ω/mile]	[V/A/mile]
Cable Index Number	Cable Equipment ID	Temperature rise due to surrounding heat sources	Induced current on Metallic Screen	Cable Capacitance	Surge Impedance	Reactance of Conductor	Reactance of Metallic Sheath	Voltage drop for Three Phase System
-	20kc_.kkS-	06.0_	k.kk	k.11	18.28	k.06	k.28	k.k0
2	20kc_.kkS-	11.8_	k.kk	k.11	18.28	k.06	k.28	k.k0
0	20kc_.kkS-	1_.A2	k.kk	k.11	18.28	k.06	k.28	k.k0
1	20kc_.kkS-	18.--	k.kk	k.11	18.28	k.06	k.28	k.k0
_	20kc_.kkS-	1-.66	k.kk	k.11	18.28	k.06	k.28	k.k0
A	20kc_.kkS-	16.k1	k.kk	k.11	18.28	k.06	k.28	k.k0
f	20kc_.kkS-	18.0-	k.kk	k.11	18.28	k.06	k.28	k.k0
8	20kc_.kkS-	16.26	k.kk	k.11	18.28	k.06	k.28	k.k0
6	20kc_.kkS-	12.-_	k.kk	k.11	18.28	k.06	k.28	k.k0
-k	20kc_.kkS-	06.8_	k.kk	k.11	18.28	k.06	k.28	k.k0
--	20kc_.kkS-	1_.1_	k.kk	k.11	18.28	k.06	k.28	k.k0
-2	20kc_.kkS-	1A.01	k.kk	k.11	18.28	k.06	k.28	k.k0
-0	_kkc_.kkS	0_.8f	k.kk	k.01	Ak.k2	k.1A	k.kk	k.k0
-1	_kkc_.kkS	12.k1	k.kk	k.01	_6.-f	k.1_	k.kk	k.k0
-_	_kkc_.kkS	12.f6	k.kk	k.01	Ak.k2	k.1A	k.kk	k.k0
-A	_kkc_.kkS	0A.-A	k.kk	k.01	Ak.k2	k.1A	k.kk	k.k0
-f	_kkc_.kkS	1-.fk	k.kk	k.01	_6.-f	k.1_	k.kk	k.k0
-8	_kkc_.kkS	10.-2	k.kk	k.01	Ak.k2	k.1A	k.kk	k.k0
-6	_kkc_.kkS	0_.f0	k.kk	k.01	Ak.k2	k.1A	k.kk	k.k0
2k	_kkc_.kkS	1k.f8	k.kk	k.01	_6.-f	k.1_	k.kk	k.k0
2-	_kkc_.kkS	12.00	k.kk	k.01	Ak.k2	k.1A	k.kk	k.k0
22	_kkc_.kkS	0_.-_	k.kk	k.01	Ak.k2	k.1A	k.kk	k.k0
20	_kkc_.kkS	1-.1_	k.kk	k.01	_6.-f	k.1_	k.kk	k.k0
21	_kkc_.kkS	1-.1_	k.kk	k.01	Ak.k2	k.1A	k.kk	k.k0

Study Summary

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T1.- a320kV, and _kkV, D8OC5cD_kkkVmu il cLD- kk CF4
Date:	_/20/2k21 2:k6:2A pM

General Simulation Data

Steady State Option	qneyLallN Foaded
Consider Electrical interaction between circuits	Bo
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	k.kk
Conductor Resistances Computation Option:	IPc3228

Standard Settings Options

General guidance	cLstou
Factor on RAC due to magnetic armour	cIGRPGLidanne
Factor on RAC due to magnetic duct	cIGRPGLidanne
Factor on λ₁ due to magnetic armour	cYMchpGLidanne
Factor on λ₁ due to magnetic duct	cIGRPGLidanne
Factor on λ₂ due to λ'₁	cYMchpGLidanne
λ''₁ computation	cIGRPGLidanne
λ₂pipe computation	cYMchpGLidanne
Wd computation	cIGRPGLidanne
T₂ computation	cIGRPGLidanne
T₄ computation	cYMchpGLidanne

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	2k.kk
Native Soil Thermal Resistivity [K.m/W]	-.-_
Consider Non-Isothermal Earth Surface	Bo

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
XamV7ll2	f.08	1.16	_.f_	A.66	k.Ak
CX 1S1	308.-0	--.8f	f.f_	f.fA	k.Ak
XamV7ll	308.-0	1.16	f.f_	A.66	k.Ak
CX 1S2	f.08	--.8f	_.f_	f.fA	k.Ak
XamV7ll0	1k.-0	1.16	_.f_	A.66	k.Ak
CX 1S2	1k.-0	--.8f	_.f_	f.fA	k.Ak

Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
-	20kc_.kkS-	-		h	Ak.kk	-.kk	3l-.-0	-k.66	f2.ff	688.kk
2	20kc_.kkS-	-		X	Ak.kk	-.kk	3l-.-0	-2.66	f6.k1	688.kk
0	20kc_.kkS-	-		c	Ak.kk	-.kk	3l-.-0	-1.66	8k.2A	688.kk
1	20kc_.kkS-	2		h	Ak.kk	-.kk	306.-0	-2.66	82.k1	688.kk
_	20kc_.kkS-	2		X	Ak.kk	-.kk	306.-0	-k.66	f_.-1	688.kk
A	20kc_.kkS-	2		c	Ak.kk	-.kk	306.-0	-1.66	80.1A	688.kk
f	20kc_.kkS-	0		h	Ak.kk	-.kk	30f.-0	-2.66	82.21	688.kk
8	20kc_.kkS-	0		X	Ak.kk	-.kk	30f.-0	-1.66	80.fk	688.kk
6	20kc_.kkS-	0		c	Ak.kk	-.kk	30f.-0	-k.66	f_.0k	688.kk
-k	20kc_.kkS-	1		h	Ak.kk	-.kk	30_.-0	-k.66	f0.2A	688.kk
--	20kc_.kkS-	1		X	Ak.kk	-.kk	30_.-0	-2.66	f6.A0	688.kk
-2	20kc_.kkS-	1		c	Ak.kk	-.kk	30_.-0	-1.66	8k.68	688.kk
-0	_kkc_.kkS	_		h	Ak.kk	-.kk	_.08	8.6_	8-.26	-22k.-8
-1	_kkc_.kkS	_		X	Ak.kk	-.kk	6.08	-k.6_	88.8_	-2k1.0_
-_	_kkc_.kkS	_		c	Ak.kk	-.kk	_.08	-2.6_	6k.k-	-2-f.k_
-A	_kkc_.kkS	_		h	Ak.kk	-.kk	6.08	8.6_	8-.kf	-2k0.88
-f	_kkc_.kkS	_		X	Ak.kk	-.kk	_.08	-k.6_	86.k0	-2-6.f-
-8	_kkc_.kkS	_		c	Ak.kk	-.kk	6.08	-2.6_	6k.k-	-2kf.k-
-6	_kkc_.kkS	A		h	Ak.kk	-.kk	08.-0	8.6_	8-._A	-202.0f
2k	_kkc_.kkS	A		X	Ak.kk	-.kk	12.-0	-k.6_	86.21	-2_k.86
2-	_kkc_.kkS	A		c	Ak.kk	-.kk	08.-0	-2.6_	6k.k-	-228.8f
22	_kkc_.kkS	A		h	Ak.kk	-.kk	12.-0	8.6_	8-._f	-2_k.1_
20	_kkc_.kkS	A		X	Ak.kk	-.kk	08.-0	-k.6_	86.21	-20-.60
21	_kkc_.kkS	A		c	Ak.kk	-.kk	12.-0	-2.6_	6k.k-	-2_0.6_

Cables Report

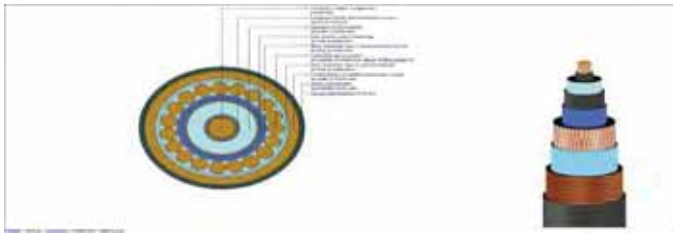
CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T1.- a3?0lkV, and _kkV, D8IOC5 cD_kkkVmu il cLD- kk CF4
Date:	_/20/2k21 2:k6:2A pM

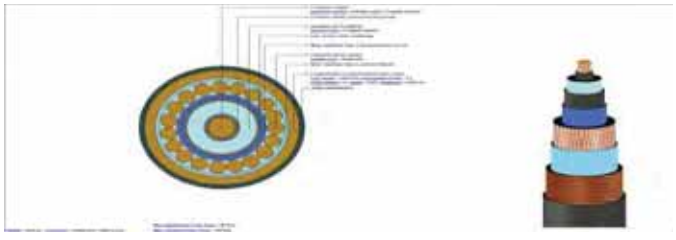
No.	Description	Unit	1
General Cable Information			
-	caEle PyLibu ent IC		20kc _.kkS-
2	BLu Eer o7cores		gin9le core
0	, oIta9e	[V_]	20k.kk
1	condLrtor hrea	[in²]	0.60
_	caEle 5verall Clau eter	[in]	_.22
A	Maxiu Lu gteadNgtate condLrtor Teu beratLre	[°c]	6k.kk
f	Maxiu Lu Pu erSenrNcondLrtor Teu beratLre	[°c]	- k_.kk
Conductor			
8	Material		cobber
6	PlentrInal ResistivitNat 2k°c	[µΩ.nu]	- .f 2
- k	Teu beratLre coe7Rntent at 2k°c	[- /K]	k.kk
--	RemBronal o7Teu beratLre coe7Rntent o7Resistanne (XPTh)	[K]	201.1_
- 2	, oILu etrimgbenRmHeat (gH)	[J/(K*nu *)]	0.1_
- 0	constrLrtion		A ge9u ents
- 1	condLrtor InsLation ghteu		PvtrLded
-_	MilWen Wires constrLrtion		InsLated Wires
- A	Ks (gVn P7Rent coe7Rntent)		k.0_
- f	Kb (proxiu itN P7Rnt coe7Rntent)		k.2k
- 8	Ciau eter	[in]	2_.1
Conductor Shield			
- 6	TLirWhess	[in]	k.- k
2k	Ciau eter	[in]	2.f 1
Insulation			
2-	Material		SFpP qn3Red
22	TUeru al ResistivitN	[K.u /W]	0_.k
20	CielentrimFoss 4antor 3(tan delta)		k.kk
21	Relative peru ittivitN 3 (ebsilon)		2_.k
2_	gbenRmInsLation Resistanne constant at Ak°4 3 (K)	[M0.1000ft]	- 8_8.kA
2A	TLirWhess	[in]	k.6-
2f	Ciau eter	[in]	1-....
Insulation Screen			
28	Material		geu i condLrtin9 gmeen
26	TLirWhess	[in]	k.k_
0k	Ciau eter	[in]	1.A_
Non Metallic Layer - Water Swellable Tape 1			
0-	Material		PSTRqCPC gPMIc5BCqcTI, P gcRPPB
02	TUeru al ResistivitN	[K.u /W]	2_.k
00	TLirWhess	[in]	k.k2
01	Ciau eter	[in]	1.A6
Concentric neutral/Skid wires			
0_	hre conmentrimBeLtral Wires hroLnd PantU core?		n/a
0A	Material		cobber
0f	PlentrInal ResistivitNat 2k°c	[µΩ.nu]	- .f 2
08	Teu beratLre coe7Rntent at 2k°c	[- /K]	k.kk
06	RemBronal o7Teu beratLre coe7Rntent o7Resistanne (XPTh)	[K]	201._k
1k	, oILu etrimgbenRmHeat (gH)	[J/(K*nu *)]	0.1_
1-	Wire TNbe		RoLnd Wires
12	Fen9tU o7FaN	[in]	1_.._A
10	BLu Eer o7Wires		1A
11	Wire GaL9e		- 1
1_	TLirWhess	[in]	k.kA
1A	Ciau eter	[in]	1.82
Sheath			
1f	Is gLeatU hroLnd PantU core?		n/a
18	Material		cobber
16	PlentrInal ResistivitNat 2k°c	[µΩ.nu]	- .f 2
_k	Teu beratLre coe7Rntent at 2k°c	[- /K]	k.kk
_.	RemBronal o7Teu beratLre coe7Rntent o7Resistanne (XPTh)	[K]	201._k
_2	, oILu etrimgbenRmHeat (gH)	[J/(K*nu *)]	0.1_
_0	corrLStation TNbe		FonRttLdinaBN corrLSated
_1	corrLStation UetRult	[in]	k.k-
__	Tabe overlab	[in]	k-_.k
_A	Tabe widtU	[in]	- ._.6-
_f	Tabe tLirWhess	[in]	k.k-
_8	hmtLu LIaton 7antor		- .2k
_6	TLirWhess	[in]	k.k-
Ak	Ciau eter	[in]	1.6-
Jacket			
A-	Material		polNetLNene
A2	TUeru al ResistivitN	[K.u /W]	0_.k
A0	TLirWhess	[in]	k.-_
A1	Ciau eter	[in]	_.22

No.	Description	Unit	1
Specific Installation Data			
A_	caEle PyLibu ent IC		20kc _.kkS-
AA	caEle 4reyLennN	[Hz]	Ak.kk
Af	gLeatU / gLield Xondin9		- condLrtor - point Xonded 4lat
A8	Foss 4antor constant (hF5 g)		k.0k
A6	condLit rtensbrLrtion		p, c CLrtt in conmete
f k	condLit u aterial tUeru al resistivitN	[K.u /W]	A.kk
f -	condLit 3Ren9 u aterial		hir
f 2	Inner diau eter o7tUe rendLit	[in]	f .68
f 0	S Lter diau eter o7tUe rendLit	[in]	8.A2

Cable ID : 230C5.00X1

caEle Title: 20kV, D_kkk Vmu il cL 3A ge9D6kA SFpPDcL rmDprNeu ian





Cables Report

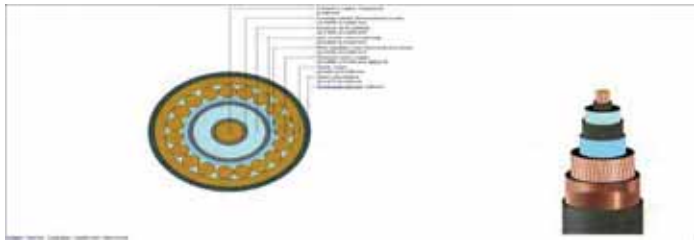
CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T1.- a320kV, and _kkV, D8OC5cD_kkkVmu il cLD- kk CF4
Date:	_/20/2k21 2:k6:2A pM

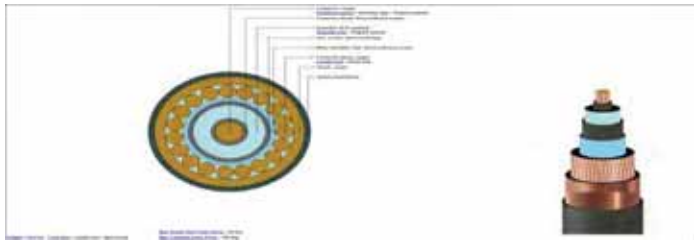
No.	Description	Unit	1
General Cable Information			
	caEle PyLibu ent IC		_kkc_.kkS
2	BLu Eer o7cores		qin9le core
0	, oltaSle	[V,]	_kk.kk
1	condLnitor hrea	[in²]	0.60
_	caEle S verall Ciau eter	[in]	_.66
A	Maxiu Lu gteadNJgtate condLnitor Teu beratLre	[°c]	6k.kk
f	Maxiu Lu Pu er9emNi condLnitor Teu beratLre	[°c]	- k_.kk
Conductor			
8	Material		cobber
6	Plentrinal ResistivitNat 2k°c	[µΩ.ru]	- .f 2
-k	Teu beratLre coe7Rntent at 2k°c	[- /K]	k.kk
--	Remlbromal o7Teu beratLre coe7Rntent o7Resistanne (XPTh)	[K]	201.1_
-2	, olLu etrimgbenlRmHeat (gH)	[J/(K°ru °)]	0.1_
-0	constrLnttion		A ge9u ents
-1	condLnitor InsLlation gNlteu		PxbrLded
-_	MilliVen Wires constrLnttion		InsLlated Wires
-A	Ks (gVln P7Rnti coe7Rntent)		k.0_
-f	Kb (proxiu itN P7Rnti coe7Rntent)		k.2k
-8	Ciau eter	[in]	2.16
Conductor Shield			
-6	TLlnNness	[in]	k.kA
2k	Ciau eter	[in]	2.A-
Insulation			
2-	Material		SFpP qnJlled
22	TUeru al ResistivitN	[K.u /W]	0._k
20	CielentrimFoss 4antor 3(tan delta)		k.kk
21	Relative peru ittivitN 3(ebsilon)		2._k
2_	gbenRmInsLlation Resistanne constant at Ak°4 3 (K)	[l0.1000ft]	-8_8.kA
2A	TLlnNness	[in]	- .22
2f	Ciau eter	[in]	_.k_
Insulation Screen			
28	Material		geu i condLnttin9 gmeen
26	TLlnNness	[in]	k.kA
0k	Ciau eter	[in]	_. f
Non Metallic Layer - Water Swellable Tape			
0-	Material		PSTRqCPC gPMlc5BCqcTI, P gcRPPB
02	TUeru al ResistivitN	[K.u /W]	2._k
00	TLlnNness	[in]	k.k1
01	Ciau eter	[in]	_.21
Concentric neutral/Skid wires			
0_	hre connentrimBeLtral Wires hroLnd PantU core?		n/a
0A	Material		cobber
0f	Plentrinal ResistivitNat 2k°c	[µΩ.ru]	- .f 2
08	Teu beratLre coe7Rntent at 2k°c	[- /K]	k.kk
06	Remlbromal o7Teu beratLre coe7Rntent o7Resistanne (XPTh)	[K]	201._k
1k	, olLu etrimgbenlRmHeat (gH)	[J/(K°ru °)]	0.1_
1-	Wire TNbe		RoLnd Wires
12	Fen9tU o7FaN	[in]	1_._A
10	BLu Eer o7Wires		0A
11	Wire GaL9e		qndeRned
1_	TLlnNness	[in]	k.k6
_1A	Ciau eter	[in]	_.1-
Sheath			
1f	Is gUeatU hroLnd PantU core?		n/a
18	Material		cobber
16	Plentrinal ResistivitNat 2k°c	[µΩ.ru]	- .f 2
_k	Teu beratLre coe7Rntent at 2k°c	[- /K]	k.kk
_:-	Remlbromal o7Teu beratLre coe7Rntent o7Resistanne (XPTh)	[K]	201._k
_2	, olLu etrimgbenlRmHeat (gH)	[J/(K°ru °)]	0.1_
_0	corrL9ation TNbe		Bon corrLSated
_1	TLlnNness	[in]	k.k-
_	Ciau eter	[in]	_.11
Jacket			
_A	Material		polNetUNene
_f	TUeru al ResistivitN	[K.u /W]	0._k
_8	TLlnNness	[in]	k.28
_6	Ciau eter	[in]	_.66

No.	Description	Unit	1
Specific Installation Data			
Ak	caEle PyLibu ent IC		_kkc_.kkS
A-	caEle 4reyLennN	[Hz]	Ak.kk
A2	gUeatU / gUeld Xondin9		MLltinaElles - point Xonded
A0	Foss 4antor constant (hFS g)		k.0k
A1	condLit nonstrLnttion		p, c CLnt in conmete
A_	condLit u aterial tUeru al resistivitN	[K.u /W]	A.kk
AA	condLit 3llin9 u aterial		hir
Af	Inner diau eter o7tUe nondLit	[in]	f .68
A8	5 ter diau eter o7tUe nondLit	[in]	8.A2

Cable ID : 500C5.00X

caEle Title _kkV, D_kkkVmu il cL 3A ge9D-22- SFpPDcL connDTaiUan





General Summary Report

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T1.-302kV, _ and DW, _O8C 5c mODWV, uL il mFO8D 54/
Date:	D:2k:2V21 6A28A p bM

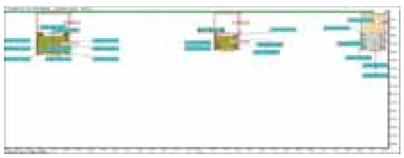
Simulation Data

Installation type:	MFltiEle 5Fut3an, s
Steady State Option	qneyFallN4oaded
Ambient temperature [°C]	2V.W
Native Soil Thermal Resistivity [K.m/W]	-.DV
Consider Non-Isothermal Earth Surface	Bo
Consider effect of soil dry out	Bo
Consider Electrical interaction between circuits	Bo
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits) [A]	V.W

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	2V.W
Native Soil Thermal Resistivity [K.m/W]	-.DV
Consider Non-Isothermal Earth Surface	Bo

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
Xau, 7ll2	p.k8	1.16	D.pD	f.66	V.f V
5X 1S1	0kD.-k	--.8p	p.pD	p.pf	V.f V
Xau, 7ll	0kD.-k	1.16	p.pD	f.66	V.f V
5X 1S2	p.k8	--.-2	D.pD	f.2f	V.f V
Xau, 7llk	1k.-k	1.16	D.pD	f.66	V.f V
5X 1S2	1k.-k	--.-2	D.pD	f.2f	V.f V



General Cable Information

Cable ID	Number of Cores	Conductor Construction	Voltage [kV]	Conductor Area [mm²]	Cable Overall Diameter [in]	Maximum Steady-State Conductor Temperature [°C]	Maximum Emergency Conductor Temperature [°C]
2kVmD.WS-	gin9le more	f ge9L ents	2kV.W	2DkD.62	D.22	6V.W	-VD.W
DWmD.WS	gin9le more	f ge9L ents	DW.W	2DkD.f 1	D.66	6V.W	-VD.W

Detailed Cable Information

Cable ID	Conductor	Insulation	Sheath / Tape	Concentric Wires	Filler	Armour	Jacket / Armour Serving
2kVmD.WS-	moEEer	S4PU qn7lled	moEEer	moEEer	n:a	n:a	PolNethNene
DWmD.WS	moEEer	S4PU qn7lled	moEEer	moEEer	n:a	n:a	PolNethNene

General Input Data

Cable	Cable ID	Circuit No.	Phase	Fq [Hz]	X [ft]	Y [ft]	DLF [p.u.]	Sheath / Shield Bonding
Cable Index Number	**Cable Equipment ID**	**Circuit No.**	**Cable Phase**	**Operating Frequency**	**X coordinate**	**Y coordinate**	**Daily Load Factor**	**Bonding Type**
-	2kVmD.WS-	-	b	f V.W	0k8.-k	-V.66	V.8D	- mondFutor - Point Xonded /lat
2	2kVmD.WS-	-	X	f V.W	0k8.-k	-2.66	V.8D	- mondFutor - Point Xonded /lat
k	2kVmD.WS-	-	m	f V.W	0k8.-k	-1.66	V.8D	- mondFutor - Point Xonded /lat
1	2kVmD.WS-	2	b	f V.W	0kf.-k	-2.66	V.8D	- mondFutor - Point Xonded /lat
D	2kVmD.WS-	2	X	f V.W	0kf.-k	-V.66	V.8D	- mondFutor - Point Xonded /lat
f	2kVmD.WS-	2	m	f V.W	0kf.-k	-1.66	V.8D	- mondFutor - Point Xonded /lat
p	2kVmD.WS-	k	b	f V.W	0k1.-k	-2.66	V.8D	- mondFutor - Point Xonded /lat
8	2kVmD.WS-	k	X	f V.W	0k1.-k	-1.66	V.8D	- mondFutor - Point Xonded /lat
6	2kVmD.WS-	k	m	f V.W	0k1.-k	-V.66	V.8D	- mondFutor - Point Xonded /lat
-V	2kVmD.WS-	1	b	f V.W	0k2.-k	-V.66	V.8D	- mondFutor - Point Xonded /lat
--	2kVmD.WS-	1	X	f V.W	0k2.-k	-2.66	V.8D	- mondFutor - Point Xonded /lat
-2	2kVmD.WS-	1	m	f V.W	0k2.-k	-1.66	V.8D	- mondFutor - Point Xonded /lat
-k	DWmD.WS	D	b	f V.W	D.k8	8.6D	V.8D	MFltiua3les - Point Xonded
-1	DWmD.WS	D	X	f V.W	6.k8	-V.1D	V.8D	MFltiua3les - Point Xonded
-D	DWmD.WS	D	m	f V.W	D.k8	--.6D	V.8D	MFltiua3les - Point Xonded
-f	DWmD.WS	D	b	f V.W	6.k8	8.6D	V.8D	MFltiua3les - Point Xonded
-p	DWmD.WS	D	X	f V.W	D.k8	-V.1D	V.8D	MFltiua3les - Point Xonded
-8	DWmD.WS	D	m	f V.W	6.k8	--.6D	V.8D	MFltiua3les - Point Xonded
-6	DWmD.WS	f	b	f V.W	1-.-k	8.6D	V.8D	MFltiua3les - Point Xonded
2V	DWmD.WS	f	X	f V.W	1D.-k	-V.1D	V.8D	MFltiua3les - Point Xonded
2-	DWmD.WS	f	m	f V.W	1-.-k	--.6D	V.8D	MFltiua3les - Point Xonded
22	DWmD.WS	f	b	f V.W	1D.-k	8.6D	V.8D	MFltiua3les - Point Xonded
2k	DWmD.WS	f	X	f V.W	1-.-k	-V.1D	V.8D	MFltiua3les - Point Xonded
21	DWmD.WS	f	m	f V.W	1D.-k	--.6D	V.8D	MFltiua3les - Point Xonded

Ampacity and Temperatures

Cable	Cable ID	I [A]	θc [°C]	θs [°C]	θa [°C]	θsurf [°C]	θduct [°C]	θair / θcasing [°C]
Cable Index Number	**Cable Equipment ID**	**Steady State Ampacity**	**Conductor temperature**	**Sheath/Shield temperature**	**Armour temperature**	**Cable surface temperature**	**Duct surface temperature**	**Mean air temperature in the tunnel / Casing surface temperature**
-	2kVmD.WS-	688.W	pV.12	f f.6p	n:a	f f.D8	f k.-f	n:a
2	2kVmD.WS-	688.W	pf.2k	p2.p1	n:a	p2.k1	f 8.6V	n:a
k	2kVmD.WS-	688.W	pp.f 8	p1.-8	n:a	pk.p8	pV.1-	n:a
1	2kVmD.WS-	688.W	p8.1k	p1.62	n:a	p1.D2	p-.-V	n:a
D	2kVmD.WS-	688.W	p2.-1	f 8.f 8	n:a	f 8.26	f 1.88	n:a
f	2kVmD.WS-	688.W	8V.-f	pf.f 1	n:a	pf.21	p2.86	n:a
p	2kVmD.WS-	688.W	p8.f 2	pD.--	n:a	p1.p-	p-.26	n:a
8	2kVmD.WS-	688.W	8V.k6	pf.8p	n:a	pf.1p	pk.-2	n:a
6	2kVmD.WS-	688.W	p2.kV	f 8.8k	n:a	f 8.11	f D.Vk	n:a
-V	2kVmD.WS-	688.W	pV.88	f p.1k	n:a	f p.V1	f k.f 2	n:a
--	2kVmD.WS-	688.W	pf.8V	pk.kV	n:a	p2.6V	f 6.1f	n:a
-2	2kVmD.WS-	688.W	p8.kp	p1.8f	n:a	p1.1f	p-.-V	n:a
-k	DWmD.WS	-22-.Df	82.f 6	pD.21	n:a	p1.V1	f 8.-D	n:a
-1	DWmD.WS	-2-2.-6	86.22	8-.p8	n:a	8V.DV	p1.kp	n:a
-D	DWmD.WS	-2-8.1f	6V.W	82.16	n:a	8-.2p	pD.D-	n:a
-f	DWmD.WS	-2--.62	82.Dk	pD.-8	n:a	pk.66	f 8.-p	n:a
-p	DWmD.WS	-22-.26	86.k8	8-.81	n:a	8V.D1	p1.k1	n:a
-8	DWmD.WS	-2-D.V2	6V.W	82.D2	n:a	8-.k-	pD.Dp	n:a
-6	DWmD.WS	-21V.8V	82.6V	pD.2f	n:a	p1.Vk	f 8.W	n:a
2V	DWmD.WS	-2D2.8k	86.D1	8-.f p	n:a	8V.k2	pk.88	n:a
2-	DWmD.WS	-2kp.6D	6V.W	82.26	n:a	8-.VD	pD.-1	n:a
22	DWmD.WS	-2D2.kp	82.88	pD.-2	n:a	pk.88	f p.pp	n:a
2k	DWmD.WS	-21V.k1	86.DD	8-.8-	n:a	8V.18	p1.-1	n:a
21	DWmD.WS	-2DD.2-	6V.W	82.--	n:a	8V.81	p1.82	n:a

Electrical Resistances

Cable	Cable ID	R₀ [Ω/mile]	ys	yp	R [Ω/mile]	R's [Ω/mile]	R'w [Ω/mile]	R'a [Ω/mile]
Cable Index Number	**Cable Equipment ID**	**DC Resistance of the conductor at 20°C**	**Skin Effect Factor**	**Proximity Effect Factor**	**AC Resistance of Conductor at Operating Temperature**	**DC Resistance of Sheath at Operating Temperature**	**DC Resistance of Concentric Wires at Operating Temperature**	**DC Resistance of Armor at Operating Temperature**
-	2kVmD.WS-	V.V-	V.-8	V.W	V.V2	V.18	V.kf	n:a
2	2kVmD.WS-	V.V-	V.-p	V.W	V.V2	V.16	V.kp	n:a
k	2kVmD.WS-	V.V-	V.-p	V.W	V.V2	V.16	V.kp	n:a
1	2kVmD.WS-	V.V-	V.-p	V.W	V.V2	V.16	V.kp	n:a
D	2kVmD.WS-	V.V-	V.-8	V.W	V.V2	V.18	V.kf	n:a
f	2kVmD.WS-	V.V-	V.-p	V.W	V.V2	V.16	V.kp	n:a
p	2kVmD.WS-	V.V-	V.-p	V.W	V.V2	V.16	V.kp	n:a
8	2kVmD.WS-	V.V-	V.-p	V.W	V.V2	V.16	V.kp	n:a
6	2kVmD.WS-	V.V-	V.-8	V.W	V.V2	V.18	V.kf	n:a
-V	2kVmD.WS-	V.V-	V.-8	V.W	V.V2	V.18	V.kf	n:a
--	2kVmD.WS-	V.V-	V.-p	V.W	V.V2	V.16	V.kp	n:a
-2	2kVmD.WS-	V.V-	V.-p	V.W	V.V2	V.16	V.kp	n:a
-k	DWmD.WS	V.V-	V.-p	V.W	V.V2	V.28	V.2f	n:a
-1	DWmD.WS	V.V-	V.-f	V.W	V.V2	V.26	V.2p	n:a
-D	DWmD.WS	V.V-	V.-f	V.W	V.V2	V.26	V.2p	n:a
-f	DWmD.WS	V.V-	V.-p	V.W	V.V2	V.28	V.2f	n:a
-p	DWmD.WS	V.V-	V.-f	V.W	V.V2	V.26	V.2p	n:a
-8	DWmD.WS	V.V-	V.-f	V.W	V.V2	V.26	V.2p	n:a
-6	DWmD.WS	V.V-	V.-p	V.W	V.V2	V.28	V.2f	n:a
2V	DWmD.WS	V.V-	V.-f	V.W	V.V2	V.26	V.2p	n:a
2-	DWmD.WS	V.V-	V.-f	V.W	V.V2	V.26	V.2p	n:a
22	DWmD.WS	V.V-	V.-p	V.W	V.V2	V.28	V.2f	n:a
2k	DWmD.WS	V.V-	V.-f	V.W	V.V2	V.26	V.2p	n:a
21	DWmD.WS	V.V-	V.-f	V.W	V.V2	V.26	V.2p	n:a

Thermal Resistances

Cable	Cable ID	T₁ [K.m/W]	T₂ [K.m/W]	T₃ [K.m/W]	T₄' [K.m/W]	T₄'' [K.m/W]	T₄''' [K.m/W]	T₄ [K.m/W]
Cable Index Number	**Cable Equipment ID**	**Thermal resistance of insulation**	**Thermal resistance of bedding**	**Thermal resistance of outer covering**	**Thermal resistance inside the duct**	**Thermal resistance of the duct**	**Thermal resistance of the external medium**	**Total external thermal resistance**
-	2kVmD.WS-	V.kk	V.W	V.Vk	V.22	V.Vp	k.pf	1.Vf
2	2kVmD.WS-	V.kk	V.W	V.Vk	V.22	V.Vp	1.-k	1.1k
k	2kVmD.WS-	V.kk	V.W	V.Vk	V.22	V.Vp	1.kk	1.f 2
1	2kVmD.WS-	V.kk	V.W	V.Vk	V.2-	V.Vp	1.kV	1.D6
D	2kVmD.WS-	V.kk	V.W	V.Vk	V.22	V.Vp	k.6V	1.-6
f	2kVmD.WS-	V.kk	V.W	V.Vk	V.2-	V.Vp	1.D2	1.8-
p	2kVmD.WS-	V.kk	V.W	V.Vk	V.2-	V.Vp	1.k2	1.f V
8	2kVmD.WS-	V.kk	V.W	V.Vk	V.2-	V.Vp	1.D1	1.82
6	2kVmD.WS-	V.kk	V.W	V.Vk	V.22	V.Vp	k.6-	1.2V
-V	2kVmD.WS-	V.kk	V.W	V.Vk	V.22	V.Vp	k.8V	1.V6
--	2kVmD.WS-	V.kk	V.W	V.Vk	V.22	V.Vp	1.-8	1.1p
-2	2kVmD.WS-	V.kk	V.W	V.Vk	V.2-	V.Vp	1.k8	1.f p
-k	DWmD.WS	V.1V	V.W	V.VD	V.-6	V.Vp	2.-p	2.1k
-1	DWmD.WS	V.1V	V.W	V.VD	V.-8	V.Vp	2.26	2.DD
-D	DWmD.WS	V.1V	V.W	V.VD	V.-8	V.Vp	2.18	2.p1
-f	DWmD.WS	V.1V	V.W	V.VD	V.-6	V.Vp	2.-6	2.1f
-p	DWmD.WS	V.1V	V.W	V.VD	V.-8	V.Vp	2.2f	2.D2
-8	DWmD.WS	V.1V	V.W	V.VD	V.-8	V.Vp	2.16	2.pD
-6	DWmD.WS	V.1V	V.W	V.VD	V.-6	V.Vp	2.--	2.k8
2V	DWmD.WS	V.1V	V.W	V.VD	V.-8	V.Vp	2.-f	2.12
2-	DWmD.WS	V.1V	V.W	V.VD	V.-8	V.Vp	2.1-	2.f f
22	DWmD.WS	V.1V	V.W	V.VD	V.-6	V.Vp	2.Vp	2.k1
2k	DWmD.WS	V.1V	V.W	V.VD	V.-8	V.Vp	2.2-	2.1f
21	DWmD.WS	V.1V	V.W	V.VD	V.-8	V.Vp	2.kD	2.f V

Losses

Cable	Cable ID	Wc [W/ft]	Wd [W/ft]	Ws [W/ft]	Wa [W/ft]	Wt [W/ft]	λ₁	λ₂
Cable Index Number	**Cable Equipment ID**	**Conductor Losses**	**Dielectric Losses**	**Metallic Screen Losses**	**Armor/Pipe Losses**	**Total Losses**	**Screen Loss Factor**	**Armour Loss Factor + Pipe Loss Factor**
-	2kVmD.WS-	2.62	V.DD	V.V2	V.W	k.DV	V.V-	V.W
2	2kVmD.WS-	2.6f	V.DD	V.V6	V.W	k.f V	V.Vk	V.W
k	2kVmD.WS-	2.6p	V.DD	V.V2	V.W	k.DD	V.V-	V.W
1	2kVmD.WS-	2.68	V.DD	V.V6	V.W	k.f 2	V.Vk	V.W
D	2kVmD.WS-	2.61	V.DD	V.V2	V.W	k.D-	V.V-	V.W
f	2kVmD.WS-	2.66	V.DD	V.V2	V.W	k.Dp	V.V-	V.W
p	2kVmD.WS-	2.68	V.DD	V.V6	V.W	k.f 2	V.Vk	V.W
8	2kVmD.WS-	2.66	V.DD	V.V2	V.W	k.Dp	V.V-	V.W
6	2kVmD.WS-	2.61	V.DD	V.V2	V.W	k.D-	V.V-	V.W
-V	2kVmD.WS-	2.6k	V.DD	V.V2	V.W	k.DV	V.V-	V.W
--	2kVmD.WS-	2.6p	V.DD	V.V6	V.W	k.f -	V.Vk	V.W
-2	2kVmD.WS-	2.68	V.DD	V.V2	V.W	k.DD	V.V-	V.W
-k	DWmD.WS	1.f V	2.V-	V.-p	V.W	f.p8	V.V1	V.W
-1	DWmD.WS	1.f V	2.V-	V.f k	V.W	p.21	V.-1	V.W
-D	DWmD.WS	1.f D	2.V-	V.-f	V.W	f.8k	V.V1	V.W
-f	DWmD.WS	1.D2	2.V-	V.-p	V.W	f.pV	V.V1	V.W
-p	DWmD.WS	1.f p	2.V-	V.f 1	V.W	p.k2	V.-1	V.W
-8	DWmD.WS	1.f k	2.V-	V.-f	V.W	f.8V	V.V1	V.W
-6	DWmD.WS	1.p1	2.V-	V.-p	V.W	f.6k	V.V1	V.W
2V	DWmD.WS	1.6-	2.V-	V.f p	V.W	p.D6	V.-1	V.W
2-	DWmD.WS	1.8V	2.V-	V.-p	V.W	f.68	V.Vk	V.W
22	DWmD.WS	1.8k	2.V-	V.-8	V.W	p.V2	V.V1	V.W
2k	DWmD.WS	1.82	2.V-	V.f D	V.W	p.18	V.-1	V.W
21	DWmD.WS	1.61	2.V-	V.-p	V.W	p.-2	V.Vk	V.W

Complementary Information

Cable	Cable ID	Δθint [°C]	[A]	[µF/mile]	[Ω]	[Ω/mile]	[Ω/mile]	[V/A/mile]
Cable Index Number	**Cable Equipment ID**	**Temperature rise due to surrounding heat sources**	**Induced current on Metallic Screen**	**Cable Capacitance**	**Surge Impedance**	**Reactance of Conductor**	**Reactance of Metallic Sheath**	**Voltage drop for Three Phase System**
-	2kVmD.WS-	kp.f 6	V.W	V.11	18.28	V.k6	V.28	V.Vk
2	2kVmD.WS-	12.pf	V.W	V.11	18.28	V.k6	V.28	V.Vk
k	2kVmD.WS-	1k.f 6	V.W	V.11	18.28	V.k6	V.28	V.Vk
1	2kVmD.WS-	1D.28	V.W	V.11	18.28	V.k6	V.28	V.Vk
D	2kVmD.WS-	k6.p2	V.W	V.11	18.28	V.k6	V.28	V.Vk
f	2kVmD.WS-	1f.18	V.W	V.11	18.28	V.k6	V.28	V.Vk
p	2kVmD.WS-	1D.1p	V.W	V.11	18.28	V.k6	V.28	V.Vk
8	2kVmD.WS-	1f.p2	V.W	V.11	18.28	V.k6	V.28	V.Vk
6	2kVmD.WS-	k6.88	V.W	V.11	18.28	V.k6	V.28	V.Vk
-V	2kVmD.WS-	k8.-D	V.W	V.11	18.28	V.k6	V.28	V.Vk
--	2kVmD.WS-	1k.kk	V.W	V.11	18.28	V.k6	V.28	V.Vk
-2	2kVmD.WS-	11.k8	V.W	V.11	18.28	V.k6	V.28	V.Vk
-k	DWmD.WS	kp.f 8	V.W	V.k1	D8.86	V.11	V.W	V.Vk
-1	DWmD.WS	12.1V	V.W	V.k1	D8.V6	V.1k	V.W	V.Vk
-D	DWmD.WS	1k.1D	V.W	V.k1	D8.86	V.11	V.W	V.Vk
-f	DWmD.WS	kp.8V	V.W	V.k1	D8.86	V.11	V.W	V.Vk
-p	DWmD.WS	12.2f	V.W	V.k1	D8.V6	V.1k	V.W	V.Vk
-8	DWmD.WS	1k.DD	V.W	V.k1	D8.86	V.11	V.W	V.Vk
-6	DWmD.WS	kp.28	V.W	V.k1	D8.86	V.11	V.W	V.Vk
2V	DWmD.WS	1-.k-	V.W	V.k1	D8.V6	V.1k	V.W	V.Vk
2-	DWmD.WS	12.pp	V.W	V.k1	D8.86	V.11	V.W	V.Vk
22	DWmD.WS	kf.6V	V.W	V.k1	D8.86	V.11	V.W	V.Vk
2k	DWmD.WS	1-.pD	V.W	V.k1	D8.V6	V.1k	V.W	V.Vk
21	DWmD.WS	12.2V	V.W	V.k1	D8.86	V.11	V.W	V.Vk

Study Summary

CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T1.- 302kV, _ and DVV, _08C 5c mODVVV, uL il mFO8D 54/
Date:	D:2k:2V21 6A28A-p bM

General Simulation Data

Steady State Option	qneyFallN 4oaded
Consider Electrical interaction between circuits	Bo
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	V.VV
Conductor Resistances Computation Option:	IUm0228

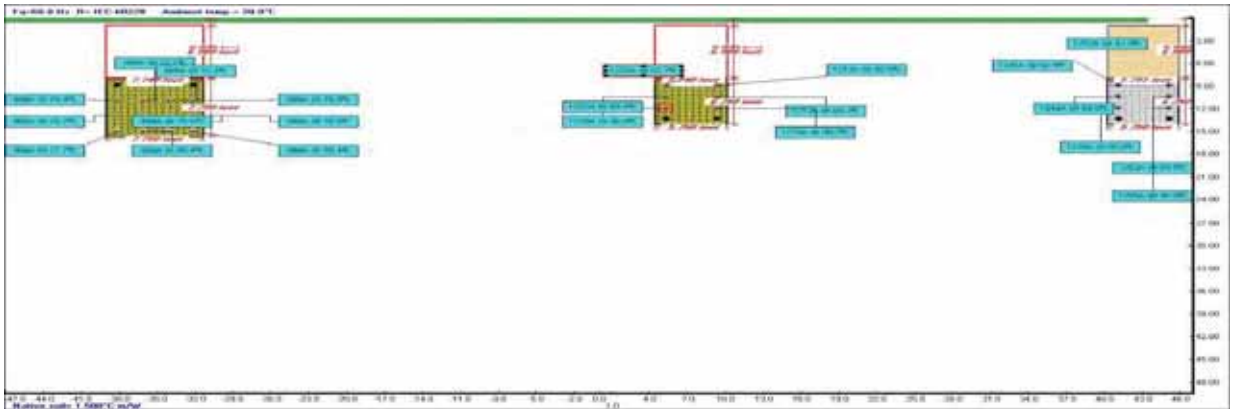
Standard Settings Options

General guidance	mFstoL
Factor on RAC due to magnetic armour	mIGRUGFidanue
Factor on RAC due to magnetic duct	mIGRUGFidanue
Factor on λ1 due to magnetic armour	mYMmbPGFidanue
Factor on λ1 due to magnetic duct	mIGRUGFidanue
Factor on λ2 due to λ'1	mYMmbPGFidanue
λ''1 computation	mIGRUGFidanue
λ2pipe computation	mYMmbPGFidanue
Wd computation	mIGRUGFidanue
T2 computation	mIGRUGFidanue
T4 computation	mYMmbPGFidanue

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	2V.VV
Native Soil Thermal Resistivity [K.m/W]	- .DV
Consider Non-Isothermal Earth Surface	Bo

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
Xau, 7ll2	p.k8	1.16	D.pD	f .66	V.f V
5X 1S1	0kD.- k	- - .8p	p.pD	p.pf	V.f V
Xau, 7ll	0kD.- k	1.16	p.pD	f .66	V.f V
5X 1S2	p.k8	- - .- 2	D.pD	f .2f	V.f V
Xau, 7llk	1k.- k	1.16	D.pD	f .66	V.f V
5X 1S2	1k.- k	- - .- 2	D.pD	f .2f	V.f V



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
-	2kVmD.WS-	-		b	f V.W	V.8D	0k8.- k	- V.66	pV.12	688.W
2	2kVmD.WS-	-		X	f V.W	V.8D	0k8.- k	- 2.66	pf .2k	688.W
k	2kVmD.WS-	-		m	f V.W	V.8D	0k8.- k	- 1.66	pp.f 8	688.W
1	2kVmD.WS-	2		b	f V.W	V.8D	0kf .- k	- 2.66	p8.1k	688.W
D	2kVmD.WS-	2		X	f V.W	V.8D	0kf .- k	- V.66	p2.- 1	688.W
f	2kVmD.WS-	2		m	f V.W	V.8D	0kf .- k	- 1.66	8V.- f	688.W
p	2kVmD.WS-	k		b	f V.W	V.8D	0k1.- k	- 2.66	p8.f 2	688.W
8	2kVmD.WS-	k		X	f V.W	V.8D	0k1.- k	- 1.66	8V.k6	688.W
6	2kVmD.WS-	k		m	f V.W	V.8D	0k1.- k	- V.66	p2.kV	688.W
- V	2kVmD.WS-	1		b	f V.W	V.8D	0k2.- k	- V.66	pV.88	688.W
- -	2kVmD.WS-	1		X	f V.W	V.8D	0k2.- k	- 2.66	pf .8V	688.W
- 2	2kVmD.WS-	1		m	f V.W	V.8D	0k2.- k	- 1.66	p8.kp	688.W
- k	DVmD.WS	D		b	f V.W	V.8D	D.k8	8.6D	82.f 6	- 22- .Df
- 1	DVmD.WS	D		X	f V.W	V.8D	6.k8	- V.1D	86.22	- 2- 2.- 6
- D	DVmD.WS	D		m	f V.W	V.8D	D.k8	- - .6D	6V.W	- 2- 8.1f
- f	DVmD.WS	D		b	f V.W	V.8D	6.k8	8.6D	82.Dk	- 2- - .62
- p	DVmD.WS	D		X	f V.W	V.8D	D.k8	- V.1D	86.k8	- 22- .26
- 8	DVmD.WS	D		m	f V.W	V.8D	6.k8	- - .6D	6V.W	- 2- D.V2
- 6	DVmD.WS	f		b	f V.W	V.8D	1- .- k	8.6D	82.6V	- 21V.8V
2V	DVmD.WS	f		X	f V.W	V.8D	1D.- k	- V.1D	86.D1	- 2D2.8k
2-	DVmD.WS	f		m	f V.W	V.8D	1- .- k	- - .6D	6V.W	- 2kp.6D
22	DVmD.WS	f		b	f V.W	V.8D	1D.- k	8.6D	82.88	- 2D2.kp
2k	DVmD.WS	f		X	f V.W	V.8D	1- .- k	- V.1D	86.DD	- 21V.k1
21	DVmD.WS	f		m	f V.W	V.8D	1D.- k	- - .6D	6V.W	- 2DD.2-

Cables Report

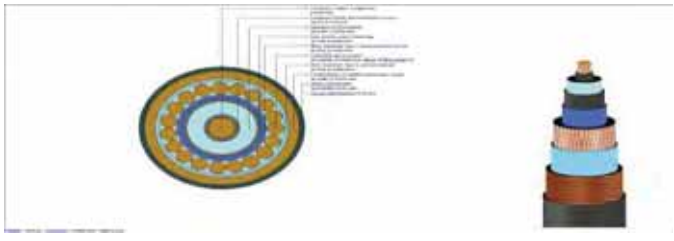
CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T1.- 302kV, _ and DVV, _08C 5 c mDDVW, uL il nF08D 5 4/
Date:	D:2k:2V21 6A28A p bM

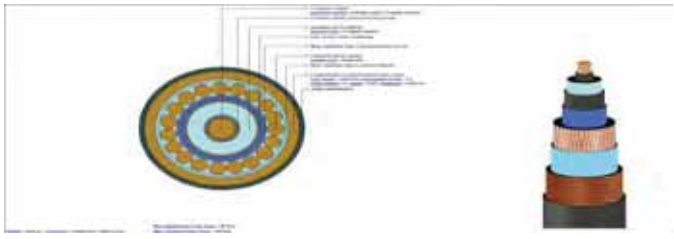
No.	Description	Unit	1
General Cable Information			
-	ma3le UyFIEL ent IS		2kVmDJWS-
2	BFL 3er o7mores		gin9le more
k	_olta9e	[_ _]	2kV.W
1	mondFutor brea	[in²]	k.6k
D	ma3le c verall 5 aL eter	[in]	D.22
f	MaxiL FL gteadNptate mondFutor TeL EeratFre	[°m]	6V.W
p	MaxiL FL UL er9enuN mondFutor TeL EeratFre	[°m]	- VD.W
Conductor			
8	Material		mbEEer
6	Ueutriual ResistivitNat 2V°m	[µΩ.uL]	- .ρ2
- V	TeL EeratFre mpe7fuient at 2V°m	[- :K]	V.W
- -	ReuiEroual o7 TeL EeratFre mpe7fuient o7 Resistanue (XUTb)	[K]	2k1.1D
- 2	_olPL etriu gEeuJfu Heat (gH)	[J:(K*uL °)]	k.1D
- k	monstrFution		f .ge9L ents
- 1	mondFutor InsFlation ghiteL		UatrFded
- D	Milli_en Wires monstrFution		InsFlated Wires
- f	Ks (g_in U9fout mpe7fuient)		V.kD
- p	KE (Provid. itN U9fout mpe7fuient)		V.2V
- 8	5 iaL eter	[in]	2.Dl
Conductor Shield			
- 6	Thiu_ness	[in]	V.- V
2V	5 iaL eter	[in]	2.p1
Insulation			
2-	Material		S4PU qn7lled
22	TherL al ResistivitN	[K.L :W]	k.DV
2k	5 ieleutriu 4oss / autor 0 (tan delta)		V.W
21	Relative PerL ittivitN0 (eSsilon)		2.DV
2D	gEeuJfu InsFlation Resistanue monstant at f°V° 0 (K)	[M0.1000ft]	- 8DB.Vf
2f	Thiu_ness	[in]	V.6-
2p	5 iaL eter	[in]	1.DD
Insulation Screen			
28	Material		geL i mondFutin9 gureen
26	Thiu_ness	[in]	V.VD
kV	5 iaL eter	[in]	1.f D
Non Metallic Layer - Water Swellable Tape 1			
k-	Material		USTRq 5 U5 gUMtmc B 5 q nfT1_U gnfKUUB
k2	TherL al ResistivitN	[K.L :W]	2.DV
kk	Thiu_ness	[in]	V.V2
k1	5 iaL eter	[in]	1.f 6
Concentric neutral/Skid wires			
kD	bre mpnuentriu BeFtral Wires broFind Uauh mpre?		n:a
kf	Material		mbEEer
kp	Ueutriual ResistivitNat 2V°m	[µΩ.uL]	- .ρ2
k8	TeL EeratFre mpe7fuient at 2V°m	[- :K]	V.W
k6	ReuiEroual o7 TeL EeratFre mpe7fuient o7 Resistanue (XUTb)	[K]	2k1.DV
1V	_olPL etriu gEeuJfu Heat (gH)	[J:(K*uL °)]	k.1D
1-	Wire TNEe		RoFnd Wires
12	4en9th o74aN	[in]	1D.Df
1k	BFL 3er o7Wires		1f
11	Wire GaF9e		- 1
1D	Thiu_ness	[in]	V.Vf
1f	5 iaL eter	[in]	1.82
Sheath			
1p	Is gheath broFind Uauh more?		n:a
18	Material		mbEEer
16	Ueutriual ResistivitNat 2V°m	[µΩ.uL]	- .ρ2
DV	TeL EeratFre mpe7fuient at 2V°m	[- :K]	V.W
D	ReuiEroual o7 TeL EeratFre mpe7fuient o7 Resistanue (XUTb)	[K]	2k1.DV
Df	_olPL etriu gEeuJfu Heat (gH)	[J:(K*uL °)]	k.1D
Dk	monrFlation TNEe		4onBtFdinaBNmonrFSated
Dl	monrFlation hetBht	[in]	V.V-
DD	TaEe overlaE	[in]	V.DV
Df	TaEe width	[in]	- D.6-
Dp	TaEe thiu_ness	[in]	V.V-
D8	buuFl Flaton 3tutor		- .2V
D6	Thiu_ness	[in]	V.V-
f V	5 iaL eter	[in]	1.6-
Jacket			
f -	Material		PolNethNene
f 2	TherL al ResistivitN	[K.L :W]	k.DV
f k	Thiu_ness	[in]	V.- D
f 1	5 iaL eter	[in]	D.22

No.	Description	Unit	1
Specific Installation Data			
f D	ma3le UyFIEL ent IS		2kVmDJWS-
f f	ma3le /reyFenuN	[Hz]	f V.W
f p	gheath : ghield Xondin9		- mondFutor - Point Xonded / lat
f 8	4oss / autor monstant (b•k-g)		V.kV
f 6	mondFit uonstrFution		P_m5:FuI in mbnurete
pV	mondFit L aterial therL al resistivitN	[K.L :W]	f .W
p-	mondFit 3Bin9 L aterial		bir
p2	Inner daL eter o7the uondFit	[in]	p.68
pk	c Fter daL eter o7the uondFit	[in]	8.f 2

Cable ID : 230C5.00X1

ma3le Title: 2kV, _ODVW , uL il nF 0 f ge9O6Vf S4PUOnF unOPrNeL ian





Cables Report

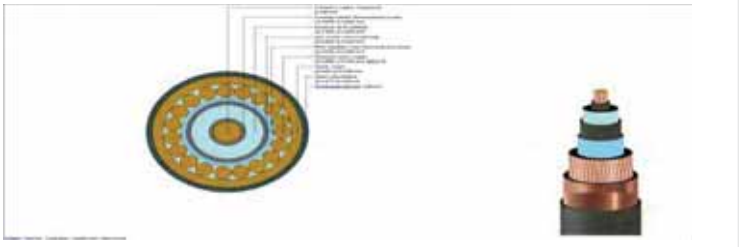
CYMCAP Version	8.2 Revision 2
Study:	Golden to Mars
Execution:	T1.- 3Qzk\V, _ and DVV, _.O8C 5c mODVVV, uL il mFO8D 5 4/
Date:	D:2k:2V21 6A28A p bM

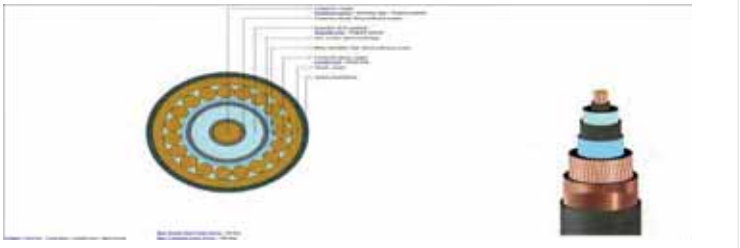
No.	Description	Unit	1
General Cable Information			
	ma3le UyFiEL ent I5		DVVmD.VVS
2	BFL 3er o7 mores		gin9le more
k	_oltz9le	[_,,,]	DVV.VV
1	mondFutor brea	[in²]	k.6k
D	ma3le c verall 5 taL eter	[in]	D.66
f	Maxil. FL gteadN0gtate mondFutor TeL EeratFre	[°m]	6V.W
p	Maxil. FL UL er9enuN mondFutor TeL EeratFre	[°m]	- V0.VV
Conductor			
8	Material		mbEEer
6	Uleutrial ResistivitNat 2V^m	[µΩ.uL]	- .p2
-V	TeL EeratFre mpe7fuient at 2V^m	[- :K]	V.W
--	ReulEroual o7TeL EeratFre mpe7fuient o7Resistanue (XUTb)	[K]	2k1.1D
-2	_olFL etriu gEeuJfu Heat (gH)	[J:(K°uL °)]	k.1D
-k	monstrFution		f ge9L ents
-1	mondFutor InsFlation gNateL		UstrFded
-D	Milli, en Wires monstrFution		InsFlated Wires
-f	Ks (g, in U7fbut mpe7fuient)		V.kD
-p	KE (ProxiL itN U7fbut mpe7fuient)		V.2V
-8	5 taL eter	[in]	2.16
Conductor Shield			
-6	Thiu, ness	[in]	V.Vf
2V	5 taL eter	[in]	2.f -
Insulation			
2-	Material		S4PU qn3lled
22	TherL al ResistivitN	[K.L :W]	k.DV
2k	5 leleutiu 4oss / autor 0(tan delta)		V.W
21	Relative PerL ittivitN0(eEsilon)		2.DV
2D	gEeuJfu InsFlation Resistanue monstant at f V^/ 0(K)	[M0.1000ft]	- 8DB.Vf
2f	Thiu, ness	[in]	- .22
2p	5 taL eter	[in]	D.VD
Insulation Screen			
28	Material		gel. i mondFutin9 gureen
26	Thiu, ness	[in]	V.Vf
kV	5 taL eter	[in]	D.- p
Non Metallic Layer - Water Swellable Tape			
k-	Material		USTRq 5 U5 gLMImc BSqmf1_U gmRUJB
k2	TherL al ResistivitN	[K.L :W]	2.DV
kk	Thiu, ness	[in]	V.V1
k1	5 taL eter	[in]	D.21
Concentric neutral/Skid wires			
kD	bre mpnuentriu BeFtral Wires broFnd Uauh mpre?		n:a
kf	Material		mbEEer
kp	Uleutrial ResistivitNat 2V^m	[µΩ.uL]	- .p2
k8	TeL EeratFre mpe7fuient at 2V^m	[- :K]	V.W
k6	ReulEroual o7TeL EeratFre mpe7fuient o7Resistanue (XUTb)	[K]	2k1.DV
1V	_olFL etriu gEeuJfu Heat (gH)	[J:(K°uL °)]	k.1D
1-	Wire TNEe		RoFnd Wires
12	4en9th o74aN	[in]	1D.Df
1k	BFL 3er o7 Wires		kf
11	Wire GaF9e		qnde7hed
1D	Thiu, ness	[in]	V.V6
1f	5 taL eter	[in]	D.1-
Sheath			
1p	Is gheath broFnd Uauh mpre?		n:a
18	Material		mbEEer
16	Uleutrial ResistivitNat 2V^m	[µΩ.uL]	- .p2
DV	TeL EeratFre mpe7fuient at 2V^m	[- :K]	V.W
D-	ReulEroual o7TeL EeratFre mpe7fuient o7Resistanue (XUTb)	[K]	2k1.DV
D2	_olFL etriu gEeuJfu Heat (gH)	[J:(K°uL °)]	k.1D
Dk	mprrF9ation TNEe		Bon mprrF9ated
D1	Thiu, ness	[in]	V.V-
DD	5 taL eter	[in]	D.11
Jacket			
Df	Material		PolNethNene
Dp	TherL al ResistivitN	[K.L :W]	k.DV
D8	Thiu, ness	[in]	V.28
D6	5 taL eter	[in]	D.66

No.	Description	Unit	1
Specific Installation Data			
fV	ma3le UyFiEL ent I5		DVVmD.VVS
f-	ma3le / reyFenuN	[Hz]	f V.W
f2	gheath : ghield Xondin9		MFitiua3les - Point Xonded
fk	4oss / autor monstant (b4c g)		V.kV
f1	mondFt uonstrFution		P_m5:Fut in mpnurete
fD	mondFt L aterial therL al resistivitN	[K.L :W]	f .W
ff	mondFt 3lin9 L aterial		bir
fp	Inner diaL eter o7the uondFt	[in]	p.68
f8	c Fter diaL eter o7the uondFt	[in]	8.f 2

Cable ID : 500C5.00X

ma3le Title	DVV, _.ODVVV, uL il mF 0f ge9O-22- S4PUOmF mpnuOTaihan





Study Summary

CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T1.1a1-230kV, 8_ DOC, 5000kcmil Cu, 100 DLF
Date:	6/4/2024 10:51:20 AM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.00
Conductor Resistances Computation Option:	IEC-228

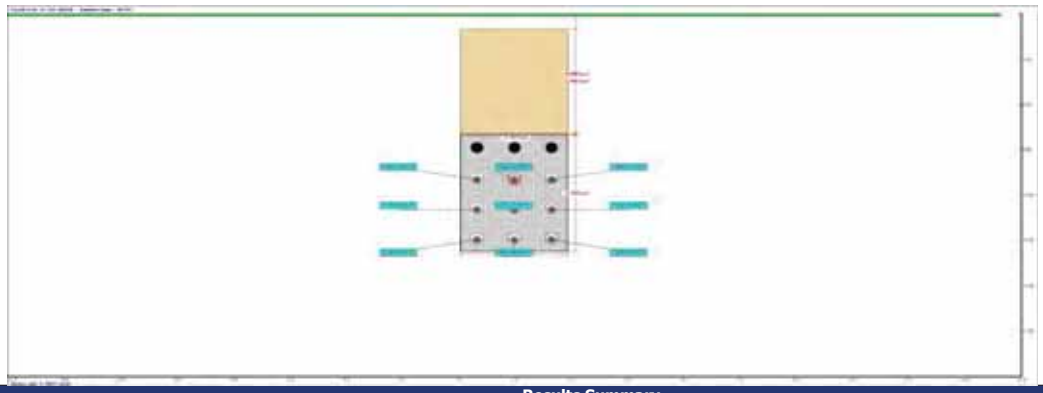
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
DB 4X3	0.00	11.88	5.75	7.75	0.60
Backfill	0.00	4.50	5.75	7.00	0.60



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	230C5.00X1	1		A	60.00	1.00	-2.00	10.99	85.07	1293.39
2	230C5.00X1	1		B	60.00	1.00	0.00	10.99	90.00	1399.97
3	230C5.00X1	1		C	60.00	1.00	2.00	10.99	85.07	1293.53
4	230C5.00X1	1		A	60.00	1.00	-2.00	12.99	88.07	1125.40
5	230C5.00X1	1		B	60.00	1.00	0.00	12.99	90.00	1067.44
6	230C5.00X1	1		C	60.00	1.00	2.00	12.99	88.07	1125.12
7	230C5.00X1	1		A	60.00	1.00	-2.00	14.99	88.11	1129.02
8	230C5.00X1	1		B	60.00	1.00	0.00	14.99	90.00	1080.40
9	230C5.00X1	1		C	60.00	1.00	2.00	14.99	88.11	1129.16

Steady State Summary

CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T1.1a1-230kV, 8_ DOC, 500kcmil Cu, 100 DLF
Date:	6/4/2024 10:51:20 AM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits) [A]	0.00

Variable	Description	Unit	Cables								
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9
General Input Data											
Cable ID	Cable Equipment ID		230CS.00X1	230CS.00X1	230CS.00X1	230CS.00X1	230CS.00X1	230CS.00X1	230CS.00X1	230CS.00X1	230CS.00X1
Circuit No.	Circuit No.		1	1	1	1	1	1	1	1	1
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
x	X coordinate	[ft]	-2.00	0.00	2.00	-2.00	0.00	2.00	-2.00	0.00	2.00
y	Y coordinate	[ft]	10.99	10.99	10.99	12.99	12.99	12.99	14.99	14.99	14.99
DLF	Daily Load Factor	[p.u.]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Bonding Type		Multicables 1 Point Bonded	Multicables 1 Point Bonded	Multicables 1 Point Bonded	Multicables 1 Point Bonded	Multicables 1 Point Bonded	Multicables 1 Point Bonded	Multicables 1 Point Bonded	Multicables 1 Point Bonded	Multicables 1 Point Bonded
Ampacity											
I	Steady State Ampacity	[A]	1293.39	1399.97	1293.53	1125.40	1067.44	1125.12	1129.02	1080.40	1129.16
I_{ss}	Steady State Ampacity without insulation temperature drop constraint	[A]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Temperatures											
Bc	Conductor temperature	[°C]	85.07	90.00	85.07	88.07	90.00	88.07	88.11	90.00	88.11
*Δ*Bins	Temperature drop across the insulation	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Bs	Sheath/Shield temperature	[°C]	79.19	83.09	79.19	83.51	85.85	83.51	83.53	85.76	83.53
Ba	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Bsurf	Cable surface temperature	[°C]	78.54	82.29	78.54	83.00	85.35	83.00	83.01	85.26	83.02
Bduct	Duct surface temperature	[°C]	73.06	75.68	73.06	78.76	81.24	78.76	78.78	81.18	78.78
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
y_s	Skin Effect Factor		0.17	0.16	0.17	0.16	0.16	0.16	0.16	0.16	0.16
y_p	Proximity Effect Factor		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Losses											
Wc	Conductor Losses	[W/ft]	5.18	6.14	5.18	3.95	3.57	3.95	3.98	3.66	3.98
Wd	Dielectric Losses	[W/ft]	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
Ws	Metallic Screen Losses	[W/ft]	0.13	0.48	0.13	0.13	0.41	0.13	0.10	0.28	0.10
Wa	Armor/Pipe Losses	[W/ft]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wt	Total Losses	[W/ft]	5.87	7.18	5.87	4.63	4.53	4.63	4.63	4.50	4.63
λ_1	Screen Loss Factor		0.03	0.08	0.03	0.03	0.11	0.03	0.03	0.08	0.03
λ_2	Armour Loss Factor + Pipe Loss Factor		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thermal resistances											
T1	Thermal Resistance Between Conductor and Screen	[K.m/W]	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
T2	Thermal Resistance Between Screen and Armour	[K.m/W]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T3	Thermal Resistance of the Jacket/Pipe Coating	[K.m/W]	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
T4	Total external thermal resistance	[K.m/W]	3.04	2.64	3.04	4.15	4.39	4.15	4.15	4.42	4.15
Others											
*Δ*Bint	Temperature rise due to surrounding heat sources	[°C]	42.52	43.24	42.52	49.77	52.72	49.77	48.96	51.91	48.95
	Induced Voltage (standing) on Sheath	[V/mile]	533.46	400.14	533.57	552.83	411.53	552.38	533.49	400.14	533.53
	Induced Voltage (standing) on Concentric Wires	[V/mile]	536.70	403.51	536.81	555.65	414.65	555.18	536.73	403.50	536.77
	Induced current on Metallic Screen	[A]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Cables Report

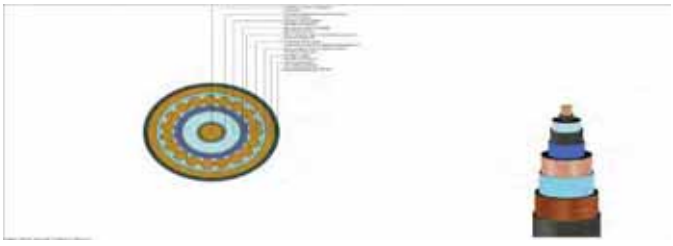
CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T1.1a1-230kV, 8_ DOC, 5000kcmil Cu, 100 DLF
Date:	6/4/2024 10:51:20 AM

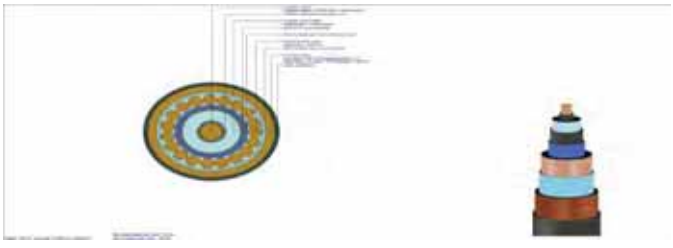
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230.00
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90.00
7	Maximum Emergency Conductor Temperature	[°C]	105.00
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.72
10	Temperature Coefficient at 20°C	[1/K]	0.00
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.45
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.20
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.10
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.50
23	Dielectric Loss Factor - (tan delta)		0.00
24	Relative Permittivity - (epsilon)		2.50
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858.06
26	Thickness	[in]	0.91
27	Diameter	[in]	4.55
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.65
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.50
33	Thickness	[in]	0.02
34	Diameter	[in]	4.69
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.72
38	Temperature Coefficient at 20°C	[1/K]	0.00
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.50
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.56
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.06
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.72
50	Temperature Coefficient at 20°C	[1/K]	0.00
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.50
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.01
55	Tape overlap	[in]	0.50
56	Tape width	[in]	15.91
57	Tape thickness	[in]	0.01
58	Accumulaton factor		1.20
59	Thickness	[in]	0.01
60	Diameter	[in]	4.91
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.50
63	Thickness	[in]	0.15
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60.00
67	Sheath / Shield Bonding		Multicables 1 Point Bonded
68	Loss Factor Constant (ALOS)		0.30
69	Conduit construction		PVC Duct in Concrete
70	Conduit material thermal resistivity	[K.m/W]	6.00
71	Conduit filling material		Air
72	Inner diameter of the conduit	[in]	7.98
73	Outer diameter of the conduit	[in]	8.62

Cable ID : 230C5.00X1

Cable Title	230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





Study Summary

CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T1.1a2-230kV, 8_ DOC, 5000kcmil Cu, 85 DLF
Date:	6/4/2024 10:02:34 AM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.00
Conductor Resistances Computation Option:	IEC-228

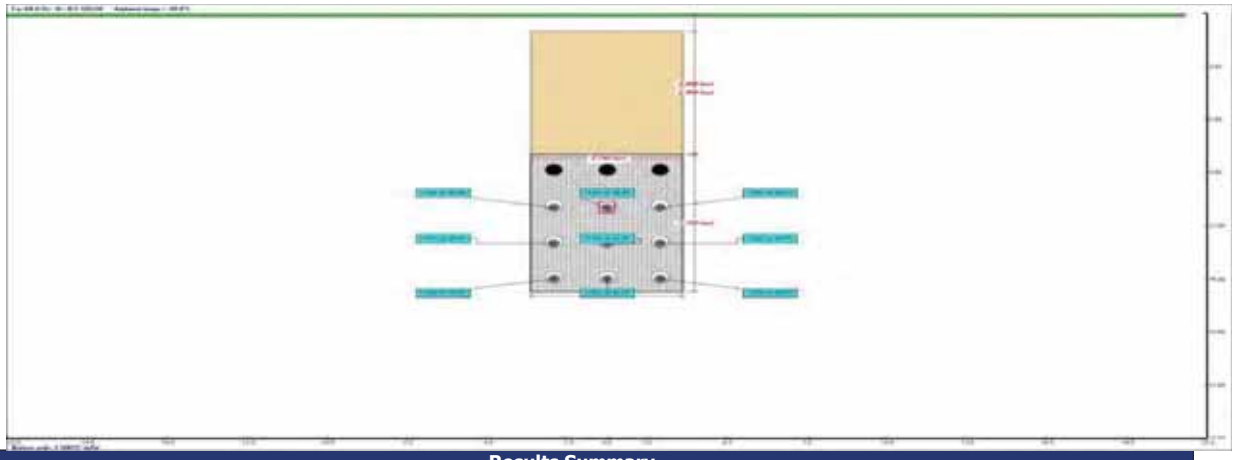
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.50
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
DB 4X3	0.00	11.88	5.75	7.75	0.60
Backfill	0.00	4.50	5.75	7.00	0.60



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	230C5.00X1	1		A	60.00	0.85	-2.00	10.99	85.56	1335.80
2	230C5.00X1	1		B	60.00	0.85	0.00	10.99	90.01	1445.25
3	230C5.00X1	1		C	60.00	0.85	2.00	10.99	85.55	1335.95
4	230C5.00X1	1		A	60.00	0.85	-2.00	12.99	88.48	1166.59
5	230C5.00X1	1		B	60.00	0.85	0.00	12.99	90.01	1119.36
6	230C5.00X1	1		C	60.00	0.85	2.00	12.99	88.48	1166.31
7	230C5.00X1	1		A	60.00	0.85	-2.00	14.99	88.81	1158.39
8	230C5.00X1	1		B	60.00	0.85	0.00	14.99	90.00	1096.17
9	230C5.00X1	1		C	60.00	0.85	2.00	14.99	88.81	1158.52

Steady State Summary

CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T1.1a2-230kV, 8_ DOC, 5000kcmil Cu, 85 DLF
Date:	6/4/2024 10:02:34 AM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.50
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits) [A]	0.00

Variable	Description	Unit	Cables								
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9
General Input Data											
Cable ID	Cable Equipment ID		230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1
Circuit No.	Circuit No.		1	1	1	1	1	1	1	1	1
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
x	X coordinate	[ft]	-2.00	0.00	2.00	-2.00	0.00	2.00	-2.00	0.00	2.00
y	Y coordinate	[ft]	10.99	10.99	10.99	12.99	12.99	12.99	14.99	14.99	14.99
DLF	Daily Load Factor	[p.u.]	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
	Bonding Type		Multicables 1 Point Bonded	Multicables 1 Point Bonded	Multicables 1 Point Bonded	Multicables 1 Point Bonded	Multicables 1 Point Bonded	Multicables 1 Point Bonded	Multicables 1 Point Bonded	Multicables 1 Point Bonded	Multicables 1 Point Bonded
Ampacity											
I	Steady State Ampacity	[A]	1335.80	1445.25	1335.95	1166.59	1119.36	1166.31	1158.39	1096.17	1158.52
I_∞	Steady State Ampacity without insulation temperature drop constraint	[A]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Temperatures											
Bc	Conductor temperature	[°C]	85.56	90.01	85.55	88.48	90.01	88.48	88.81	90.00	88.81
ΔBins	Temperature drop across the insulation	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Bs	Sheath/Shield temperature	[°C]	79.30	82.66	79.29	83.61	85.48	83.60	83.99	85.65	83.99
Ba	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Bsurf	Cable surface temperature	[°C]	78.60	81.81	78.60	83.06	84.93	83.05	83.45	85.14	83.45
Bduct	Duct surface temperature	[°C]	72.79	74.79	72.78	78.54	80.45	78.53	79.02	80.95	79.02
Resistances											
Re	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
ys	Skin Effect Factor		0.17	0.16	0.17	0.16	0.16	0.16	0.16	0.16	0.16
yp	Proximity Effect Factor		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Losses											
Wc	Conductor Losses	[W/ft]	5.53	6.55	5.53	4.25	3.93	4.25	4.19	3.77	4.19
Wd	Dielectric Losses	[W/ft]	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
Ws	Metallic Screen Losses	[W/ft]	0.14	0.51	0.14	0.14	0.45	0.14	0.11	0.29	0.11
Wa	Armor/Pipe Losses	[W/ft]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wt	Total Losses	[W/ft]	6.23	7.61	6.23	4.94	4.93	4.94	4.85	4.61	4.85
λ_1	Screen Loss Factor		0.03	0.08	0.03	0.03	0.11	0.03	0.03	0.08	0.03
λ_2	Armour Loss Factor + Pipe Loss Factor		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thermal resistances											
T1	Thermal Resistance Between Conductor and Screen	[K.m/W]	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
T2	Thermal Resistance Between Screen and Armour	[K.m/W]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T3	Thermal Resistance of the Jacket/Pipe Coating	[K.m/W]	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
T4	Total external thermal resistance	[K.m/W]	2.87	2.47	2.87	3.89	4.01	3.89	3.98	4.30	3.98
Others											
ΔBint	Temperature rise due to surrounding heat sources	[°C]	42.88	43.28	42.88	49.90	52.18	49.90	49.60	52.32	49.60
	Induced Voltage (standing) on Sheath	[V/mile]	550.45	412.88	550.56	570.43	424.64	569.97	550.48	412.88	550.52
	Induced Voltage (standing) on Concentric Wires	[V/mile]	553.79	416.35	553.91	573.34	427.85	572.86	553.82	416.35	553.86
	Induced current on Metallic Screen	[A]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Cables Report

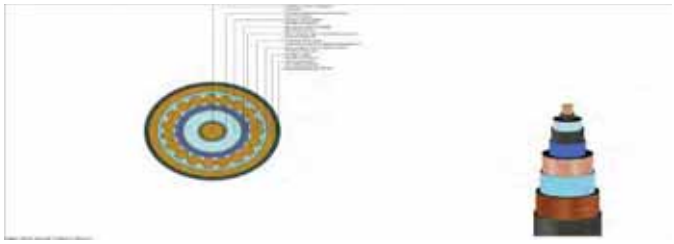
CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T1.1a2-230kV, 8_ DOC, 5000kcmil Cu, 85 DLF
Date:	6/4/2024 10:02:34 AM

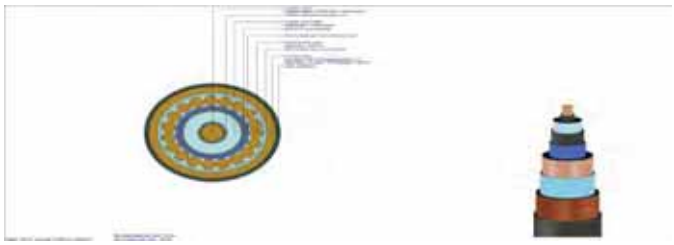
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230.00
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90.00
7	Maximum Emergency Conductor Temperature	[°C]	105.00
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.72
10	Temperature Coefficient at 20°C	[1/K]	0.00
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.45
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.20
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.10
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.50
23	Dielectric Loss Factor - (tan delta)		0.00
24	Relative Permittivity - (epsilon)		2.50
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858.06
26	Thickness	[in]	0.91
27	Diameter	[in]	4.55
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.65
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	3.50
33	Thickness	[in]	0.02
34	Diameter	[in]	4.69
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.72
38	Temperature Coefficient at 20°C	[1/K]	0.00
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.50
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.56
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.06
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.72
50	Temperature Coefficient at 20°C	[1/K]	0.00
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.50
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.01
55	Tape overlap	[in]	0.50
56	Tape width	[in]	15.91
57	Tape thickness	[in]	0.01
58	Accumulaton factor		1.20
59	Thickness	[in]	0.01
60	Diameter	[in]	4.91
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.50
63	Thickness	[in]	0.15
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60.00
67	Sheath / Shield Bonding		Multicables 1 Point Bonded
68	Loss Factor Constant (ALOS)		0.30
69	Conduit construction		PVC Duct in Concrete
70	Conduit material thermal resistivity	[K.m/W]	6.00
71	Conduit filling material		Air
72	Inner diameter of the conduit	[in]	7.98
73	Outer diameter of the conduit	[in]	8.62

Cable ID : 230C5.00X1

Cable Title	230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





Study Summary

CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T2.1a1-300kV, 8_ DOC, 3000k5c il Cm 100 DuL
Date:	F6/6202/ 4:13:/4 AM

General Simulation Data

Steady State Option	Uneqmally uoaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.00
Conductor Resistances Computation Option:	IEC-228

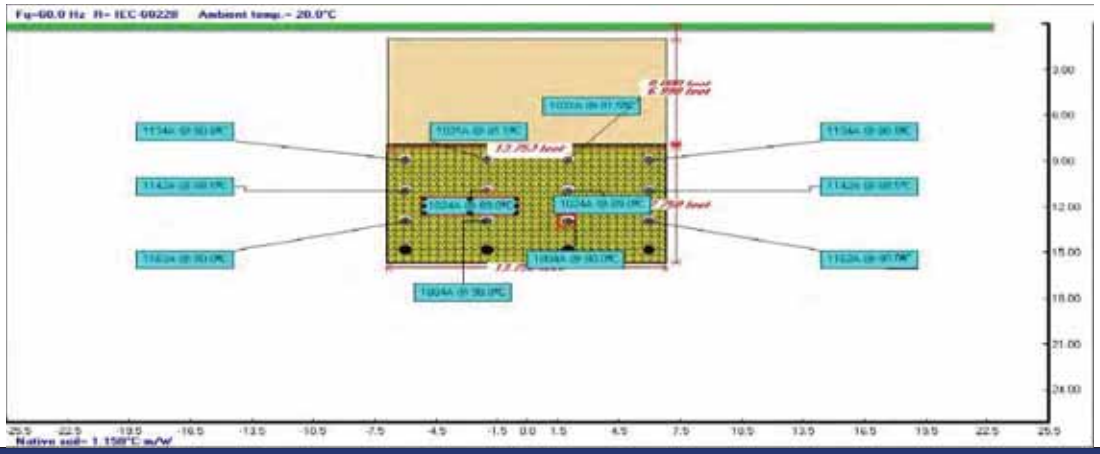
Standard Settings Options

General guidance	Cnstoc
Factor on RAC due to magnetic armour	CIGREGmidan5e
Factor on RAC due to magnetic duct	CIGREGmidan5e
Factor on λ1 due to magnetic armour	CYMCPAGmidan5e
Factor on λ1 due to magnetic duct	CIGREGmidan5e
Factor on λ2 due to λ'1	CYMCPAGmidan5e
λ"1 computation	CIGREGmidan5e
λ2pipe computation	CYMCPAGmidan5e
Wd computation	CIGREGmidan5e
T2 computation	CIGREGmidan5e
T4 computation	CYMCPAGmidan5e

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.13
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
DB /X/	0.00	11.88	14.73	7.73	0.F0
Ba5kfill	0.00	/.30	14.73	7.00	0.F0



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	300C3.00X	1		P	F0.00	1.00	-F.00	8.93	80.77	114/.08
2	300C3.00X	1		B	F0.00	1.00	-2.00	10.93	88.97	1024.34
4	300C3.00X	1		C	F0.00	1.00	2.00	12.93	90.00	1004.9F
/	300C3.00X	1		P	F0.00	1.00	F.00	8.93	80.77	114/.09
3	300C3.00X	1		B	F0.00	1.00	-F.00	10.93	88./9	11/1.97
F	300C3.00X	1		C	F0.00	1.00	-2.00	12.93	90.00	1004.94
7	300C3.00X	1		P	F0.00	1.00	2.00	8.93	81.30	1041./1
8	300C3.00X	1		B	F0.00	1.00	F.00	10.93	88./9	11/1.9F
9	300C3.00X	1		C	F0.00	1.00	-F.00	12.93	90.00	11F1.33
10	300C3.00X	1		P	F0.00	1.00	-2.00	8.93	81.30	1041.49
11	300C3.00X	1		B	F0.00	1.00	2.00	10.93	88.9F	1024.31
12	300C3.00X	1		C	F0.00	1.00	F.00	12.93	90.00	11F1.34

Steady State Summary

CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T2.1a1-300kV, R, DDC, 3000kSc 6 Cnj 100 DuL
Data:	P@!$202[4:13;/4 AM

Simulation Data

Installation type:	Multiple Drillbanks
Steady State Option	Uncrpnally usadad
Ambient temperature [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.13
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits) [A]	0.00

Variable	Description	Unit	Cables											
Cable No.	Cable Index Nne ber		1	2	4	/	3	F	7	8	9	10	11	12
General Input Data														
Cable ID	Cable Eqmlpc ent ID		300C1.00X	300C1.00X	300C1.00X	300C1.00X	300C1.00X	300C1.00X	300C1.00X	300C1.00X	300C1.00X	300C1.00X	300C1.00X	300C1.00X
CrSnt No.	CrSnt No.		1	1	1	1	1	1	1	1	1	1	1	1
Ahase	Cable Ahase		P	B	C	P	B	C	P	B	C	P	B	C
Lq	Operating Lreqmen5y	[Hz]	F0.00	F0.00	F0.00	F0.00	F0.00	F0.00	F0.00	F0.00	F0.00	F0.00	F0.00	F0.00
x	X Soordinate	[ft]	-F.00	-2.00	2.00	F.00	-F.00	-2.00	2.00	F.00	-F.00	-2.00	2.00	F.00
y	Y Soordinate	[ft]	8.93	10.93	12.93	8.93	10.93	12.93	8.93	10.93	12.93	8.93	10.93	12.93
DuL	Dwlly uaed LaTbor	[p.m]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Bonding Type		MnltiSables 1 Aoint Bonded	MnltiSables 1 Aoint Bonded	MnltiSables 1 Aoint Bonded	MnltiSables 1 Aoint Bonded	MnltiSables 1 Aoint Bonded	MnltiSables 1 Aoint Bonded	MnltiSables 1 Aoint Bonded	MnltiSables 1 Aoint Bonded	MnltiSables 1 Aoint Bonded	MnltiSables 1 Aoint Bonded	MnltiSables 1 Aoint Bonded	MnltiSables 1 Aoint Bonded
Ampacity														
I	Steady State Pc paSty	[F]	114/.08	1024.34	1004.9F	114/.09	11/1.97	1004.94	1041/.1	11/1.9F	11F1.33	1041.49	1024.31	11F1.34
I_0	Steady State Pc paSty withomt inmtation tac peraitmo drop Sonstraint	[F]	nSa	nSa	nSa	nSa	nSa	nSa	nSa	nSa	nSa	nSa	nSa	nSa
Temperatures														
θS	CondnSlor tac peraitmo	[°C]	80.77	88.97	90.00	80.77	88./9	90.00	81.30	88./9	90.00	81.30	88.9F	90.00
ΔθIns	Tac paraitmo drop aDross the inmtation	[°C]	nSa	nSa	nSa	nSa	nSa	nSa	nSa	nSa	nSa	nSa	nSa	nSa
θa	SheathSShield tac peraitmo	[°C]	7/.20	84.28	8/./7	7/.20	81.73	8/./7	73.84	81.7/	84.03	73.84	84.28	84.03
θa	Prc ore tac paraitmo	[°C]	nSa	nSa	nSa	nSa	nSa	nSa	nSa	nSa	nSa	nSa	nSa	nSa
θamf	Cable smfaSe tac peraitmo	[°C]	74.12	82.27	84.3/	74.12	80.39	84.34	7/.8F	80.39	81.92	7/.8F	82.27	81.92
ΔθdSI	DnSI smfaSe tac peraitmo	[°C]	F7.8/	77./9	79.12	F7.84	73.09	79.12	70.20	73.09	7F.38	70.20	77./9	7F.38
Resistances														
R_0	DC ResistanSe of the SondnSlor at 20°C	[Ohs ile]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
R	PC ResistanSe of the CondnSlor at Operating Tac peraitmo	[Ohs ile]	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
ys	Skin EffeSt LaTbor		0.17	0.1F	0.1F	0.17	0.1F	0.1F	0.17	0.1F	0.1F	0.17	0.1F	0.1F
yp	Aroxic ity EffeSt LaTbor		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Losses														
WS	CondnSlor uosses	[WIR]	4.9/	4.27	4.1F	4.9/	/.0T	4.1F	4.27	/.0T	/.24	4.27	4.27	/.24
Wd	DelaSerS uosses	[WIR]	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
Wa	MetalS5 SSreen uosses	[WIR]	0.11	0./ 0	0.11	0.11	0./ 2	0.11	0.12	0./ 2	0.11	0.12	0./ 0	0.11
Ww	Prc orSkpe uosses	[WIR]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wt	Total uosses	[WIR]	F.0F	3.F9	3.28	F.0F	F.30	3.28	3./ 0	F.30	F.43	3./ 0	3.F9	F.43
$λ_1$	SSreen uose LaTbor		0.04	0.12	0.0/	0.04	0.10	0.0/	0.0/	0.10	0.04	0.0/	0.12	0.04
$λ_2$	Prc ore uose LaTbor + Ape uose LaTbor		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thermal resistances														
T1	Therc al ResistanSe Between CondnSlor and SSreen	[K.c 6W]	0./ 0	0./ 0	0./ 0	0./ 0	0./ 0	0./ 0	0./ 0	0./ 0	0./ 0	0./ 0	0./ 0	0./ 0
T2	Therc al ResistanSe Between SSreen and Prc ore	[K.c 6W]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T4	Therc al ResistanSe of the JaSentKpe Coating	[K.c 6W]	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Tj	Total external therc al resistanSe	[K.c 6W]	2.F7	4.4/	4.F7	2.F7	2.8/	4.F7	4.10	2.8/	2.97	4.10	4.4/	2.97
Others														
ΔθInt	Tac paraitmo rise dne to snrromnding heat sorrSas	[°C]	4F.41	/8.F4	3F.27	4F.41	/ /.0F	3F.27	/ 2./F	/ /.0F	/ 3.03	/ 2./F	/ 8.F4	/ 3.03
	InstmSed Voltage (standing) on SheaSh	[Vlt ile]	/0/.32	414.F8	/ 1/.21	/0/.32	410.39	/ 1/.21	/ 1/.3/	410.39	/0/.7/	/ 1/.3/	414.F8	/0/.7/
	InstmSed Voltage (standing) on ConSentrS Wires	[Vlt ile]	/0F.8F	41F.0/	/ 1F./ 0	/0F.8F	414.00	/ 1F./ 0	/ 1F.74	414.00	/07.09	/ 1F.74	41F.0/	/07.09
	InstmSed Tmmant on MetalS5 SSreen	[F]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Cables Report

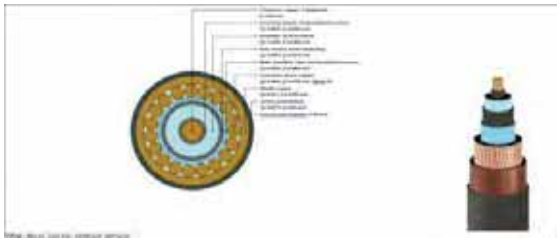
CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T2.1a1-300kV, 8_ DOC, 3000kSc ll Cm; 100 DuL
Date:	F6/ 0202/ 4:13:/ 4 AM

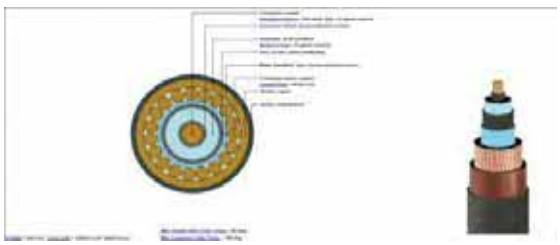
No.	Description	Unit	1
General Cable Information			
1	Cable Eqnipc ent ID		300C3.00X
2	Nre ber of Cores		Single Core
4	Voltage	[kV]	300.00
/	Condr8tor Prea	[in²]	4.94
3	Cable Overall Diac eter	[in]	3.99
F	Maxic re. Steady-State Condr8tor Tec peratrre	[°C]	90.00
7	Maxic re. Ec ergenSy Condr8tor Tvc peratrre	[°C]	103.00
Conductor			
8	Material		Copper
9	Ele5tr5al Resistivity at 20°C	[μΩ.5c]	1.72
10	Tvc peratrre Coeff5Sient at 20°C	[1/K]	0.00
11	Re5ipro5al of Tec peratrre Coeff5Sient of Resistan5e (BETP)	[K]	24/ ./ 3
12	Volre etr5 Spe5if5 Heat (SH)	[JKK°5c ²)]	4./ 3
14	Constrn8tion		F Segc ents
1/	Condr8tor Inentation Systec		Extrn8ed
13	Milliken Wires Constrn8tion		Inentated Wires
1F	Ka (Skin Effe5t Coeff5Sient)		0.43
17	Kp (Anoxic ity Effe5t Coeff5Sient)		0.20
18	Diac eter	[in]	2./ 9
Conductor Shield			
19	Thi5kness	[in]	0.0F
20	Diac eter	[in]	2.F1
Insulation			
21	Material		XuAE Unfilled
22	Therc al Resistivity	[K.c 6W]	4.30
24	Diele5tri5 Loss La5tor - (tan delta)		0.00
2/	Relative Aerc ittivity - (epsilon)		2.30
23	Spe5if5 Inentation Resistan5e Constant at F0°L - (K)	[60. 1000ft]	1838.0F
2F	Thi5kness	[in]	1.22
27	Diac eter	[in]	3.03
Insulation Screen			
28	Material		Sec i Condr8ting Sfreen
29	Thi5kness	[in]	0.0F
40	Diac eter	[in]	3.17
Non Metallic Layer - Water Swellable Tape			
41	Material		EXTRUDED SEMICONDUCTIVE SCREEN
42	Therc al Resistivity	[K.c 6W]	2.30
44	Thi5kness	[in]	0.0/
4/	Diac eter	[in]	3.2/
Concentric neutral/Skid wires			
43	Pre Con5entri5 Nentral Wires Promed Ea5h Core?		n¼
4F	Material		Copper
47	Ele5tri5al Resistivity at 20°C	[μΩ.5c]	1.72
48	Tec peratrew Coeff5Sient at 20°C	[1/K]	0.00
49	Re5ipro5al of Tec peratrre Coeff5Sient of Resistan5e (BETP)	[K]	24/ .30
/0	Volre etr5 Spe5if5 Heat (SH)	[JKK°5c ²)]	4./ 3
/1	Wire Type		Rorred Wires
/2	Length of say	[in]	/ 3.3F
/4	Nre ber of Wires		4F
//	Wire Gange		Undefined
/3	Thi5kness	[in]	0.09
/F	Diac eter	[in]	3./ 1
Sheath			
/7	Is Sheath Promed Ea5h Core?		n¼
/8	Material		Copper
/9	Ele5tri5al Resistivity at 20°C	[μΩ.5c]	1.72
30	Tec peratrew Coeff5Sient at 20°C	[1/K]	0.00
31	Re5ipro5al of Tec peratrre Coeff5Sient of Resistan5e (BETP)	[K]	24/ .30
32	Volre etr5 Spe5if5 Heat (SH)	[JKK°5c ²)]	4./ 3
34	Corrrgation Type		Non Corrrgated
3/	Thi5kness	[in]	0.03
33	Diac eter	[in]	3./ /
Jacket			
3F	Material		Ashylthylene
37	Therc al Resistivity	[K.c 6W]	4.30
38	Thi5kness	[in]	0.28
39	Diac eter	[in]	3.99

No.	Description	Unit	1
Specific Installation Data			
F0	Cable Eqnipc ent ID		300C3.00X
F1	Cable Lreqnen5y	[Hz]	F0.00
F2	Sheath 6Shield Bonding		Mnt5Sables 1 Asint Bonded
F4	oss La5tor Constant (PuOS)		0.40
F/	Condnt Sonstrn8tion		AVC Dn8t in Con5nite
F3	Condnt c aterial therc al resistivity	[K.c 6W]	F.00
FF	Condnt filling c aterial		Pir
F7	Inner diac eter of the Sondnt	[in]	7.98
F8	Onter diac eter of the Sondnt	[in]	8.F2

Cable ID : 500C5.00X

Cable Title	300kV, 3000kSc ll Cm- F Seg, 1221 XuAE, CmCon5, Taihan





Study Summary

CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T2.1a2-300kV, 8_ DOC, 3000k5c il Cm; 83DuL
Date:	F6/ 6202/ 104104: 0 AM

General Simulation Data

Steady State Option	Uneqmally uoaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.00
Conductor Resistances Computation Option:	IEC-228

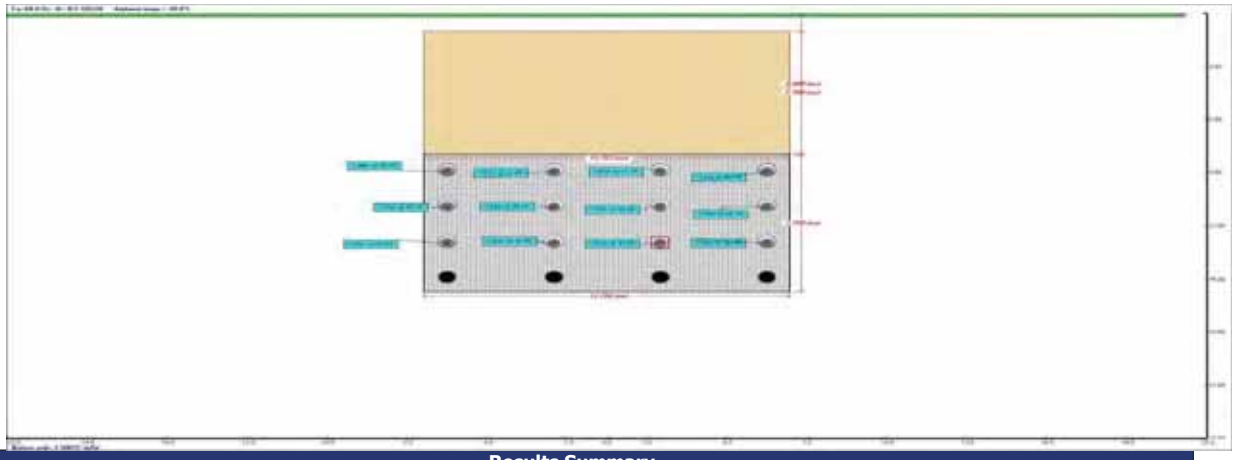
Standard Settings Options

General guidance	Cmstoc
Factor on RAC due to magnetic armour	CIGREGmidan5e
Factor on RAC due to magnetic duct	CIGREGmidan5e
Factor on λ_1 due to magnetic armour	CYMCAPGmidan5e
Factor on λ_1 due to magnetic duct	CIGREGmidan5e
Factor on λ_2 due to λ'_1	CYMCAPGmidan5e
λ''_1 computation	CIGREGmidan5e
$\lambda_2$pipe computation	CYMCAPGmidan5e
Wd computation	CIGREGmidan5e
T_2 computation	CIGREGmidan5e
T_4 computation	CYMCAPGmidan5e

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.30
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
DB / X/	0.00	11.88	1: .73	7.73	0.F0
Ba5kfill	0.00	/ .30	1: .73	7.00	0.F0



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	300C3.00X	1		A	F0.00	0.83	-F.00	8.93	80.9:	11/ / .29
2	300C3.00X	1		B	F0.00	0.83	-2.00	10.93	88.F2	1037.97
:	300C3.00X	1		C	F0.00	0.83	2.00	12.93	90.00	10/ 2.: F
/	300C3.00X	1		A	F0.00	0.83	F.00	8.93	80.9:	11/ / .: F
3	300C3.00X	1		B	F0.00	0.83	-F.00	10.93	88.: :	11/ 9./ 0
F	300C3.00X	1		C	F0.00	0.83	-2.00	12.93	90.00	10/ 2.28
7	300C3.00X	1		A	F0.00	0.83	2.00	8.93	81./ 0	10F: .07
8	300C3.00X	1		B	F0.00	0.83	F.00	10.93	88.: :	11/ 9./ 0
9	300C3.00X	1		C	F0.00	0.83	-F.00	12.93	90.00	11F3.07
10	300C3.00X	1		A	F0.00	0.83	-2.00	8.93	81./ 0	10F: .02
11	300C3.00X	1		B	F0.00	0.83	2.00	10.93	88.F2	1037.97
12	300C3.00X	1		C	F0.00	0.83	F.00	12.93	90.00	11F3.02

Steady State Summary

CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T2.1a2-300kV_6_ DOC_ 3000kSc II Cry 830kL
Date:	7/9/2032 10:26:06 A.M.

Simulation Data

Installation type	Multiple Ductbanks
Steady State Option	Unevenly loaded
Ambient temperature [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.30
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits) [A]	0.00

Variable	Description	Unit	Cables											
Cable No	Cable Index Nre ber		1	2	:	/	3	7	7	8	9	10	11	12
General Input Data														
Cable ID	Cable Ecmpc ent ID		300C5.00X	300C5.00X	300C5.00X	300C5.00X	300C5.00X	300C5.00X	300C5.00X	300C5.00X	300C5.00X	300C5.00X	300C5.00X	300C5.00X
CirSnk No.	CirSnk No.		1	1	1	1	1	1	1	1	1	1	1	1
Phase	Cable Phase		A	B	C	A	B	C	A	B	C	A	B	C
Ln	Operating Lnopnen'Sy	[Hz]	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
x	X Soordinate	[ft]	-F.00	-2.00	2.00	F.00	-F.00	-2.00	2.00	F.00	-F.00	-2.00	2.00	F.00
y	Y Soordinate	[ft]	8.93	10.93	12.93	8.93	10.93	12.93	8.93	10.93	12.93	8.93	10.93	12.93
DzL	Delty uoed Lx/Sor	[p.m]	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
	Bonding Type		MnldSaNres 1 Point Bonded	MnldSaNres 1 Point Bonded	MnldSaNres 1 Point Bonded	MnldSaNres 1 Point Bonded	MnldSaNres 1 Point Bonded	MnldSaNres 1 Point Bonded	MnldSaNres 1 Point Bonded	MnldSaNres 1 Point Bonded	MnldSaNres 1 Point Bonded	MnldSaNres 1 Point Bonded	MnldSaNres 1 Point Bonded	MnldSaNres 1 Point Bonded
Ampacity														
I	Steady State Ac paSty	[A]	11/ .29	1037.97	10/2 .- F	11/ / .- F	11/9./0	10/2.28	10P-.07	11/9./0	11P3.07	10P-.02	1037.97	11P3.02
I_{ss}	Steady State Ac paSty withoni inerlation tac peratmre drop Sonstraint	[A]	nNa	nNa	nNa	nNa	nNa	nNa	nNa	nNa	nNa	nNa	nNa	nNa
Temperatures														
θS	ConstrBtor tac peratmre	[°C]	80.9-	88.F2	90.00	80.9-	88.- :	90.00	81./ 0	88.- :	90.00	81./ 0	88.F2	90.00
Δθins	Tac peratmre drop across the insnlation	[°C]	nNa	nNa	nNa	nNa	nNa	nNa	nNa	nNa	nNa	nNa	nNa	nNa
θs	SheathSNield tac peratmre	[°C]	7/ .2F	82.F/	8/ .13	7/ .2F	81.32	8/ ./	7 1./ F	81.32	8/ .02	7 1./ F	82.F/	8/ .02
θa	Arc cnre tac peratmre	[°C]	nNa	nNa	nNa	nNa	nNa	nNa	nNa	nNa	nNa	nNa	nNa	nNa
θsref	Cable snefaSe tac peratmre	[°C]	7/ .17	81.39	8/ .1F	7/ .17	80./ F	8/ .1F	7/ ./ F	80./ F	81.88	7/ ./ F	81.38	81.88
ΔθdrθI	DrdS snefaSe tac peratmre	[°C]	F7.82	7F.38	7B.3:	F7.81	7/ .81	7B.3:	F9.F0	7/ .80	7F.12	F9.F0	7F.38	7F.12
Resistances														
Rs	DC ResistanSe of the SondnBtor at 20°C	[Ohi Re]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
R	AC ResistanSe of the ConstrBtor at Operating Tac peratmre	[Ohi Re]	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
ys	Skin Effe/ft Lx/Sor		0.17	0.1F	0.1F	0.17	0.1F	0.1F	0.17	0.1F	0.1F	0.17	0.1F	0.1F
yp	Proxic ity Effe/ft Lx/Sor		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Losses														
WS	ConstrBtor uosses	[WIR]	/.01	-./9	-./0	/.01	/.12	-./0	-./7	/.12	/.23	-./7	-./9	/.23
Wd	DielsSrbS uosses	[WIR]	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
Wa	MetalS5 SSreen uosses	[WIR]	0.11	0./-	0.12	0.11	0./2	0.12	0.1-	0./2	0.11	0.1-	0./-	0.11
Wa	Arc orPipe uosses	[WIR]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wt	Total uosses	[WIR]	F.1/	3.9/	3.3/	F.1/	F.3F	3.3/	3.F1	F.3F	F-.8	3.F1	3.9/	F-.8
λ1	SSreen uoss Lx/Sor		0.0:	0.12	0.0/	0.0:	0.10	0.0/	0.0/	0.10	0.0:	0.0/	0.12	0.0:
λ2	Arc cnre uoss Lx/Sor + Pipe uoss Lx/Sor		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thermal resistances														
T1	Therc al ResistanSe Between ConstrBtor and SSreen	[K.c 6W]	0./0	0./0	0./0	0./0	0./0	0./0	0./0	0./0	0./0	0./0	0./0	0./0
T2	Therc al ResistanSe Between SSreen and Arc cnre	[K.c 6W]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T:	Therc al ResistanSe of the JaSketPipe Coating	[K.c 6W]	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
TJ	Total external therc al resistanSe	[K.c 6W]	2.F/	-.1F	-./8	2.F/	2.81	-./8	2.9P	2.81	2.9P	2.9P	-.1F	2.9P
Others														
ΔθInt	Tac peratmre rou dne to snrrorndng heat sorrSes	[°C]	8.9F	/8.2:	30.02	8.9F	/./ 39	30.02	/2.- 3	/./ 39	/3.F7	/2.- 3	/8.22	/3.F7
	InstrBed Voltage (standing) on Sheath	[Vlc Re]	/12.-3	:19.73	/22.2-	/12.-3	:1F.F0	/22.2-	/22.3F	:1F.F0	/12.37	/22.3F	:19.73	/12.37
	InstrBed Voltage (standing) on ConSentrS Wires	[Vlc Re]	/1/.7-	:22.13	/2/ /3	/1/.7-	:19.03	/2/ /3	/2/.79	:19.03	/1/.9F	/2/.79	:22.13	/1/.9F
	InstrBed Srenent on MetalS SSreen	[A]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Cables Report

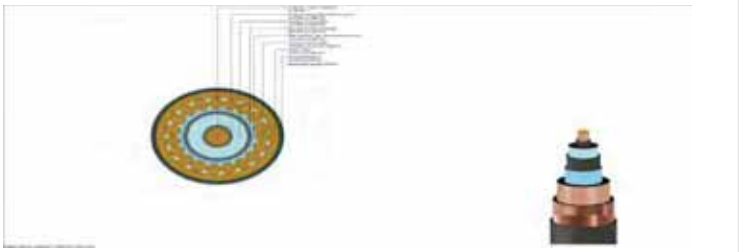
CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T2.1a2-300kV, 8_ DOC, 3000k5c il Cmj 83DuL
Date:	F6/6202/ 104t04 0 AM

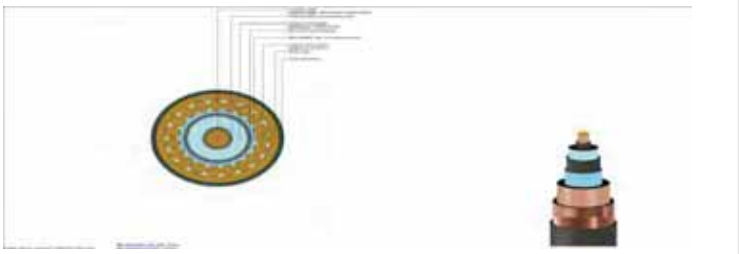
No.	Description	Unit	1
General Cable Information			
1	Cable Eqntpc ent ID		300C3.00X
2	Nnc ber of Cores		Single Core
: :	Voltage	[kV]	300.00
/	Condnt8tor Area	[in²]	: .9:
3	Cable Overall Diac eter	[in]	3.99
F	Maxic nc Steady-State Condnt8tor Tec peratrne	[°C]	90.00
7	Maxic nc Ec ergen5y Condnt8tor Tec peratrne	[°C]	103.00
Conductor			
8	Material		Copper
9	Ele5tn5al Resistivity at 20°C	[µΩ.5c]	1.72
10	Tec peratrne Coeffi5ient at 20°C	[1t€]	0.00
11	Re5ipro5al of Tec peratrne Coeffi5ient of Resistan5e (BETA)	[K]	2: / ./ 3
12	Volnc etri5 Spe5if5 Heat (SH)	[J€(K*5c °)]	: ./ 3
1:	Constrn8tion		F Segc ents
1/	Condnt8tor Insnlation Systec		Extrnded
13	Milliken Wires Constrn8tion		Insnlated Wires
1F	Ks (Skin Effe5t Coeffi5ient)		0. : 3
17	Kp (Proxic ity Effe5t Coeffi5ient)		0.20
18	Diac eter	[in]	2. / 9
Conductor Shield			
19	Thi5kness	[in]	0.0F
20	Diac eter	[in]	2.F1
Insulation			
21	Material		XuPE Unfilled
22	Therc al Resistivity	[K.c 6W]	: .30
2:	Diele5tri5 uoss La5tor - (tan delta)		0.00
2/	Relative Perc ittivity - (epsilon)		2.30
23	Spe5if5 Insnlation Resistan5e Constant at F0°L - (K)	[M0.1000ft]	1838.0F
2F	Thi5kness	[in]	1.22
27	Diac eter	[in]	3.03
Insulation Screen			
28	Material		Sec i Condn8ting SSreen
29	Thi5kness	[in]	0.0F
:0	Diac eter	[in]	3.17
Non Metallic Layer - Water Swellable Tape			
:1	Material		EXTRUDED SEMICONDUCTIVE SCREEN
:2	Therc al Resistivity	[K.c 6W]	2.30
::	Thi5kness	[in]	0.0/
:/	Diac eter	[in]	3.2/
Concentric neutral/Skid wires			
:3	Are ConSentri5 Nentral Wires Aromnd Ea5h Core?		n6a
:F	Material		Copper
:7	Ele5tri5al Resistivity at 20°C	[µΩ.5c]	1.72
:8	Tec peratrne Coeffi5ient at 20°C	[1t€]	0.00
:9	Re5ipro5al of Tec peratrne Coeffi5ient of Resistan5e (BETA)	[K]	2: / .30
/0	Volnc etri5 Spe5if5 Heat (SH)	[J€(K*5c °)]	: ./ 3
/1	Wire Type		Romnd Wires
/2	uength of uay	[in]	/ 3.3F
/:	Nnc ber of Wires		: F
//	Wire Gantge		Undefined
/3	Thi5kness	[in]	0.09
/F	Diac eter	[in]	3./ 1
Sheath			
/7	Is Sheath Aromnd Ea5h Core?		n6a
/8	Material		Copper
/9	Ele5tri5al Resistivity at 20°C	[µΩ.5c]	1.72
30	Tec peratrne Coeffi5ient at 20°C	[1t€]	0.00
31	Re5ipro5al of Tec peratrne Coeffi5ient of Resistan5e (BETA)	[K]	2: / .30
32	Volnc etri5 Spe5if5 Heat (SH)	[J€(K*5c °)]	: ./ 3
3:	Corrngation Type		Non Corrngated
3/	Thi5kness	[in]	0.01
33	Diac eter	[in]	3./ /
Jacket			
3F	Material		Polyethylene
37	Therc al Resistivity	[K.c 6W]	: .30
38	Thi5kness	[in]	0.28
39	Diac eter	[in]	3.99

No.	Description	Unit	1
Specific Installation Data			
F0	Cable Eqntpc ent ID		300C3.00X
F1	Cable Lreqrnen5y	[Hz]	F0.00
F2	Sheath 6 Shield Bonding		Mnti5ables 1 Point Bonded
F:	uoss La5tor Constant (AuC5)		0. : 0
F/	Condnit Sonstrn8tion		PVC Dn8t in ConSrete
F3	Condnit c aterial therc al resistivity	[K.c 6W]	F.00
FF	Condnit filling c aterial		Air
F7	Inner diac eter of the Sondnit	[in]	7.98
F8	Onter diac eter of the Sondnit	[in]	8.F2

Cable ID : 500C5.00X

Cable Title: 300kV, 3000k5c il Cm- F Seg, 1221 XuPE, CmCon5, Taihan





Study Summary

CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T- .1a132- 0kV and , 00kV_8D OC5_, 000kcmil 5u_100 OLF
Date:	6/4/2024 12:26:22 AM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.00
Conductor Resistances Computation Option:	IE53228

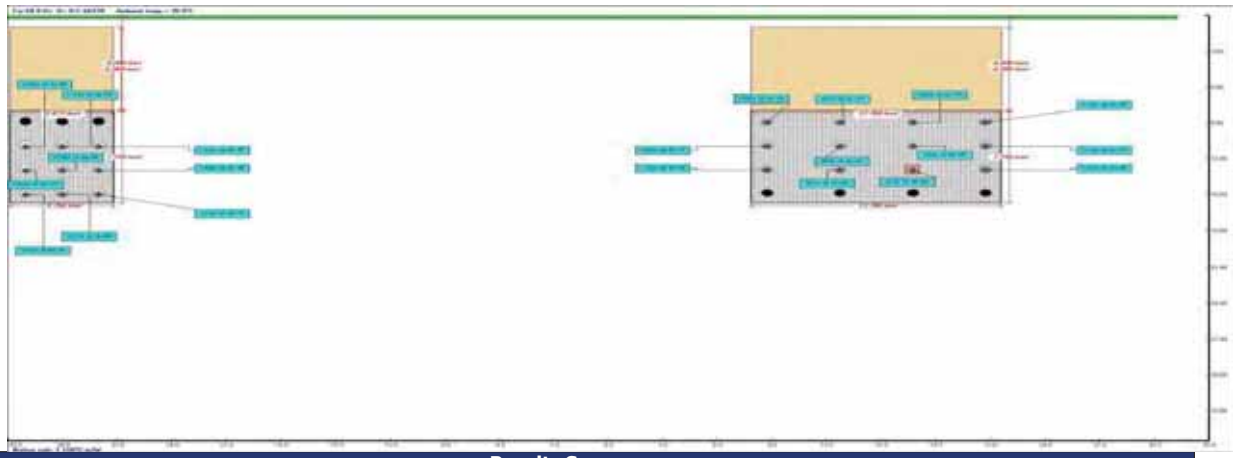
Standard Settings Options

General guidance	5ustom
Factor on RAC due to magnetic armour	5IGREGuidance
Factor on RAC due to magnetic duct	5IGREGuidance
Factor on λ₁ due to magnetic armour	5YM5PAGuidance
Factor on λ₁ due to magnetic duct	5IGREGuidance
Factor on λ₂ due to λ'₁	5YM5PAGuidance
λ''₁ computation	5IGREGuidance
λ₂pipe computation	5YM5PAGuidance
Wd computation	5IGREGuidance
T₂ computation	5IGREGuidance
T₄ computation	5YM5PAGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1.1,
Consider Non-Isothermal Earth Surface	No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
BackXll	3·0.04	4.47	, .68	6.77	0.60
BackXll	14.f ,	4.47	1- .f ,	6.77	0.60
OB 494	14.f ,	11.8f	1- .f ,	f .f 6	0.60
OB 49-	3·0.00	11.8f	, .f ,	f .f 6	0.60



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	2- 05, .0091	1		P	60.00	1.00	3·2.00	10.77	84.86	12, 8.- f
2	2- 05, .0091	1		B	60.00	1.00	3·0.00	10.77	70.00	1- f 4.24
-	2- 05, .0091	1		5	60.00	1.00	328.00	10.77	8, .- 2	12, 7.f f
4	2- 05, .0091	1		P	60.00	1.00	3·2.00	12.77	88.00	1088., 7
,	2- 05, .0091	1		B	60.00	1.00	3·0.00	12.77	70.00	1027.61
6	2- 05, .0091	1		5	60.00	1.00	328.00	12.77	88., 2	1088.80
f	2- 05, .0091	1		P	60.00	1.00	3·2.00	14.77	88.1,	10f 8.02
8	2- 05, .0091	1		B	60.00	1.00	3·0.00	14.77	70.00	1021.1-
7	2- 05, .0091	1		5	60.00	1.00	328.00	14.77	88.f -	10f 6.40
10	, 005, .009	2		P	60.00	1.00	8.f ,	8.7,	80.2-	1082.44
11	, 005, .009	2		B	60.00	1.00	12.f ,	10.7,	88.62	787.02
12	, 005, .009	2		5	60.00	1.00	16.f ,	12.7,	70.00	7f 8.84
1-	, 005, .009	2		P	60.00	1.00	20.f ,	8.7,	80.- 0	1107.01
14	, 005, .009	2		B	60.00	1.00	8.f ,	10.7,	88.06	1088.76
1,	, 005, .009	2		5	60.00	1.00	12.f ,	12.7,	70.00	76f .02
16	, 005, .009	2		P	60.00	1.00	16.f ,	8.7,	81.08	100, .- 0
1f	, 005, .009	2		B	60.00	1.00	20.f ,	10.7,	88.12	111f .74
18	, 005, .009	2		5	60.00	1.00	8.f ,	12.7,	70.00	110, .f 8
17	, 005, .009	2		P	60.00	1.00	12.f ,	8.7,	81.04	77f .16
20	, 005, .009	2		B	60.00	1.00	16.f ,	10.7,	88.64	778.00
21	, 005, .009	2		5	60.00	1.00	20.f ,	12.7,	70.00	1142.27

Steady State Summary

CYMCAP Version	8.2 Revision 1
Study	Golden to Mini
Description:	3 - Jul 2 - 6 kV and 2 6kV, 400 CKTS _ 600 cmil Cu, 600 OLP
Date:	6/4/2024 12:16:22 AM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature (°C)	20.00
Native Soil Thermal Resistivity (Km/W)	1.1
Consider Non-Geothermal Earth Surface	No
Consider effect of soil dry out	No
Consider thermal interaction between circuits	Yes
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits) (A)	0.20

Variable	Description	Unit	Cables																			
Table No.	Table Data Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
General Input Data																							
Table ID	Table Equipment ID		2-35_600	2-35_600	2-15_600	2-35_600	2-15_600	2-35_600	2-35_600	2-15_600	2-35_600	600_600	600_600	600_600	600_600	600_600	600_600	600_600	600_600	600_600	600_600	600_600	600_600
Circuit No.	Circuit No.		1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2
Phase	Table Phase		P	B	S	P	B	S	P	B	S	P	B	S	P	B	S	P	B	S	P	B	S
Fq	Operating Frequency	(Hz)	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
x	X coordinate	(ft)	3.165	3.665	3.915	3.165	3.665	3.915	3.165	3.665	3.915	3.165	3.665	3.915	3.165	3.665	3.915	3.165	3.665	3.915	3.165	3.665	3.915
y	Y coordinate	(ft)	10.77	10.77	10.77	13.77	13.77	13.77	14.77	14.77	14.77	8.7	8.7	8.7	11.7	11.7	11.7	10.7	10.7	10.7	13.7	13.7	13.7
OLF	Cable Load Factor	(p.u.)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Bonding Type		Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded	Multiple Point Bonded
Ampacity																							
I	Single Style Ampacity	(A)	1,314.7	1,314.24	1,313.77	1,088.7	1,087.61	1,086.80	1,078.02	1,087.11	1,089.40	1,082.44	1,087.03	1,078.84	1,087.01	1,086.76	1,087.02	1,085.1	1,111.74	1,111.28	1,087.16	1,087.10	1,082.27
I_t	Single Style Ampacity without insulation temperature drop constraint	(A)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Temperatures																							
Ts	Conductor temperature	(°C)	84.66	70.90	6.72	84.69	70.90	66.72	84.51	70.90	88.71	85.31	66.82	70.69	84.70	84.26	70.90	81.88	86.12	70.90	81.84	84.64	70.90
ΔTins	Temperature drop across the insulation	(°C)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ss	Sheath/Shield temperature	(°C)	77.28	6.---	77.7	8.73	84.12	84.2	8.--5	86.86	84.-	14.31	8.-9	8.67	74.5	81.87	84.5	8.--5	82.78	8.--8	7.--	8.-2	8.---
Ss	Pipe or Tube temperature	(°C)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ss_ave	Table surface temperature	(°C)	78.64	8.2_6	77.31	8.-2-	8.-6	8.7 4	8.--8	6.7	84.66	7.--20	82.---	8.-84	7.-31	80.81	8.-5	74.17	80.-8	82.56	74.61	8.2.17	82.3
Ts_ext	Duct surface temperature	(°C)	7.-4_	7 6.18	7.-87	7.724	81.80	77.7_	7.5_7	82.04	80.17	6.6.3-	77.76	7.5_7	81.88	7_.67	7.724	78.24	7_.24	77.62	78.--	77.6_	77.31
Resistances																							
Rs	DC Resistance of the conductor at 20°C	(Ω/mile)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
R	AC Resistance of the Conductor at Operating Temperature	(Ω/mile)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
xs	Skin Effect Factor	(-)	0.2	0.16	0.2	0.16	0.16	0.16	0.16	0.16	0.16	0.17	0.16	0.16	0.16	0.2	0.16	0.16	0.16	0.16	0.2	0.16	0.16
xp	Proximity Effect Factor	(-)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Losses																							
Wc	Conductor Losses	(W/ft)	4.70	-.73	4.72	-.73	-.2	-.75	-.6	-.2	-.82	-.-7	-.5	-.66	-.76	-.73	3.7-	-.12	3.51	-.73	-.8	-.5	-.11
Wd	Dielectric Losses	(W/ft)	0.-1	0.-1	0.-1	0.-1	0.-1	0.-1	0.-1	0.-1	0.-1	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01
Ws	Metallic Screen Losses	(W/ft)	0.2-	0.44	0.3-	0.12	0.-8	0.12	0.07	0.5_	0.09	0.13	0.-8	0.11	0.11	0.-8	0.13	0.12	0.43	0.13	0.-8	0.11	0.-8
Wa	Pressure Pipe Losses	(W/ft)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wt	Total Losses	(W/ft)	-.8	0.74	-.98	0.-7	0.38	0.-7	0.-6	0.37	0.98	-.8_	-.13	-.44	-.13	-.98	0.37	-.6-	-.3-	0.-3	-.74	-.36	-.-1	0.31
I_2	Screen Loss Factor	(-)	0.0-	0.08	0.0-	0.0-	0.11	0.0-	0.0-	0.09	0.0-	0.0-	0.12	0.04	0.0-	0.10	0.04	0.09	0.10	0.0-	0.09	0.12	0.0-
I_3	Pressure Loss Factor = Pipe Loss Factor	(-)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thermal resistances																							
T1	Thermal Resistance Between Conductor and Screen	(K.m/W)	0.--	0.--	0.--	0.--	0.--	0.--	0.--	0.--	0.--	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T2	Thermal Resistance Between Screen and Armour	(K.m/W)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T3	Thermal Resistance of the Jacket/Duct Facing	(K.m/W)	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-
T4	Total external thermal resistance	(K.m/W)	-.20	-.27	-.22	-.43	-.70	-.68	-.44	-.--	-.47	-.80	-.27	-.84	-.86	-.27	-.27	-.21	-.2-	-.--	-.96		
Others																							
Amt	Temperature rise due to surrounding heat sources	(°C)	4.-47	44.2-	4.-36	-.681	-.-5	-.7-2	-.0.5	-.-73	-.131	-.7-2	47.-2	-.16-	-8.5	4.-8	1.--	42.17	44.-5	44.30	42.78	4.710	4.78
	Induced Voltage (during) on Sheath	(V/mile)	21.78	-8.42	20.11	-.1.-6	-7.26	-.647	2.-7	68.67	-16.91	-.7.64	-5.2-	4.-3.76	68.62	-0.117	4.--11	-70.13	-.-61.86	436.-8	-67.68	21.-51	4.2-.6
	Induced Voltage (during) on Concentric Wires	(V/mile)	-17.10	76.97	-17.24	-.-.97	468.86	-.7.-5	-16.5	76.14	-13.77	-62.86	-88.18	4.-.86	6.-76	-5.-.7	4.6.11	-7.-5.	0.-.35	437.68	-72.83	-86.5	4.86.47
	Induced current on Metallic Screen	(A)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Cables Report

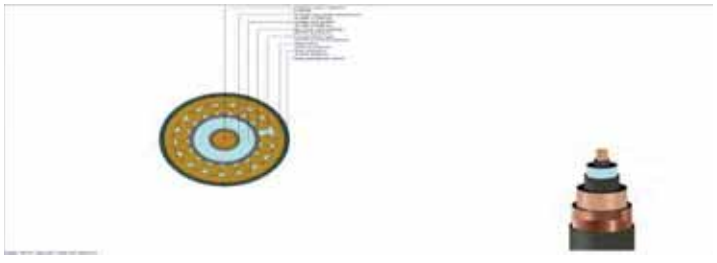
CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T-.1a13Z-0kV and , 00kV_8D OC5_, 000kcmil 5u_100 OLF
Date:	6/4/2024 12:26:22 AM

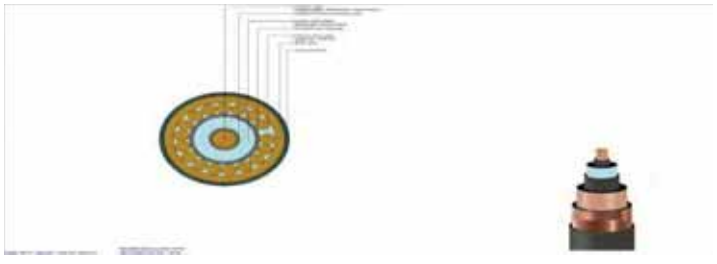
No.	Description	Unit	1
General Cable Information			
1	Sable Equipment IO		, 005, .009
2	Number oX5ores		Single Sore
-	Voltage	[kV]	, 00.00
4	Sonductor Prea	[in²]	- .7-
,	Sable Cverall Oiameter	[in]	, .77
6	Maximum Steady3tate Sonductor Temperature	[°5]	70.00
f	Maximum Emergency Sonductor Temperature	[°5]	10, .00
Conductor			
8	Material		Sopper
7	Electrical Resistivity at 20°5	[µΩ.cm]	1.f 2
10	Temperature Soe%cient at 20°5	[1/K]	0.00
11	Reciprocal oXTemperature Soe%cient oXResistance (BETP)	[K]	2- 4.4,
12	Volumetric Speci%c Heat (SH)	[J/(K*cm³)]	- .4,
1-	Sonstruction		6 Segments
14	Sonductor Insulation System		Extruded
1,	Milliken Wires Sonstruction		Insulated Wires
16	Ks (Skin E%ect Soe%cient)		0. - ,
1f	Kp (Aroximity E%ect Soe%cient)		0.20
18	Oiameter	[in]	2.47
Conductor Shield			
17	Thickness	[in]	0.06
20	Oiameter	[in]	2.61
Insulation			
21	Material		9LAE Un%lled
22	Thermal Resistivity	[K.m/W]	- ., 0
2-	Oielectric Loss Factor 3(tan delta)		0.00
24	Relative Aermittivity 3(epsilon)		2., 0
2,	Spec%c Insulation Resistance Sonstant at 60°F 3(K)	[M: 1000ft]	18, 8.06
26	Thickness	[in]	1.22
2f	Oiameter	[in]	, .0,
Insulation Screen			
28	Material		Semi Sonducting Screen
27	Thickness	[in]	0.06
-0	Oiameter	[in]	, .1f
Concentric neutral/Skid wires			
-1	Pre Soncentric Neutral Wires Pround Each Sore?		n/a
-2	Material		Sopper
--	Electrical Resistivity at 20°5	[µΩ.cm]	1.f 2
-4	Temperature Soe%cient at 20°5	[1/K]	0.00
-,	Reciprocal oXTemperature Soe%cient oXResistance (BETP)	[K]	2- 4., 0
-6	Volumetric Speci%c Heat (SH)	[J/(K*cm³)]	- .4,
-f	Wire Type		Round Wires
-8	Length oXLay	[in]	4, ., 6
-7	Number oXWires		-6
40	Wire Gauge		Unde%ned
41	Thickness	[in]	0.12
42	Oiameter	[in]	, .41
Sheath			
4-	Is Sheath Pround Each Sore?		n/a
44	Material		Sopper
4,	Electrical Resistivity at 20°5	[µΩ.cm]	1.f 2
46	Temperature Soe%cient at 20°5	[1/K]	0.00
4f	Reciprocal oXTemperature Soe%cient oXResistance (BETP)	[K]	2- 4., 0
48	Volumetric Speci%c Heat (SH)	[J/(K*cm³)]	- .4,
47	Sorrugation Type		Non Sorrugated
,0	Thickness	[in]	0.01
,1	Oiameter	[in]	, .44
Jacket			
,2	Material		Aolyethylene
, -	Thermal Resistivity	[K.m/W]	- ., 0
,4	Thickness	[in]	0.28
,,	Oiameter	[in]	, .77

No.	Description	Unit	1
Specific Installation Data			
,6	Sable Equipment IO		, 005, .009
,f	Sable Frequency	[Hz]	60.00
,8	Sheath / Shield Bonding		Multicables 1 Aoint Bonded
,7	Loss Factor Sonstant (PLCS)		0. - 0
60	Sonduit construction		AVS Ouct in Soncrete
61	Sonduit material thermal resistivity	[K.m/W]	6.00
62	Sonduit %ling material		Pir
6-	Inner diameter oXthe conduit	[in]	f .78
64	Cuter diameter oXthe conduit	[in]	8.62

Cable ID : 233C2.33X

Sable Title	, 00kV_, 000kcmil 5u 36 Seg_1221 9LAE_5u 5onc_Taihan





Cables Report

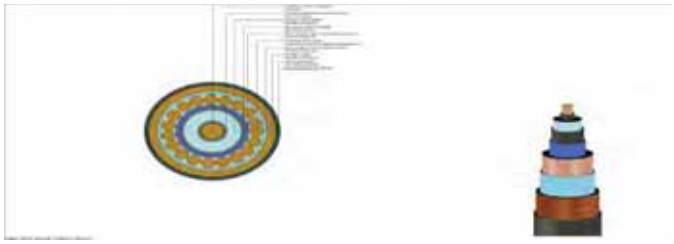
CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T-.1a132-0kV and , 00kV_8DOC5_, 000kcmil 5u_100 OLF
Date:	6/4/2024 12:26:22 AM

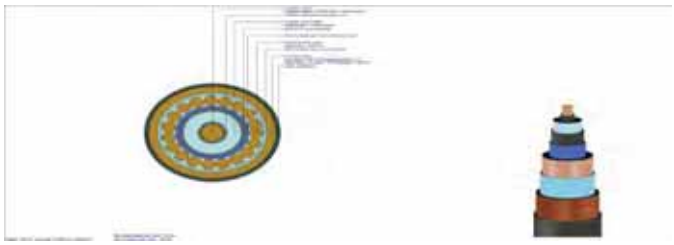
No.	Description	Unit	1
General Cable Information			
1	Sable Equipment ID		2-05, .0091
2	Number oXSores		Single Sore
-	Voltage	[kV]	2-0.00
4	Sonductor Prea	[in²]	-.7-
,	Sable Cverall Diameter	[in]	,.22
6	Maximum SteadyStSate Sonductor Temperature	[°S]	70.00
f	Maximum Emergency Sonductor Temperature	[°S]	10, .00
Conductor			
8	Material		Sopper
7	Electrical Resistivity at 20°S	[µΩ.cm]	1.f 2
10	Temperature SoeXcient at 20°S	[1/K]	0.00
11	Reciprocal oXTemperature SoeXcient oXResistance (BETP)	[K]	2-4.4,
12	Volumetric SpeciXc Heat (SH)	[J/(K*cm³)]	-.4,
1-	Sonstruction		6 Segments
14	Sonductor Insulation System		Extruded
1,	Milliken Wires Sonstruction		Insulated Wires
16	Ks (Skin EXect SoeXcient)		0-,
1f	Kp (Arosimity EXect SoeXcient)		0.20
18	Diameter	[in]	2-, 4
Conductor Shield			
17	Thickness	[in]	0.10
20	Diameter	[in]	2.f 4
Insulation			
21	Material		9LAE UnXked
22	Thermal Resistivity	[K.m/W]	-.,0
2-	Dielectric Loss Factor 3(tan delta)		0.00
24	Relative Aermittivity 3(epsilon)		2-, 0
2,	SpeciXc Insulation Resistance Sonstant at 60°F 3(K)	[M.1000ft]	18, 8.06
26	Thickness	[in]	0.71
2f	Diameter	[in]	4-, ,
Insulation Screen			
28	Material		Semi Sonducting Screen
27	Thickness	[in]	0.0,
-0	Diameter	[in]	4.6,
Non Metallic Layer - Water Swellable Tape 1			
-1	Material		E9TRUOEO SEMISCNOUSTIVE SSREEN
-2	Thermal Resistivity	[K.m/W]	2-, 0
- -	Thickness	[in]	0.02
-4	Diameter	[in]	4.67
Concentric neutral/Skid wires			
-,	Pre Soncentric Neutral Wires Pround Each Sore?		n/a
-6	Material		Sopper
-f	Electrical Resistivity at 20°S	[µΩ.cm]	1.f 2
-8	Temperature SoeXcient at 20°S	[1/K]	0.00
-7	Reciprocal oXTemperature SoeXcient oXResistance (BETP)	[K]	2-4-, 0
40	Volumetric SpeciXc Heat (SH)	[J/(K*cm³)]	-.4,
41	Wire Type		Round Wires
42	Length oXLay	[in]	4, -, 6
4-	Number oXWires		46
44	Wire Gauge		14
4,	Thickness	[in]	0.06
46	Diameter	[in]	4.82
Sheath			
4f	Is Sheath Pround Each Sore?		n/a
48	Material		Sopper
47	Electrical Resistivity at 20°S	[µΩ.cm]	1.f 2
,0	Temperature SoeXcient at 20°S	[1/K]	0.00
,1	Reciprocal oXTemperature SoeXcient oXResistance (BETP)	[K]	2-4-, 0
,2	Volumetric SpeciXc Heat (SH)	[J/(K*cm³)]	-.4,
,-	Sorrugation Type		Longitudinally Sorrugated
,4	Sorrugation height	[in]	0.01
,,	Tape overlap	[in]	0-, 0
,6	Tape width	[in]	1-, .71
,f	Tape thickness	[in]	0.01
,8	Pccumulaton Xactor		1.20
,7	Thickness	[in]	0.01
60	Diameter	[in]	4.71
Jacket			
61	Material		Aolyethylene
62	Thermal Resistivity	[K.m/W]	-.,0
6-	Thickness	[in]	0.1,
64	Diameter	[in]	,.22

No.	Description	Unit	1
Specific Installation Data			
6,	Sable Equipment ID		2-05, .0091
66	Sable Frequency	[Hz]	60.00
6f	Sheath / Shield Bonding		Multicables 1 Aoint Bonded
68	Loss Factor Sonstant (PLCS)		0-.0
67	Sonduit construction		AVS Oact in Soncrete
f0	Sonduit material thermal resistivity	[K.m/W]	6.00
f1	Sonduit XIling material		Pir
f2	Inner diameter oXthe conduit	[in]	f.78
f-	Cuter diameter oXthe conduit	[in]	8.62

Cable ID : 053C2.33X1

Sable Title: 2-0kV_,, 000 kcmil 5u 3 6 Seg_706 9LAE_5u cn_Arysmian





Study Summary

CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T- .1a232- 0kV and , 00kV_8D OC5_, 000kcmil 5u_8, OLF
Date:	6/4/2024 12:- 4:- A UM

General Simulation Data

Steady State Option	qneyuallIN Loaded
Consider Electrical interaction between circuits	I o
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.00
Conductor Resistances Computation Option:	EY53228

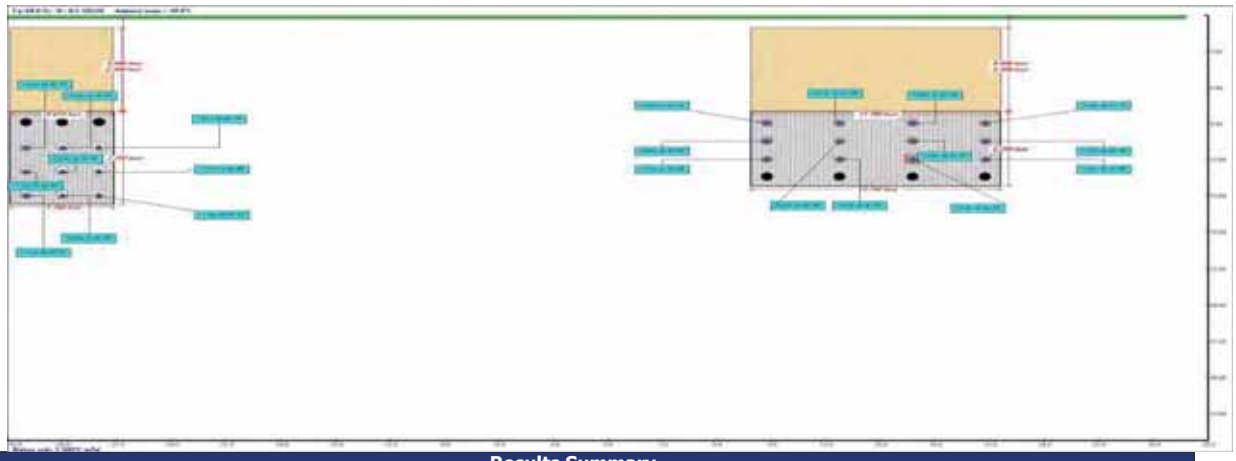
Standard Settings Options

General guidance	5ustom
Factor on RAC due to magnetic armour	5EGRYGuidance
Factor on RAC due to magnetic duct	5EGRYGuidance
Factor on λ₁ due to magnetic armour	5PM5BUGuidance
Factor on λ₁ due to magnetic duct	5EGRYGuidance
Factor on λ₂ due to λ'₁	5PM5BUGuidance
λ''₁ computation	5EGRYGuidance
λ₂pipe computation	5PM5BUGuidance
Wd computation	5EGRYGuidance
T₂ computation	5EGRYGuidance
T₄ computation	5PM5BUGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1., 0
Consider Non-Isothermal Earth Surface	I o

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
Xack7ll	3-0.04	4.4A	, .68	6.AA	0.60
Xack7ll	14.f ,	4.4A	1- .f ,	6.AA	0.60
OX 494	14.f ,	11.12	1- .f ,	6.26	0.60
OX 49-	3-0.00	11.8f	, .f ,	f .f 6	0.60



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	2- 05, .0091	1		B	60.00	0.8,	3-2.00	10.AA	8, .- -	1- 00., 8
2	2- 05, .0091	1		X	60.00	0.8,	3-0.00	10.AA	A0.00	141A.8-
-	2- 05, .0091	1		5	60.00	0.8,	328.00	10.AA	8, .f 1	1- 01.A,
4	2- 05, .0091	1		B	60.00	0.8,	3-2.00	12.AA	88.41	11- 0., 4
,	2- 05, .0091	1		X	60.00	0.8,	3-0.00	12.AA	A0.00	1082., ,
6	2- 05, .0091	1		5	60.00	0.8,	328.00	12.AA	88.8-	11- 0.f 2
f	2- 05, .0091	1		B	60.00	0.8,	3-2.00	14.AA	88.86	1111.62
8	2- 05, .0091	1		X	60.00	0.8,	3-0.00	14.AA	A0.00	1040.- f
A	2- 05, .0091	1		5	60.00	0.8,	328.00	14.AA	8A.- -	1110.08
10	, 005, .009	2		B	60.00	0.8,	8.f ,	8.A,	82.0f	10A4.6-
11	, 005, .009	2		X	60.00	0.8,	12.f ,	10.4,	88.88	1020.16
12	, 005, .009	2		5	60.00	0.8,	16.f ,	11.A,	A0.00	101- .12
1-	, 005, .009	2		B	60.00	0.8,	20.f ,	8.A,	82.11	111f .86
14	, 005, .009	2		X	60.00	0.8,	8.f ,	10.4,	88.6-	10A, .A-
1,	, 005, .009	2		5	60.00	0.8,	12.f ,	11.A,	A0.00	1002.A8
16	, 005, .009	2		B	60.00	0.8,	16.f ,	8.A,	82., 6	10- 0.40
1f	, 005, .009	2		X	60.00	0.8,	20.f ,	10.4,	88.6A	1121., ,
18	, 005, .009	2		5	60.00	0.8,	8.f ,	11.A,	A0.00	1108.8A
1A	, 005, .009	2		B	60.00	0.8,	12.f ,	8.A,	82., 4	102- .0-
20	, 005, .009	2		X	60.00	0.8,	16.f ,	10.4,	88.A0	1028.2A
21	, 005, .009	2		5	60.00	0.8,	20.f ,	11.A,	A0.00	1140.A-

Steady State Summary

CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T-.1a232-0kV and ,00kV_8D OC5_, 000kcmil 5u_8, OLF
Date:	6/4/2024 12:-4:-A UM

Simulation Data

Installation type:	Multiple Ouctbanks
Steady State Option	qneyuallN Loaded
Ambient temperature [°C]	20.00
Native Soil Thermal Resistivity [K.m/W]	1., 0
Consider Non-Isothermal Earth Surface	I o
Consider effect of soil dry out	I o
Consider Electrical interaction between circuits	I o
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits) [A]	0.00

Cables

Variable	Description	Unit	1	2	-	4	,	6	f	8	A	10	11
5able I o.	5able Endex I umber		1	2	-	4	,	6	f	8	A	10	11
General Input Data													
5able EO	5able Yyuipment EO		2-05, .0091	2-05, .0091	2-05, .0091	2-05, .0091	2-05, .0091	2-05, .0091	2-05, .0091	2-05, .0091	2-05, .0091	, 005, .009	, 005, .009
5ircuit I o.	5ircuit I o.		1	1	1	1	1	1	1	1	1	2	2
Uhase	5able Uhase		B	X	5	B	X	5	B	X	5	B	X
Fy	Cperating FreyuencN	[Hz]	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
x	9 coordinate	[7]	3-2.00	3-0.00	328.00	3-2.00	3-0.00	328.00	3-2.00	3-0.00	328.00	8.f ,	12.f ,
N	P coordinate	[7]	10.AA	10.AA	10.AA	12.AA	12.AA	12.AA	14.AA	14.AA	14.AA	8.A,	10.4,
OLF	OailN Load Factor	[p.u.]	0.8,	0.8,	0.8,	0.8,	0.8,	0.8,	0.8,	0.8,	0.8,	0.8,	0.8,
	Xonding TNpe		Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded
Ampacity													
E	SteadN State BmpacitN	[B]	1-00., 8	141A8-	1-01.A,	11-0., 4	1082., ,	11-0.f 2	1111.62	1040.-f	1110.08	10A4.6-	1020.16
Eb	SteadN State BmpacitN without insulation temperature drop constraint	[B]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Temperatures													
θc	5onductor temperature	[°5]	8, .--	A0.00	8, .f 1	88.41	A0.00	88.8-	88.86	A0.00	8A.--	82.0f	88.88
Δθins	Temperature drop across the insulation	[°5]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θs	Sheath/Shield temperature	[°5]	f A.-8	82.A0	fA.f 4	8-.81	8, .f4	84.2-	84.40	86.0,	84.88	f , A-	8-.-0
θa	Brmour temperature	[°5]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsur7	5able sur7ace temperature	[°5]	f 8.f 2	82.08	f A.08	8-.2A	8, .2-	8-.f 1	8-.8A	8, ., 8	84.-8	f 4.8A	82.2f
θduct	Ouct sur7ace temperature	[°5]	f -.1A	f , .2A	f -., 4	f A.02	81.01	f A.44	fA.f 8	81.f f	80.28	6A.84	f f .-8
Resistances													
Ro	O5 Resistance o7 the conductor at 20°5	[Ω/mile]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
R	B5 Resistance o7 the 5onductor at Cperating Temperature	[Ω/mile]	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Ks	Skin Y77ect Factor		0.1f	0.16	0.1f	0.16	0.16	0.16	0.16	0.16	0.16	0.1f	0.16
Kp	UroximitN Y77ect Factor		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Losses													
Wc	5onductor Losses	[W/7]	, .24	6.-2	, .26	-.AA	-.6f	4.00	-.86	-.-A	-.8,	-.68	-.2,
Wd	Oielectric Losses	[W/7]	0., ,	0., ,	0., ,	0., ,	0., ,	0., ,	0., ,	0., ,	0., ,	2.01	2.01
Ws	Metallic Screen Losses	[W/7]	0.14	0., 0	0.14	0.1-	0.42	0.1-	0.10	0.26	0.10	0.14	0., ,
Wa	Brmor/Uipe Losses	[W/7]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wt	Total Losses	[W/7]	, .A-	f .-f	, .A	4.6f	4.6,	4.68	4., 1	4.21	4., 1	, .84	, .82
λ1	Screen Loss Factor		0.0-	0.08	0.0-	0.0-	0.11	0.0-	0.0-	0.08	0.0-	0.04	0.1f
λ2	Brmour Loss Factor + Uipe Loss Factor		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thermal resistances													
T1	Thermal Resistance Xetween 5onductor and Screen	[K.m/W]	0.--	0.--	0.--	0.--	0.--	0.--	0.--	0.--	0.--	0.40	0.40
T2	Thermal Resistance Xetween Screen and Brmour	[K.m/W]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-	Thermal Resistance o7 the Jacket/Uipe 5oating	[K.m/W]	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0,	0.0,
T4	Total external thermal resistance	[K.m/W]	-.02	2., f	-.0-	4.1-	4.28	4.1,	4.-1	4f ,	4.-,	2.86	-.26
Others													
Δθint	Temperature rise due to surrounding heat sources	[°5]	4-.f A	44.20	44.1-	, 0.8A	, -.26	, 1.-1	, 1.0f	, -.A-	, 1., A	41.-1	4A.2,
	Enduced Voltage (standing) on Sheath	[V/mile]	, -1.f 2	-AA.88	, --.88	, , 0.82	411.28	, , 2.Af	, -1.26	-AA.A-	, -4.4,	-06.10	262.18
	Enduced Voltage (standing) on 5oncentric Wires	[V/mile]	, -4.A,	40-.24	, -f .12	, , -.6-	414.-A	, , , .f8	, -4., 0	40-.2A	, -f .6f	-0A.28	26, .-8
	Enduced current on Metallic Screen	[B]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Variable	12	1-	14	1,	16	1f	18	1A	20	21
5able I o.	12	1-	14	1,	16	1f	18	1A	20	21
General Input Data										
5able EO	, 005, .009	, 005, .009	, 005, .009	, 005, .009	, 005, .009	, 005, .009	, 005, .009	, 005, .009	, 005, .009	, 005, .009
5ircuit I o.	2	2	2	2	2	2	2	2	2	2
Uhase	5	B	X	5	B	X	5	B	X	5
Fy	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
x	16.f ,	20.f ,	8.f ,	12.f ,	16.f ,	20.f ,	8.f ,	12.f ,	16.f ,	20.f ,
N	11.A,	8.A,	10.4,	11.A,	8.A,	10.4,	11.A,	8.A,	10.4,	11.A,
OLF	0.8,	0.8,	0.8,	0.8,	0.8,	0.8,	0.8,	0.8,	0.8,	0.8,
	Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded	Multicables 1 Uoint Xonded
Ampacity										
E	101-.12	111f .86	10A, A-	1002.A8	10-0.40	1121., ,	1108.8A	102-.0-	1028.2A	1140.A-
Eb	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Temperatures										
θc	A0.00	82.11	88.6-	A0.00	82., 6	88.6A	A0.00	82., 4	88.A0	A0.00
Δθins	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θs	84.4f	f , .f6	82.40	84., ,	f 6.A6	82.22	8-.64	f f .00	8-.2,	8-.-4
θa	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsur7	8-., 2	f 4.6A	81.28	8-.61	f 6.00	81.06	82., f	f6.0,	82.21	82.2-
θduct	f A.02	6A.4A	f , .A4	f A.1f	f 1.-1	f , ., 4	f f ., -	f 1.41	f f .2f	f 6.AA
Resistances										
Ro	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
R	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Ks	0.16	0.1f	0.16	0.16	0.1f	0.16	0.16	0.1f	0.16	0.16
Kp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Losses										
Wc	-.21	-.84	-.f ,	-.1,	-.2f	-.A-	-.8,	-.22	-.-0	4.08
Wd	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
Ws	0.1,	0.1,	0., f	0.1,	0.16	0., A	0.1,	0.16	0., 6	0.1,
Wa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wt	, .-8	6.01	6.--	, .-1	, .44	6., -	6.01	, .-A	, .88	6.24
λ1	0.0,	0.04	0.1,	0.0,	0.0,	0.1,	0.04	0.0,	0.1f	0.04
λ2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thermal resistances										
T1	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
T2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-	0.0,	0.0,	0.0,	0.0,	0.0,	0.0,	0.0,	0.0,	0.0,	0.0,
T4	-.60	2.f f	2.A,	-.6,	-.14	2.8,	-.1f	-.1f	-.2-	-.04
Others										
Δθint	, 0.A2	40.f -	46.10	, 1.16	44.20	4, .40	4f ., ,	44.-6	4A.06	46.64
	-f 8.8,	-0f .26	260.f 0	-f A.0A	-1-.68	260., 0	-f -.20	-1-.4,	262.14	-f2.00
	-81.8-	-10.42	26-.A-	-82.0f	-16.6A	26-.f -	-f 6.-1	-16.4f	26, .-4	-f , .14
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Cables Report

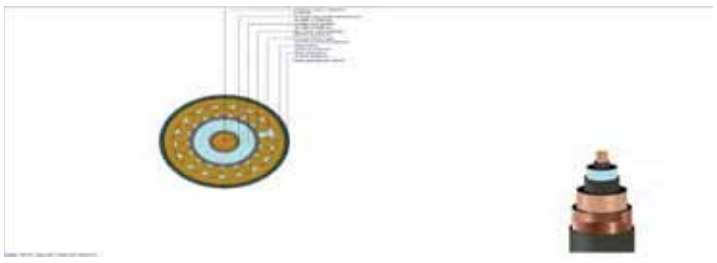
CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T-.1a232-0kV and , 00kV_8D OC5_, 000kcmil 5u_8, OLF
Date:	6/4/2024 12:-4:- A UM

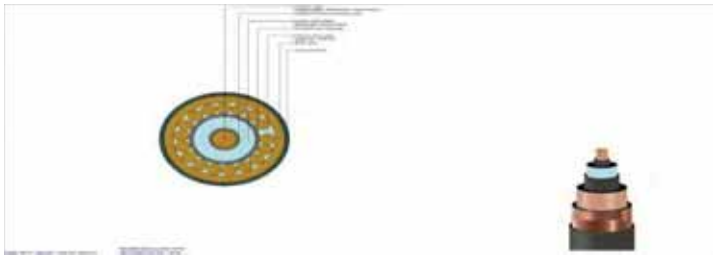
No.	Description	Unit	1
General Cable Information			
1	Sable Yvuipment ID		, 005, .009
2	I umber o7Sores		Single Sore
-	Voltage	[kV]	, 00.00
4	Sonductor Brea	[in²]	- ,A-
,	Sable Cverall Oiameter	[in]	, .AA
6	Maximum SteadNBState Sonductor Temperature	[°S]	A0.00
f	Maximum YmergencN Sonductor Temperature	[°S]	10, .00
Conductor			
8	Material		Sopper
A	Yiectrical ResistivitN at 20°S	[µΩ.cm]	1.f 2
10	Temperature Soe7Ycient at 20°S	[1/K]	0.00
11	Reciprocal o7Temperature Soe7Ycient o7Resistance (XYTB)	[K]	2-4.4,
12	Volumetric Speci7c Heat (SH)	[J/(K*cm³)]	- .4,
1-	Sonstruction		6 Segments
14	Sonductor Insulation SNitem		Yxtruded
1,	Milliken Wires Sonstruction		Insulated Wires
16	Ks (Skin Y7fct Soe7Ycient)		0.-,
1f	Kp (UroximitN Y7fct Soe7Ycient)		0.20
18	Oiameter	[in]	2.4A
Conductor Shield			
1A	Thickness	[in]	0.06
20	Oiameter	[in]	2.61
Insulation			
21	Material		9LUY qn7Illed
22	Thermal ResistivitN	[K.m/W]	- ., 0
2-	Oielectric Loss Factor 3(tan delta)		0.00
24	Relative Uermittivit N 3(epsilon)		2., 0
2,	Speci7c Insulation Resistance Sonstant at 60°F 3(K)	[MΩ.1000ft]	18, 8.06
26	Thickness	[in]	1.22
2f	Oiameter	[in]	, .0,
Insulation Screen			
28	Material		Semi Sonducting Screen
2A	Thickness	[in]	0.06
-0	Oiameter	[in]	, .1f
Concentric neutral/Skid wires			
-1	Bre Soncentric I eutral Wires Bround Yach Sore?		n/a
-2	Material		Sopper
--	Yiectrical ResistivitN at 20°S	[µΩ.cm]	1.f 2
-4	Temperature Soe7Ycient at 20°S	[1/K]	0.00
-,	Reciprocal o7Temperature Soe7Ycient o7Resistance (XYTB)	[K]	2-4., 0
-6	Volumetric Speci7c Heat (SH)	[J/(K*cm³)]	- .4,
-f	Wire TNpe		Round Wires
-8	Length o7LaN	[in]	4, ., 6
-A	I umber o7Wires		-6
40	Wire Gauge		qnde7ned
41	Thickness	[in]	0.12
42	Oiameter	[in]	, .41
Sheath			
4-	Bs Sheath Bround Yach Sore?		n/a
44	Material		Sopper
4,	Yiectrical ResistivitN at 20°S	[µΩ.cm]	1.f 2
46	Temperature Soe7Ycient at 20°S	[1/K]	0.00
4f	Reciprocal o7Temperature Soe7Ycient o7Resistance (XYTB)	[K]	2-4., 0
48	Volumetric Speci7c Heat (SH)	[J/(K*cm³)]	- .4,
4A	Sorrugation TNpe		I on Sorrugated
, 0	Thickness	[in]	0.01
, 1	Oiameter	[in]	, .44
Jacket			
, 2	Material		UslNethNene
, -	Thermal ResistivitN	[K.m/W]	- ., 0
, 4	Thickness	[in]	0.28
, ,	Oiameter	[in]	, .AA

No.	Description	Unit	1
Specific Installation Data			
, 6	Sable Yvuipment ID		, 005, .009
, f	Sable FreyuencN	[Hz]	60.00
, 8	Sheath / Shield Xonding		Multicables 1 Uoint Xonded
, A	Loss Factor Sonstant (BLCS)		0.-0
60	Sonduit construction		UV5 Ouct in Soncrete
61	Sonduit material thermal resistivitN	[K.m/W]	6.00
62	Sonduit Jlling material		Bir
6-	Bnner diameter o7the conduit	[in]	f .A8
64	Cuter diameter o7the conduit	[in]	8.62

Cable ID : 233C2.33X

Sable Title	, 00kV_, 000kcmil 5u 36 Seg_1221 9LUY_5u Sonc_Taihan





Cables Report

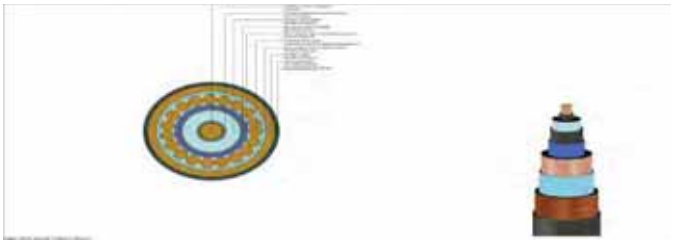
CYMCAP Version	8.2 Revision 1
Study:	Golden to Mars
Execution:	T-_1a2℁- 0kV and , 00kV_8D OC5_,, 000kcmil 5u_8, OLF
Date:	6/4/2024 12:-4:- A UM

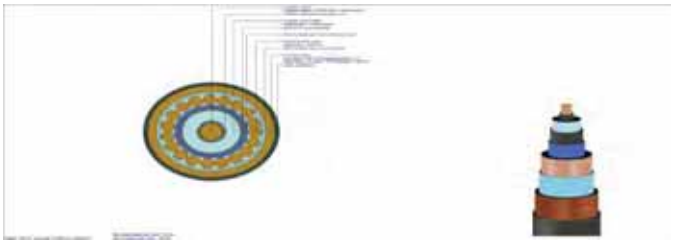
No.	Description	Unit	1
General Cable Information			
1	Sable Yuuipment ID		2-05, .0091
2	I umber o7Sores		Single Sore
-	Voltage	[kV]	2-0.00
4	Sonductor Brea	[in²]	-.A-
,	Sable Cverall Diameter	[in]	,.22
6	Maximum SteadNStaIe Sonductor Temperature	[°S]	A0.00
f	Maximum YmergencN Sonductor Temperature	[°S]	10, .00
Conductor			
8	Material		Sopper
A	Ylectrical ResistivitNat 20°S	[µΩ.cm]	1.f 2
10	Temperature Soe7Rcient at 20°S	[1/K]	0.00
11	Reciprocal o7 Temperature Soe7Rcient o7Resistance (XYTB)	[K]	2-4.4,
12	Volumetric Speci7c Heat (SH)	[J/(K*cm³)]	-.4,
1-	Sonstruction		6 Segments
14	Sonductor Insulation SNstem		Yxtruded
1,	Milliken Wires Sonstruction		Insulated Wires
16	Ks (Skin Y7Rect Soe7Rcient)		0-,
1f	Kp (ProximitN Y7Rct Soe7Rcient)		0.20
18	Diameter	[in]	2-, 4
Conductor Shield			
1A	Thickness	[in]	0.10
20	Diameter	[in]	2.f 4
Insulation			
21	Material		9LUY qn3Bed
22	Thermal ResistivitN	[K.m/W]	-.,0
2-	Dielectric Loss Factor 3(tan delta)		0.00
24	Relative UermittivitN 3(epsilon)		2-, 0
2,	Speci7c Insulation Resistance Sonstant at 60°F 3(K)	[M0.1000ft]	18, 8.06
26	Thickness	[in]	0.A1
2f	Diameter	[in]	4-, ,
Insulation Screen			
28	Material		Semi Sonducting Screen
2A	Thickness	[in]	0.0,
-0	Diameter	[in]	4.6,
Non Metallic Layer - Water Swellable Tape 1			
-1	Material		Y9TRqOYO SYMESCI Oq.5TBiY SSRYY1
-2	Thermal ResistivitN	[K.m/W]	2-, 0
- -	Thickness	[in]	0.02
-4	Diameter	[in]	4.6A
Concentric neutral/Skid wires			
-,	Bre Soncentric I utral Wires Bround Yach Sore?		n/a
-6	Material		Sopper
-f	Ylectrical ResistivitNat 20°S	[µΩ.cm]	1.f 2
-8	Temperature Soe7Rcient at 20°S	[1/K]	0.00
-A	Reciprocal o7 Temperature Soe7Rcient o7Resistance (XYTB)	[K]	2-4-, 0
40	Volumetric Speci7c Heat (SH)	[J/(K*cm³)]	-.4,
41	Wire TNpe		Round Wires
42	Length o7LaN	[in]	4, -, 6
4-	I umber o7Wires		46
44	Wire Gauge		14
4,	Thickness	[in]	0.06
46	Diameter	[in]	4.82
Sheath			
4f	Bs Sheath Bround Yach Sore?		n/a
4B	Material		Sopper
4A	Ylectrical ResistivitNat 20°S	[µΩ.cm]	1.f 2
,0	Temperature Soe7Rcient at 20°S	[1/K]	0.00
,1	Reciprocal o7 Temperature Soe7Rcient o7Resistance (XYTB)	[K]	2-4-, 0
,2	Volumetric Speci7c Heat (SH)	[J/(K*cm³)]	-.4,
,-	Sorrugation TNpe		LongitudinalIN Sorrugated
,4	Sorrugation height	[in]	0.01
,,	Tape overlap	[in]	0-, 0
,6	Tape width	[in]	1-, .A1
,f	Tape thickness	[in]	0.01
,8	Bccumulaton 7actor		1.20
,A	Thickness	[in]	0.01
60	Diameter	[in]	4.A1
Jacket			
61	Material		UsiNethNene
62	Thermal ResistivitN	[K.m/W]	-.,0
6-	Thickness	[in]	0.1,
64	Diameter	[in]	,.22

No.	Description	Unit	1
Specific Installation Data			
6,	Sable Yuuipment ID		2-05, .0091
66	Sable FreyuencN	[Hz]	60.00
6f	Sheath / Shield Xonding		Multicables 1 Ubnit Xonded
68	Loss Factor Sonstant (BLCS)		0-.0
6A	Sonduit construction		LW5 Ouct in Soncrete
f0	Sonduit material thermal resistivitN	[K.m/W]	6.00
f1	Sonduit 3lling material		Bir
f2	Bnner diameter o7the conduit	[in]	f .A8
f-	Cuter diameter o7the conduit	[in]	8.62

Cable ID : 053C2.33X1

Sable Title: 2-0kV_,, 000 kcmil 5u 3 6 Seg_.A06 9LUY_5u cn_UrNsmian





APPENDIX B UG CABLE CUTSHEETS

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XLPE insulated, concentric neutral high voltage power cable with segmental oxidized Copper conductor, metal moisture barrier tape, HDPE jacket

Type Designation: P/N 20235918 5000 kcmil Segmental Oxidized Copper 230kV

Reference Standards	ICEA S-108-720, AEIC CS9		
Temperature Rating	Maximum conductor operating temperature:	90° C	
	Maximum conductor emergency operation temperature:	105° C	
	Maximum permissible conductor temperature at short circuit:	250° C	
Construction:			
Conductor	Class B segmental compacted oxidized Copper conductor		
	Nominal cross-sectional area	5000 kcmil	2535 mm²
	Number of segments	6	
	Number of strands per segment (1 Aluminum center wire)	85	
	Approximate diameter	2.540 inches	64.5 mm
Conductor Shield	[2] Semi-conducting tape applied helical intercalated	50% overlap	
	[2] Semi-conducting tape applied helical intercalated	50% overlap	
	[1] Extruded semi-conducting thermoset	Super Smooth	
	Minimum point thickness	30 mils	0.76 mm
Insulation	Extruded cross-linked polyethylene compound	Super Clean	
	Minimum point thickness	815 mils	20.7 mm
	Nominal thickness	906 mils	23.0 mm
	Maximum eccentricity (Tmax-Tmin)/Tmax	10%	
Insulation Shield	[1] Extruded semi-conducting thermoset		
	Minimum point thickness	40 mils	1.02 mm
	Maximum point thickness	100 mils	2.54 mm
Bedding	[2] Water swellable semi-conducting tape applied helical intercalated	50% overlap	
Concentric Neutral	[46] Wires, #14 AWG, solid bare soft drawn copper		1.63 mm
Bedding	[1] Copper tape	gapped	
	[2] Water swellable semi-conducting tape applied helical	50% overlap	
Metal Moisture Barrier	[1] Laminated Copper tape applied longitudinally folded and bonded to the jacket	6 mils	0.15 mm
Jacket	Extruded black high density polyethylene compound, graphite coated		
	Minimum point thickness	125 mils	3.18 mm
	Maximum point thickness	185 mils	4.70 mm
Complete Cable	Approximate diameter	5.22 inches	132.5 mm
	Approximate weight	22.8 lbs/ft	33.9 kg/m

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Marking:

Marks of Origin	Emboss or indent print on the outer sheath: manufacturer, type of insulation, insulation thickness, conductor size and material, rated voltage, year of manufacture at intervals of not more than three feet.
	Length marking

Electrical Data:

Nominal voltage	230 kV	
Highest system voltage	242 kV	
Basic impulse insulation level (BIL)	1050 kV	
Maximum DC resistance of conductor at 25 °C	0.00224 Ω/kft	
Maximum voltage stress (conductor shield / insulation interface)	196 V/mil	7.7 kV/mm
Minimum voltage stress (insulation / insulation shield interface)	117 V/mil	4.6 kV/mm
Capacitance (nominal)	0.080 µF/kft	0.262 µF/km
Dielectric Constant	2.4	
Maximum permissible short-circuit current (thermal)	15 Cycles	
Composite Metallic Sheath (concentric neutral and laminated copper sheath) - ICEA P-45-482 (T_{init} at 75 °C and T_{final} 200 °C)	40 kA	

Mechanical Data:

Minimum bending radius	104 inches	2.64 m
Maximum pulling tension (with pulling eye)	40,000 lbs	18,143.7 kg
Maximum sidewall-pressure	1,500 lbs/ft	2,232.2 kg/m

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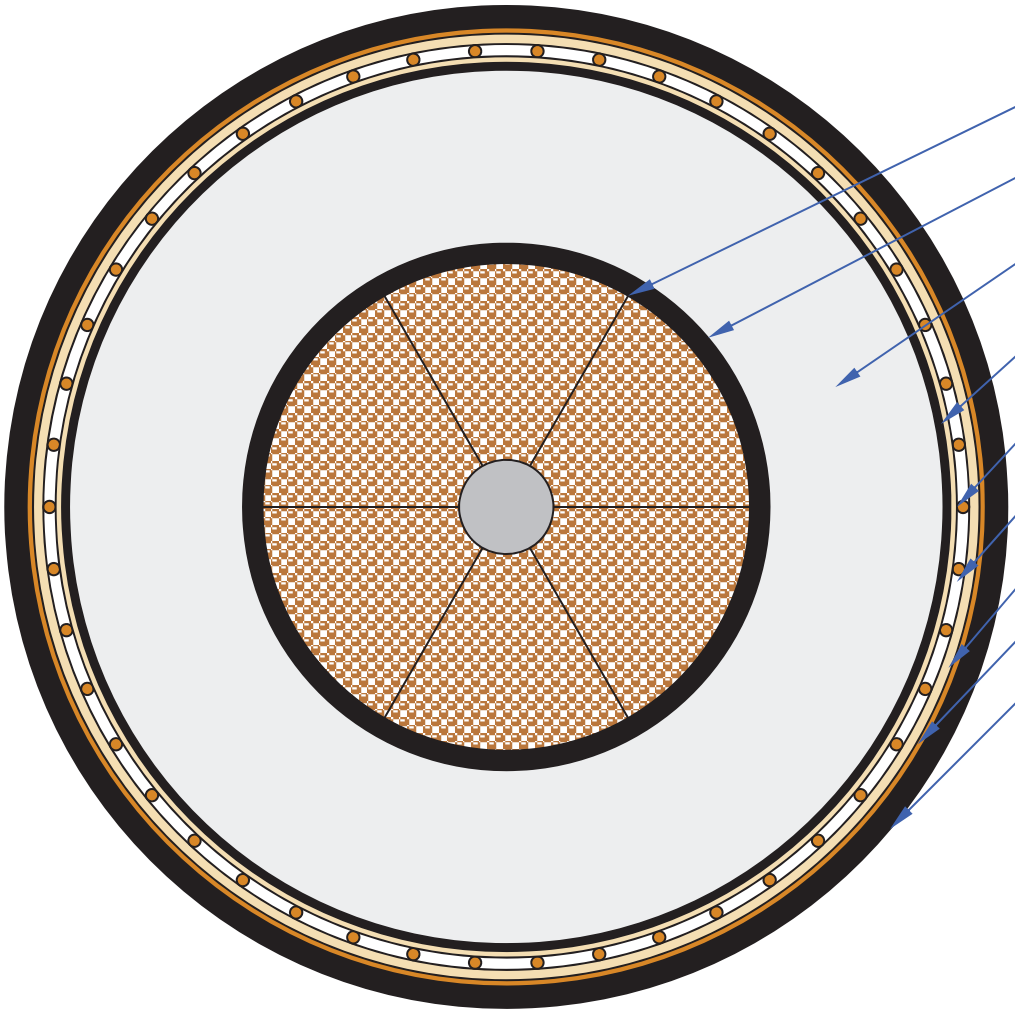


CONDUCTOR:
Diameter= 2.540" (64.5mm)

CONDUCTOR SHIELD:
Diameter= 2.74" (69.6mm)

INSULATION:
Diameter= 4.55" (115.6mm)

INSULATION SHIELD:
Diameter= 4.65" (118.1mm)

BEDDING TAPE:
Diameter= 4.69" (119.1mm)

CONCENTRIC NEUTRAL:
Diameter= 4.82" (122.4mm)

BEDDING TAPE:
Diameter= 4.90" (124.5mm)

METALLIC BARRIER:
Diameter= 4.92" (125.0mm)

JACKET:
Diameter= 5.22" (132.6mm)

APPROXIMATE WEIGHT:
22.8 lbs/ft (33.9 kg/m)

Notes:

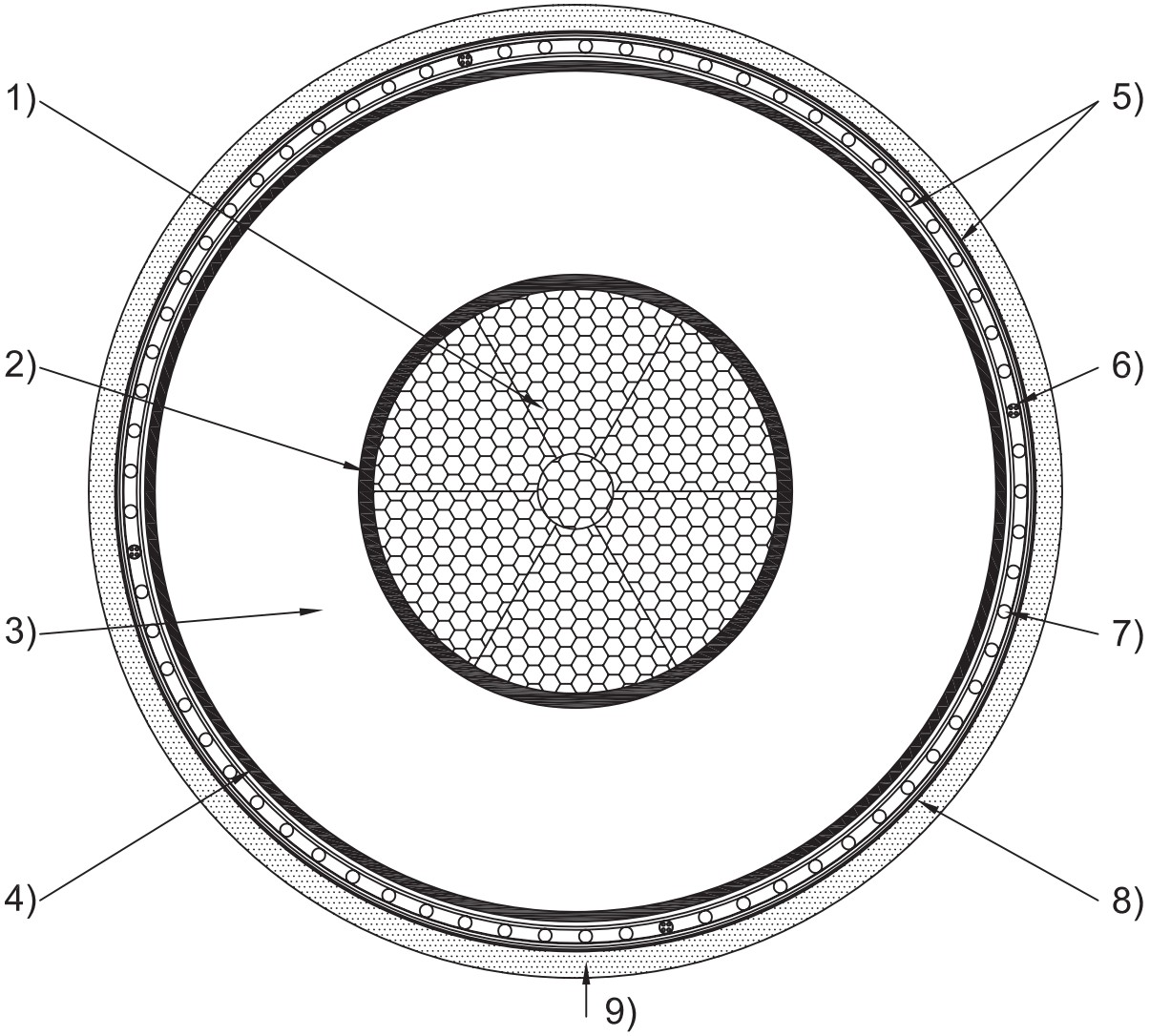
1. All dimensions are nominal and subject to manufacturing tolerances
2. Drawing is not to scale

Prepared by:	Approved by:
Dale Vinczi	Frank Kuchta

Cross section of 500kV 1C x 5000KCMIL XLPE CABLE (CU / XLPE / CWS / MDPE)

6 Seg, compacted enamel coated copper conductor, XLPE insulation, Copper wire screen + CU-foil sheath, MDPE + Semi-con PE outer jacket

RATED VOLTAGE : 500 kV	CONDUCTOR SIZE : 5000 kcmil	BASIC STANDARD : AEIC CS9



No.	DESCRIPTION	MATERIAL	Thickness (mil)	Diameter Approx., inch
1)	CONDUCTOR	1 Central + 6 seg, Enamel coated copper wires	-	2.49
2)	CONDUCTOR SCREEN	Semi - conductive tape & Semi - conductive compound	59.1	2.67
3)	INSULATION	Cross - linked polyethylene [XLPE]	1220.5	5.12
4)	INSULATION SCREEN	Semi-conductive compound	59.1	5.23
5)	WATER BLOCKING LAYER	Semi-conductive swellable tape	Each 19.7 / 16.9	-
6)	FIBER OPTIC CABLE	4 Single mode fiber optic cable in S/S	78.7 x 4EA	5.49
7)	METALLIC SCREEN	Annealed copper wires with equalizing tape	86.6 x 36EA	5.51
8)	METALLIC SHEATH	PE Laminated copper tape	11.0	5.60
9)	OUTER JACKET	Black MDPE & Semi-con PE Outer Jacket	157.5 39.4	5.99
COMPLETED CABLE		- Weight : Approx. 25.5 lb/ft - Fault Duty : 25 kA / 0.5 sec - Maximum D.C. resistance of conductor at 20°C : 0.00219 ohm/1000ft - Power frequency test (Withstand) voltage : A.C 580 kV for 60 min		

DWG. No.	500E5000IXOWE-C180118	REV.	0	DIM.	inch	Scale	N/S	taihan

APPENDIX C UNDERGROUND ROUTE COST ESTIMATES

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route 1
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 21,387
NUMBER OF CIRCUITS: 1
ROUTE LENGTH (mile): 4.06
NUMBER OF CABLES PER PHASE: 4

PREPARED BY Akaylia Morgan 8/30/2024
CHECKED BY Gustavo Constreras 8/30/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	230 kV 5000 kcmil Cu XLPE Cable	L.F.	267,924	$ 212.20	$ 56,853,472.80	$ 25.47	$ 6,824,024.28	$ 63,677,497.08
U02	Spare 230 kV 5000 kcmil Cu XLPE Cable	L.F.	2,800	$ 212.20	$ 594,160.00	$ -	$ -	$ 594,160.00
U03	230 kV Open Air Terminators	EA.	24	$ 19,098.00	$ 458,352.00	$ 26,525.00	$ 636,600.00	$ 1,094,952.00
U04	Spare 230 kV Open Air Terminators	EA.	1	$ 19,098.00	$ 19,098.00	$ -	$ -	$ 19,098.00
U05	230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	230 kV Cable Splice	EA.	108	$ 20,689.50	$ 2,234,466.00	$ 26,525.00	$ 2,864,700.00	$ 5,099,166.00
U08	Spare 230 kV Cable Splice	EA.	1	$ 20,689.50	$ 20,689.50	$ -	$ -	$ 20,689.50
U09	230 kV Lightning Arrester	EA.	24	$ 7,427.00	$ 178,248.00	$ 3,713.50	$ 89,124.00	$ 267,372.00
U10	Spare 230 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	89,308	$ 12.74	$ 1,137,783.92	$ 8.49	$ 758,224.92	$ 1,896,008.84
U12	Link Box Without SVL's	EA.	40	$ 5,305.00	$ 212,200.00	$ 1,803.70	$ 72,148.00	$ 284,348.00
U13	Link Box With SVL's	EA.	40	$ 7,957.50	$ 318,300.00	$ 1,803.70	$ 72,148.00	$ 390,448.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	22,327	$ 4.34	$ 96,865.58	$ 5.42	$ 121,025.00	$ 217,890.58
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 124,972.22	$ 124,972.22	$ 534,506.18	$ 534,506.18	$ 659,478.40
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 5,878.17	$ 5,878.17	$ 150,470.20	$ 150,470.20	$ 156,348.37
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 238,031.63	$ 238,031.63	$ 238,031.63
				SUBTOTAL	**$ 62,261,913.19**		**$ 12,361,002.21**	**$ 74,622,915.40**
			CONTINGENCY	**20.00%**	**$ 12,452,382.64**		**$ 2,472,200.44**	**$ 14,924,583.08**
				TOTAL	**$ 74,714,295.83**		**$ 14,833,202.65**	**$ 89,547,498.48**

POWER CABLE DUCT SIZE: 8
NUMBER OF POWER CABLE DUCTS: 16
NUMBER OF OTHER DUCTS: 5
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	21,140	$ 190.28	$ 4,022,417.63	$ 334.93	$ 7,080,335.18	$ 11,102,752.81
C02	Rock Excavation (Trench & Vault)	C.Y.	9,827	$ -	$ -	$ 203.57	$ 2,000,439.95	$ 2,000,439.95
C03a	Concrete Encased Duct Bank	L.F.	21,140	$ 786.17	$ 16,619,633.80	$ 2,047.10	$ 43,275,694.00	$ 59,895,327.80
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	40,858	$ 135.39	$ 5,531,624.51	$ 22.92	$ 936,441.91	$ 6,468,066.42
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	1,450	$ 124.65	$ 180,745.02	$ 185.30	$ 268,687.59	$ 449,432.61
C07	Splice Vault Material	EA.	18	$ 75,671.08	$ 1,362,079.44	$ -	$ -	$ 1,362,079.44
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	18	$ 26,692.85	$ 480,471.30	$ 43,289.75	$ 779,215.50	$ 1,259,686.80
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 101,227.50	$ 101,227.50	$ 101,227.50	$ 101,227.50	$ 202,455.00
C10	Communication Handholes	EA.	9	$ 7,810.77	$ 70,296.93	$ 11,716.15	$ 105,445.35	$ 175,742.28
C11	Conduit Proofing (Civil)	L.S.	1	$ 74,983.33	$ 74,983.33	$ 524,883.33	$ 524,883.33	$ 599,866.66
C12	Substation Termination Structures	EA.	8	$ 31,170.30	$ 249,362.40	$ 35,999.98	$ 287,999.84	$ 537,362.24
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 579,321.45	$ 579,321.45	$ 492,510.71	$ 492,510.71	$ 1,071,832.16
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 72,627.50	$ 72,627.50	$ 1,847,073.70	$ 1,847,073.70	$ 1,919,701.20
C19	Grading and Access Road	L.F.	0	$ -	$ -	$ -	$ -	$ -
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 44,196.84	$ 44,196.84	$ 4,668,301.05	$ 4,668,301.05	$ 4,712,497.89
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 4,271,982.02	$ 4,271,982.02	$ 4,271,982.02
C22	Dewatering	L.S.	1	$ 913,231.84	$ 913,231.84	$ 1,522,327.26	$ 1,522,327.26	$ 2,435,559.10
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 1,242,536.29	$ 1,242,536.29	$ 1,242,536.29
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 448,682.94	$ 448,682.94	$ 448,682.94
				SUBTOTAL	**$ 30,302,219.49**		**$ 69,853,784.12**	**$ 100,156,003.61**
			CONTINGENCY	**20.00%**	**$ 6,060,443.90**		**$ 13,970,756.82**	**$ 20,031,200.72**
				TOTAL	**$ 36,362,663.39**		**$ 83,824,540.94**	**$ 120,187,204.33**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 45,326.60	$ 45,326.60	$ 861,205.40	$ 861,205.40	$ 906,532.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 391,500.00	$ 391,500.00	$ 7,438,500.00	$ 7,438,500.00	$ 7,830,000.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 10,486,735.14	$ 10,486,735.14	$ 10,486,735.14	$ 10,486,735.14	$ 20,973,470.28
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 10,923,561.74**		**$ 18,786,440.54**	**$ 29,710,002.28**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 74,714,295.83	$ 14,833,202.65	$ 89,547,498.48
CIVIL WORKS	LOT	$ 36,362,663.39	$ 83,824,540.94	$ 120,187,204.33
PROJECT OVERHEAD COSTS	LOT	$ 10,923,561.74	$ 18,786,440.54	$ 29,710,002.28
PROJECT TOTAL	**LOT**	**$ 122,000,520.96**	**$ 117,444,184.14**	**$ 239,444,705.09**
PROJECT TOTAL	**COST / MILE**	**$ 30,119,359.92**	**$ 28,994,496.29**	**$ 59,113,856.22**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route 1
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 21,387
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 4.06
NUMBER OF CABLES PER PHASE: 4
CHECKED BY Gustavo Constreras 8/30/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 5
NUMBER OF POWER CABLE DUCTS: 16
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 230 kV Golden to Mars UG Route 1 Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 21387-ft for a (1)-Circuit, (4)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (16)-8in power conduits with (5) smaller conduits with overall ductbank dimensions of 86-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (459)-total working days for duct bank trenching activities. (45)-total working days for splice vault installations. (60)-total working days for cable pulling. (132)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $906532 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $7830000 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	230 kV		
PROJECT NAME:	Golden to Mars UG Route 1	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE		
ROUTE LENGTH (ft):	21,387	NUMBER OF CIRCUITS:	1	PREPARED BY Akaylia Morgan	8/30/2024
ROUTE LENGTH (mile):	4.06	NUMBER OF CABLES PER PHASE:	4	CHECKED BY Gustavo Constreras	8/30/2024

POWER CABLE DUCT SIZE:	8	NUMBER OF OTHER DUCTS:	5
NUMBER OF POWER CABLE DUCTS:	16	TYPICAL DUCT BANK DIMENSIONS:	86-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 267924-ft, with an additional spare cable length of 2800-ft. The accessories to be installed include: (24)- 230 kV Open Air Terminators, with (1)-Spare 230 kV Open Air Terminators. (108)-230 kV Cable Splice, with (1)-Spare 230 kV Cable Splice. (24)-230 kV Lightning Arrester, with (1)-Spare 230
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.32% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2800-ft and standard splice vault spacing of 2400-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (120)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 21140-ft with an average duct bank depth of cover of 5.39 feet, with a further breakdown
CIV-2	A total of 9827-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 9811-Cubic Yards of rock were assumed for open cut trenching and 15-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 21140-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (16)-8-inch power conduits as well as (5)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 86-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 40858-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 1450-linear feet. Surface restoration costs also included (5)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (18) splice vaults as well as excavation for (18) splice vaults. Assumed splice vault dimensions were: 10-ft width by 26-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (18)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in
CIV-9	This cost estimate included material and installation for (9)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (16)-power conduits for (10)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (8)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 19937-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	Not Used
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.45% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (605)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars, UG Route 1, 85%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 19,239
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 3.65
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 8/30/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	500 kV 5000 kcmil Cu XLPE Cable	L.F.	305,985	$ 265.25	$ 81,162,521.25	$ 25.47	$ 7,793,437.95	$ 88,955,959.20
U02	Spare 500 kV 5000 kcmil Cu XLPE Cable	L.F.	2,000	$ 265.25	$ 530,500.00	$ -	$ -	$ 530,500.00
U03	500 kV Open Air Terminators	EA.	30	$ 38,196.00	$ 1,145,880.00	$ 53,050.00	$ 1,591,500.00	$ 2,737,380.00
U04	Spare 500 kV Open Air Terminators	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U05	500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	500 kV Cable Splice	EA.	165	$ 41,379.00	$ 6,827,535.00	$ 53,050.00	$ 8,753,250.00	$ 15,580,785.00
U08	Spare 500 kV Cable Splice	EA.	1	$ 41,379.00	$ 41,379.00	$ -	$ -	$ 41,379.00
U09	500 kV Lightning Arrester	EA.	30	$ 7,427.00	$ 222,810.00	$ 3,713.50	$ 111,405.00	$ 334,215.00
U10	Spare 500 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	20,399	$ 12.74	$ 259,883.26	$ 8.49	$ 173,187.51	$ 433,070.77
U12	Link Box Without SVL's	EA.	60	$ 5,305.00	$ 318,300.00	$ 1,803.70	$ 108,222.00	$ 426,522.00
U13	Link Box With SVL's	EA.	60	$ 7,957.50	$ 477,450.00	$ 1,803.70	$ 108,222.00	$ 585,672.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	20,399	$ 4.34	$ 88,500.96	$ 5.42	$ 110,574.15	$ 199,075.11
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 177,043.98	$ 177,043.98	$ 711,300.21	$ 711,300.21	$ 888,344.19
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 6,531.30	$ 6,531.30	$ 167,189.11	$ 167,189.11	$ 173,720.41
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 388,262.86	$ 388,262.86	$ 388,262.86
				SUBTOTAL	**$ 91,303,957.75**		**$ 20,016,550.79**	**$ 111,320,508.54**
			CONTINGENCY	**20.00%**	**$ 18,260,791.55**		**$ 4,003,310.16**	**$ 22,264,101.71**
				TOTAL	**$ 109,564,749.30**		**$ 24,019,860.95**	**$ 133,584,610.25**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 69-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	18,783	$ 186.72	$ 3,506,999.20	$ 395.55	$ 7,429,385.94	$ 10,936,385.14
C02	Rock Excavation (Trench & Vault)	C.Y.	16,138	$ -	$ -	$ 203.56	$ 3,285,004.89	$ 3,285,004.89
C03a	Concrete Encased Duct Bank	L.F.	18,783	$ 1,180.21	$ 22,167,884.43	$ 2,594.33	$ 48,729,300.39	$ 70,897,184.82
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	80,755	$ 135.39	$ 10,933,142.52	$ 22.92	$ 1,850,858.25	$ 12,784,000.77
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	630	$ 282.02	$ 177,673.52	$ 390.41	$ 245,959.78	$ 423,633.30
C07	Splice Vault Material	EA.	33	$ 91,292.60	$ 3,012,655.80	$ -	$ -	$ 3,012,655.80
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	33	$ 24,148.00	$ 796,884.00	$ 43,150.63	$ 1,423,970.79	$ 2,220,854.79
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 185,583.75	$ 185,583.75	$ 185,583.75	$ 185,583.75	$ 371,167.50
C10	Communication Handholes	EA.	13	$ 7,810.77	$ 101,540.01	$ 11,716.15	$ 152,309.95	$ 253,849.96
C11	Conduit Proofing (Civil)	L.S.	1	$ 112,474.99	$ 112,474.99	$ 787,324.99	$ 787,324.99	$ 899,799.98
C12	Substation Termination Structures	EA.	10	$ 61,651.75	$ 616,517.50	$ 71,354.68	$ 713,546.80	$ 1,330,064.30
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 542,288.68	$ 542,288.68	$ 460,903.62	$ 460,903.62	$ 1,003,192.30
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 71,974.38	$ 71,974.38	$ 1,830,463.33	$ 1,830,463.33	$ 1,902,437.71
C19	Grading and Access Road	L.F.	0	$ -	$ -	$ -	$ -	$ -
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 39,269.01	$ 39,269.01	$ 5,717,348.79	$ 5,717,348.79	$ 5,756,617.80
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 5,365,218.31	$ 5,365,218.31	$ 5,365,218.31
C22	Dewatering	L.S.	1	$ 823,648.64	$ 823,648.64	$ 1,373,585.16	$ 1,373,585.16	$ 2,197,233.80
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 2,273,557.10	$ 2,273,557.10	$ 2,273,557.10
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 749,477.15	$ 749,477.15	$ 749,477.15
				SUBTOTAL	**$ 43,088,536.43**		**$ 82,573,798.99**	**$ 125,662,335.42**
			CONTINGENCY	**20.00%**	**$ 8,617,707.29**		**$ 16,514,759.80**	**$ 25,132,467.08**
				TOTAL	**$ 51,706,243.72**		**$ 99,088,558.79**	**$ 150,794,802.50**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 45,545.35	$ 45,545.35	$ 865,361.65	$ 865,361.65	$ 910,907.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 426,937.50	$ 426,937.50	$ 8,111,812.50	$ 8,111,812.50	$ 8,538,750.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 13,105,765.55	$ 13,105,765.55	$ 13,105,765.55	$ 13,105,765.55	$ 26,211,531.10
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 13,578,248.40**		**$ 22,082,939.70**	**$ 35,661,188.10**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 109,564,749.30	$ 24,019,860.95	$ 133,584,610.25
CIVIL WORKS	LOT	$ 51,706,243.72	$ 99,088,558.79	$ 150,794,802.50
PROJECT OVERHEAD COSTS	LOT	$ 13,578,248.40	$ 22,082,939.70	$ 35,661,188.10
PROJECT TOTAL	**LOT**	**$ 174,849,241.42**	**$ 145,191,359.44**	**$ 320,040,600.85**
PROJECT TOTAL	**COST / MILE**	**$ 47,986,069.69**	**$ 39,846,685.27**	**$ 87,832,754.95**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars, UG Route 1, 85%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 19,239
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 3.65
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 8/30/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 69-in High

GENERAL PROJECT SUMMARY

GEN-1	The 500 kV Golden to Mars, UG Route 1, 85%DLF Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 19239-ft for a (1)-Circuit, (5)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (20)-8in power conduits with (6) smaller conduits with overall ductbank dimensions of 206-in Wide X 69-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (408)-total working days for duct bank trenching activities. (66)-total working days for splice vault installations. (90)-total working days for cable pulling. (195)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $910907 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $8538750 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	500 kV			
PROJECT NAME:	Golden to Mars, UG Route 1, 85%DLF	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE			
ROUTE LENGTH (ft):	19,239	NUMBER OF CIRCUITS:	1	PREPARED BY	Akaylia Morgan	8/30/2024
ROUTE LENGTH (mile):	3.65	NUMBER OF CABLES PER PHASE:	5	CHECKED BY	Gustavo Constreras	8/30/2024

POWER CABLE DUCT SIZE:	8	NUMBER OF OTHER DUCTS:	6
NUMBER OF POWER CABLE DUCTS:	20	TYPICAL DUCT BANK DIMENSIONS:	206-in Wide X 69-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 305985-ft, with an additional spare cable length of 2000-ft. The accessories to be installed include: (30)- 500 kV Open Air Terminators, with (1)-Spare 500 kV Open Air Terminators. (165)-500 kV Cable Splice, with (1)-Spare 500 kV Cable Splice. (30)-500 kV Lightning Arrester, with (1)-Spare 500
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.35% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 1700-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (180)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 18783-ft with an average duct bank depth of cover of 5.39 feet, with a further breakdown
CIV-2	A total of 16138-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 16106-Cubic Yards of rock were assumed for open cut trenching and 32-Cubic Yards of rock
CIV-3	This cost estimate included an assumed total installation length of 18783-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (20)-8-inch power conduits as well as (6)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 206-in Wide X 69-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 80755-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 630-linear feet. Surface restoration costs also included (5)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (33) splice vaults as well as excavation for (33) splice vaults. Assumed splice vault dimensions were: 15-ft width by 40-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (33)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in
CIV-9	This cost estimate included material and installation for (13)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (20)-power conduits for (12)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (10)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 18609-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	Not Used
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.6% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (1288)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 1, 100%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 19,239
NUMBER OF CIRCUITS: 1
ROUTE LENGTH (mile): 3.65
NUMBER OF CABLES PER PHASE: 5

PREPARED BY Akaylia Morgan 8/30/2024
CHECKED BY Gustavo Constreras 8/30/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	500 kV 5000 kcmil Cu XLPE Cable	L.F.	305,985	$ 265.25	$ 81,162,521.25	$ 25.47	$ 7,793,437.95	$ 88,955,959.20
U02	Spare 500 kV 5000 kcmil Cu XLPE Cable	L.F.	2,000	$ 265.25	$ 530,500.00	$ -	$ -	$ 530,500.00
U03	500 kV Open Air Terminators	EA.	30	$ 38,196.00	$ 1,145,880.00	$ 53,050.00	$ 1,591,500.00	$ 2,737,380.00
U04	Spare 500 kV Open Air Terminators	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U05	500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	500 kV Cable Splice	EA.	165	$ 41,379.00	$ 6,827,535.00	$ 53,050.00	$ 8,753,250.00	$ 15,580,785.00
U08	Spare 500 kV Cable Splice	EA.	1	$ 41,379.00	$ 41,379.00	$ -	$ -	$ 41,379.00
U09	500 kV Lightning Arrester	EA.	30	$ 7,427.00	$ 222,810.00	$ 3,713.50	$ 111,405.00	$ 334,215.00
U10	Spare 500 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	20,399	$ 12.74	$ 259,883.26	$ 8.49	$ 173,187.51	$ 433,070.77
U12	Link Box Without SVL's	EA.	60	$ 5,305.00	$ 318,300.00	$ 1,803.70	$ 108,222.00	$ 426,522.00
U13	Link Box With SVL's	EA.	60	$ 7,957.50	$ 477,450.00	$ 1,803.70	$ 108,222.00	$ 585,672.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	20,399	$ 4.34	$ 88,500.96	$ 5.42	$ 110,574.15	$ 199,075.11
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 177,043.98	$ 177,043.98	$ 711,300.21	$ 711,300.21	$ 888,344.19
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 6,531.30	$ 6,531.30	$ 167,189.11	$ 167,189.11	$ 173,720.41
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 388,262.86	$ 388,262.86	$ 388,262.86
				SUBTOTAL	**$ 91,303,957.75**		**$ 20,016,550.79**	**$ 111,320,508.54**
			CONTINGENCY	**20.00%**	**$ 18,260,791.55**		**$ 4,003,310.16**	**$ 22,264,101.71**
				TOTAL	**$ 109,564,749.30**		**$ 24,019,860.95**	**$ 133,584,610.25**

POWER CABLE DUCT SIZE: 8
NUMBER OF POWER CABLE DUCTS: 20
NUMBER OF OTHER DUCTS: 6
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	18,783	$ 190.29	$ 3,574,042.92	$ 414.62	$ 7,787,575.73	$ 11,361,618.65
C02	Rock Excavation (Trench & Vault)	C.Y.	18,235	$ -	$ -	$ 203.57	$ 3,712,133.28	$ 3,712,133.28
C03a	Concrete Encased Duct Bank	L.F.	18,783	$ 1,335.16	$ 25,078,310.28	$ 2,626.12	$ 49,326,411.96	$ 74,404,722.24
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	80,755	$ 135.39	$ 10,933,142.52	$ 22.92	$ 1,850,858.25	$ 12,784,000.77
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	630	$ 282.02	$ 177,673.52	$ 390.41	$ 245,959.78	$ 423,633.30
C07	Splice Vault Material	EA.	33	$ 91,292.60	$ 3,012,655.80	$ -	$ -	$ 3,012,655.80
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	33	$ 24,148.00	$ 796,884.00	$ 43,150.63	$ 1,423,970.79	$ 2,220,854.79
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 185,583.75	$ 185,583.75	$ 185,583.75	$ 185,583.75	$ 371,167.50
C10	Communication Handholes	EA.	13	$ 7,810.77	$ 101,540.01	$ 11,716.15	$ 152,309.95	$ 253,849.96
C11	Conduit Proofing (Civil)	L.S.	1	$ 112,474.99	$ 112,474.99	$ 787,324.99	$ 787,324.99	$ 899,799.98
C12	Substation Termination Structures	EA.	10	$ 61,651.75	$ 616,517.50	$ 71,354.68	$ 713,546.80	$ 1,330,064.30
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 542,288.68	$ 542,288.68	$ 460,903.62	$ 460,903.62	$ 1,003,192.30
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 71,974.38	$ 71,974.38	$ 1,830,463.33	$ 1,830,463.33	$ 1,902,437.71
C19	Grading and Access Road	L.F.	0	$ -	$ -	$ -	$ -	$ -
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 39,269.01	$ 39,269.01	$ 5,931,323.93	$ 5,931,323.93	$ 5,970,592.94
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 5,579,193.45	$ 5,579,193.45	$ 5,579,193.45
C22	Dewatering	L.S.	1	$ 823,648.64	$ 823,648.64	$ 1,373,585.16	$ 1,373,585.16	$ 2,197,233.80
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 2,273,557.10	$ 2,273,557.10	$ 2,273,557.10
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 752,264.11	$ 752,264.11	$ 752,264.11
				SUBTOTAL	**$ 46,066,006.00**		**$ 84,386,965.98**	**$ 130,452,971.98**
			CONTINGENCY	**20.00%**	**$ 9,213,201.20**		**$ 16,877,393.20**	**$ 26,090,594.40**
				TOTAL	**$ 55,279,207.20**		**$ 101,264,359.18**	**$ 156,543,566.38**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 45,545.35	$ 45,545.35	$ 865,361.65	$ 865,361.65	$ 910,907.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 426,937.50	$ 426,937.50	$ 8,111,812.50	$ 8,111,812.50	$ 8,538,750.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 14,506,408.83	$ 14,506,408.83	$ 14,506,408.83	$ 14,506,408.83	$ 29,012,817.66
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 14,978,891.68**		**$ 23,483,582.98**	**$ 38,462,474.66**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 109,564,749.30	$ 24,019,860.95	$ 133,584,610.25
CIVIL WORKS	LOT	$ 55,279,207.20	$ 101,264,359.18	$ 156,543,566.38
PROJECT OVERHEAD COSTS	LOT	$ 14,978,891.68	$ 23,483,582.98	$ 38,462,474.66
PROJECT TOTAL	**LOT**	**$ 179,822,848.18**	**$ 148,767,803.10**	**$ 328,590,651.28**
PROJECT TOTAL	**COST / MILE**	**$ 49,351,038.95**	**$ 40,828,213.54**	**$ 90,179,252.50**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 1, 100%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 19,239
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 3.65
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 8/30/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 500 kV Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 19239-ft for a (1)-Circuit, (5)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (20)-8in power conduits with (6) smaller conduits with overall ductbank dimensions of 206-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (408)-total working days for duct bank trenching activities. (66)-total working days for splice vault installations. (90)-total working days for cable pulling. (195)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $910907 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $8538750 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	500 kV			
PROJECT NAME:	Golden to Mars UG Route 1, 100%DLF	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE			
ROUTE LENGTH (ft):	19,239	NUMBER OF CIRCUITS:	1	PREPARED BY	Akaylia Morgan	8/30/2024
ROUTE LENGTH (mile):	3.65	NUMBER OF CABLES PER PHASE:	5	CHECKED BY	Gustavo Constreras	8/30/2024

POWER CABLE DUCT SIZE:	8	NUMBER OF OTHER DUCTS:	6
NUMBER OF POWER CABLE DUCTS:	20	TYPICAL DUCT BANK DIMENSIONS:	206-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 305985-ft, with an additional spare cable length of 2000-ft. The accessories to be installed include: (30)- 500 kV Open Air Terminators, with (1)-Spare 500 kV Open Air Terminators. (165)-500 kV Cable Splice, with (1)-Spare 500 kV Cable Splice. (30)-500 kV Lightning Arrester, with (1)-Spare 500
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.35% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 1700-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (180)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 18783-ft with an average duct bank depth of cover of 5.39 feet, with a further breakdown
CIV-2	A total of 18235-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 18203-Cubic Yards of rock were assumed for open cut trenching and 32-Cubic Yards of rock
CIV-3	This cost estimate included an assumed total installation length of 18783-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (20)-8-inch power conduits as well as (6)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 206-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 80755-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 630-linear feet. Surface restoration costs also included (5)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (33) splice vaults as well as excavation for (33) splice vaults. Assumed splice vault dimensions were: 15-ft width by 40-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (33)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in
CIV-9	This cost estimate included material and installation for (13)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (20)-power conduits for (12)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (10)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 18609-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	Not Used
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.58% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (1288)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route 2
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 18,377
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 3.49
NUMBER OF CABLES PER PHASE: 4
CHECKED BY Gustavo Constreras 8/30/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	230 kV 5000 kcmil Cu XLPE Cable	L.F.	230,364	$ 212.20	$ 48,883,240.80	$ 25.47	$ 5,867,371.08	$ 54,750,611.88
U02	Spare 230 kV 5000 kcmil Cu XLPE Cable	L.F.	2,800	$ 212.20	$ 594,160.00	$ -	$ -	$ 594,160.00
U03	230 kV Open Air Terminators	EA.	24	$ 19,098.00	$ 458,352.00	$ 26,525.00	$ 636,600.00	$ 1,094,952.00
U04	Spare 230 kV Open Air Terminators	EA.	1	$ 19,098.00	$ 19,098.00	$ -	$ -	$ 19,098.00
U05	230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	230 kV Cable Splice	EA.	84	$ 20,689.50	$ 1,737,918.00	$ 26,525.00	$ 2,228,100.00	$ 3,966,018.00
U08	Spare 230 kV Cable Splice	EA.	1	$ 20,689.50	$ 20,689.50	$ -	$ -	$ 20,689.50
U09	230 kV Lightning Arrester	EA.	24	$ 7,427.00	$ 178,248.00	$ 3,713.50	$ 89,124.00	$ 267,372.00
U10	Spare 230 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	76,788	$ 12.74	$ 978,279.12	$ 8.49	$ 651,930.12	$ 1,630,209.24
U12	Link Box Without SVL's	EA.	32	$ 5,305.00	$ 169,760.00	$ 1,803.70	$ 57,718.40	$ 227,478.40
U13	Link Box With SVL's	EA.	32	$ 7,957.50	$ 254,640.00	$ 1,803.70	$ 57,718.40	$ 312,358.40
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	19,197	$ 4.34	$ 83,286.09	$ 5.42	$ 104,058.62	$ 187,344.71
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 124,972.22	$ 124,972.22	$ 519,509.52	$ 519,509.52	$ 644,481.74
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 1,959.39	$ 1,959.39	$ 50,156.73	$ 50,156.73	$ 52,116.12
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 223,210.11	$ 223,210.11	$ 223,210.11
				SUBTOTAL	**$ 53,512,030.12**		**$ 10,485,496.98**	**$ 63,997,527.10**
			CONTINGENCY	**20.00%**	**$ 10,702,406.02**		**$ 2,097,099.40**	**$ 12,799,505.42**
				TOTAL	**$ 64,214,436.14**		**$ 12,582,596.38**	**$ 76,797,032.52**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 5
NUMBER OF POWER CABLE DUCTS: 16
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	18,185	$ 151.16	$ 2,748,795.18	$ 282.66	$ 5,140,070.78	$ 7,888,865.96
C02	Rock Excavation (Trench & Vault)	C.Y.	3,920	$ -	$ -	$ 203.56	$ 798,042.98	$ 798,042.98
C03a	Concrete Encased Duct Bank	L.F.	18,185	$ 786.17	$ 14,296,501.45	$ 2,047.10	$ 37,226,513.50	$ 51,523,014.95
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	30,087	$ 135.39	$ 4,073,375.76	$ 22.92	$ 689,576.77	$ 4,762,952.53
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	500	$ 221.58	$ 110,790.83	$ 189.37	$ 94,686.75	$ 205,477.58
C07	Splice Vault Material	EA.	14	$ 75,671.08	$ 1,059,395.12	$ -	$ -	$ 1,059,395.12
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	14	$ 26,692.85	$ 373,699.90	$ 43,423.89	$ 607,934.46	$ 981,634.36
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 78,732.50	$ 78,732.50	$ 78,732.50	$ 78,732.50	$ 157,465.00
C10	Communication Handholes	EA.	9	$ 7,810.77	$ 70,296.93	$ 11,716.15	$ 105,445.35	$ 175,742.28
C11	Conduit Proofing (Civil)	L.S.	1	$ 59,986.67	$ 59,986.67	$ 419,906.66	$ 419,906.66	$ 479,893.33
C12	Substation Termination Structures	EA.	8	$ 31,170.30	$ 249,362.40	$ 35,999.98	$ 287,999.84	$ 537,362.24
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 520,721.61	$ 520,721.61	$ 442,591.95	$ 442,591.95	$ 963,313.56
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 9,796.88	$ 9,796.88	$ 249,155.63	$ 249,155.63	$ 258,952.51
C19	Grading and Access Road	L.F.	14,820	$ 63.13	$ 935,586.60	$ 94.69	$ 1,403,305.80	$ 2,338,892.40
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 38,018.75	$ 38,018.75	$ 3,880,964.75	$ 3,880,964.75	$ 3,918,983.50
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 3,540,045.46	$ 3,540,045.46	$ 3,540,045.46
C22	Dewatering	L.S.	1	$ 790,363.72	$ 790,363.72	$ 1,319,206.86	$ 1,319,206.86	$ 2,109,570.58
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 930,418.18	$ 930,418.18	$ 930,418.18
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 454,465.12	$ 454,465.12	$ 454,465.12
				SUBTOTAL	**$ 25,415,424.30**		**$ 57,669,063.34**	**$ 83,084,487.64**
			CONTINGENCY	**20.00%**	**$ 5,083,084.86**		**$ 11,533,812.67**	**$ 16,616,897.53**
				TOTAL	**$ 30,498,509.16**		**$ 69,202,876.01**	**$ 99,701,385.17**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 41,264.10	$ 41,264.10	$ 784,017.90	$ 784,017.90	$ 825,282.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 292,500.00	$ 292,500.00	$ 5,557,500.00	$ 5,557,500.00	$ 5,850,000.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 8,824,920.88	$ 8,824,920.88	$ 8,824,920.88	$ 8,824,920.88	$ 17,649,841.76
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 9,158,684.98**		**$ 15,166,438.78**	**$ 24,325,123.76**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 64,214,436.14	$ 12,582,596.38	$ 76,797,032.52
CIVIL WORKS	LOT	$ 30,498,509.16	$ 69,202,876.01	$ 99,701,385.17
PROJECT OVERHEAD COSTS	LOT	$ 9,158,684.98	$ 15,166,438.78	$ 24,325,123.76
PROJECT TOTAL	**LOT**	**$ 103,871,630.28**	**$ 96,951,911.16**	**$ 200,823,541.45**
PROJECT TOTAL	**COST / MILE**	**$ 29,843,946.67**	**$ 27,855,802.96**	**$ 57,699,749.62**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route 2
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 18,377
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 3.49
NUMBER OF CABLES PER PHASE: 4
CHECKED BY Gustavo Constreras 8/30/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 5
NUMBER OF POWER CABLE DUCTS: 16
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 230 kV Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 18377-ft for a (1)-Circuit, (4)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (16)-8in power conduits with (5) smaller conduits with overall ductbank dimensions of 86-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (329)-total working days for duct bank trenching activities. (35)-total working days for splice vault installations. (48)-total working days for cable pulling. (108)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $825282 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $5850000 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	230 kV		
PROJECT NAME:	Golden to Mars UG Route 2	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE		
ROUTE LENGTH (ft):	18,377	NUMBER OF CIRCUITS:	1	PREPARED BY Akaylia Morgan	8/30/2024
ROUTE LENGTH (mile):	3.49	NUMBER OF CABLES PER PHASE:	4	CHECKED BY Gustavo Constreras	8/30/2024

POWER CABLE DUCT SIZE:	8	NUMBER OF OTHER DUCTS:	5
NUMBER OF POWER CABLE DUCTS:	16	TYPICAL DUCT BANK DIMENSIONS:	86-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 230364-ft, with an additional spare cable length of 2800-ft. The accessories to be installed include: (24)- 230 kV Open Air Terminators, with (1)-Spare 230 kV Open Air Terminators. (84)-230 kV Cable Splice, with (1)-Spare 230 kV Cable Splice. (24)-230 kV Lightning Arrester, with (1)-Spare 230 kV
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.35% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2800-ft and standard splice vault spacing of 2400-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (96)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 18185-ft with an average duct bank depth of cover of 4.47 feet, with a further breakdown
CIV-2	A total of 3920-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 3913-Cubic Yards of rock were assumed for open cut trenching and 8-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 18185-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (16)-8-inch power conduits as well as (5)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 86-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 30087-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 500-linear feet. Surface restoration costs also included (2)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (14) splice vaults as well as excavation for (14) splice vaults. Assumed splice vault dimensions were: 10-ft width by 26-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (14)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in
CIV-9	This cost estimate included material and installation for (9)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (16)-power conduits for (8)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (8)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 17877-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 14820-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.55% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (432)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 2, 85%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 19,064
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 3.62
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 8/30/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	500 kV 5000 kcmil Cu XLPE Cable	L.F.	301,860	$ 265.25	$ 80,068,365.00	$ 25.47	$ 7,688,374.20	$ 87,756,739.20
U02	Spare 500 kV 5000 kcmil Cu XLPE Cable	L.F.	2,000	$ 265.25	$ 530,500.00	$ -	$ -	$ 530,500.00
U03	500 kV Open Air Terminators	EA.	30	$ 38,196.00	$ 1,145,880.00	$ 53,050.00	$ 1,591,500.00	$ 2,737,380.00
U04	Spare 500 kV Open Air Terminators	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U05	500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	500 kV Cable Splice	EA.	165	$ 41,379.00	$ 6,827,535.00	$ 53,050.00	$ 8,753,250.00	$ 15,580,785.00
U08	Spare 500 kV Cable Splice	EA.	1	$ 41,379.00	$ 41,379.00	$ -	$ -	$ 41,379.00
U09	500 kV Lightning Arrester	EA.	30	$ 7,427.00	$ 222,810.00	$ 3,713.50	$ 111,405.00	$ 334,215.00
U10	Spare 500 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	20,124	$ 12.74	$ 256,379.76	$ 8.49	$ 170,852.76	$ 427,232.52
U12	Link Box Without SVL's	EA.	60	$ 5,305.00	$ 318,300.00	$ 1,803.70	$ 108,222.00	$ 426,522.00
U13	Link Box With SVL's	EA.	60	$ 7,957.50	$ 477,450.00	$ 1,803.70	$ 108,222.00	$ 585,672.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	20,124	$ 4.34	$ 87,307.88	$ 5.42	$ 109,083.49	$ 196,391.37
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 177,043.98	$ 177,043.98	$ 711,300.21	$ 711,300.21	$ 888,344.19
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 5,094.41	$ 5,094.41	$ 130,407.51	$ 130,407.51	$ 135,501.92
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 383,902.00	$ 383,902.00	$ 383,902.00
				SUBTOTAL	**$ 90,203,668.03**		**$ 19,866,519.17**	**$ 110,070,187.20**
			CONTINGENCY	**20.00%**	**$ 18,040,733.61**		**$ 3,973,303.83**	**$ 22,014,037.44**
				TOTAL	**$ 108,244,401.64**		**$ 23,839,823.00**	**$ 132,084,224.64**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 69-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	18,608	$ 147.59	$ 2,746,337.49	$ 341.16	$ 6,348,067.71	$ 9,094,405.20
C02	Rock Excavation (Trench & Vault)	C.Y.	7,362	$ -	$ -	$ 203.55	$ 1,498,590.34	$ 1,498,590.34
C03a	Concrete Encased Duct Bank	L.F.	18,608	$ 1,180.21	$ 21,961,347.68	$ 2,594.33	$ 48,275,292.64	$ 70,236,640.32
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	68,484	$ 135.39	$ 9,271,813.91	$ 22.92	$ 1,569,613.97	$ 10,841,427.88
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	500	$ 316.91	$ 158,454.49	$ 359.72	$ 179,861.89	$ 338,316.38
C07	Splice Vault Material	EA.	33	$ 91,292.60	$ 3,012,655.80	$ -	$ -	$ 3,012,655.80
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	33	$ 28,117.22	$ 927,868.26	$ 50,007.32	$ 1,650,241.56	$ 2,578,109.82
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 185,583.75	$ 185,583.75	$ 185,583.75	$ 185,583.75	$ 371,167.50
C10	Communication Handholes	EA.	13	$ 7,810.77	$ 101,540.01	$ 11,716.15	$ 152,309.95	$ 253,849.96
C11	Conduit Proofing (Civil)	L.S.	1	$ 112,474.99	$ 112,474.99	$ 787,324.99	$ 787,324.99	$ 899,799.98
C12	Substation Termination Structures	EA.	8	$ 61,651.75	$ 493,214.00	$ 71,354.68	$ 570,837.44	$ 1,064,051.44
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 541,835.50	$ 541,835.50	$ 460,450.43	$ 460,450.43	$ 1,002,285.93
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 13,715.63	$ 13,715.63	$ 348,817.88	$ 348,817.88	$ 362,533.51
C19	Grading and Access Road	L.F.	14,801	$ 63.13	$ 934,387.13	$ 94.69	$ 1,401,506.69	$ 2,335,893.82
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 38,903.13	$ 38,903.13	$ 5,447,549.68	$ 5,447,549.68	$ 5,486,452.81
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 5,098,700.07	$ 5,098,700.07	$ 5,098,700.07
C22	Dewatering	L.S.	1	$ 819,327.15	$ 819,327.15	$ 1,367,318.34	$ 1,367,318.34	$ 2,186,645.49
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 1,914,261.97	$ 1,914,261.97	$ 1,914,261.97
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 758,885.04	$ 758,885.04	$ 758,885.04
				SUBTOTAL	**$ 41,319,458.92**		**$ 78,015,214.34**	**$ 119,334,673.26**
			CONTINGENCY	**20.00%**	**$ 8,263,891.78**		**$ 15,603,042.87**	**$ 23,866,934.65**
				TOTAL	**$ 49,583,350.70**		**$ 93,618,257.21**	**$ 143,201,607.91**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 43,714.10	$ 43,714.10	$ 830,567.90	$ 830,567.90	$ 874,282.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 39,562.50	$ 39,562.50	$ 751,687.50	$ 751,687.50	$ 791,250.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 12,663,589.76	$ 12,663,589.76	$ 12,663,589.76	$ 12,663,589.76	$ 25,327,179.52
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 12,746,866.36**		**$ 14,245,845.16**	**$ 26,992,711.52**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 108,244,401.64	$ 23,839,823.00	$ 132,084,224.64
CIVIL WORKS	LOT	$ 49,583,350.70	$ 93,618,257.21	$ 143,201,607.91
PROJECT OVERHEAD COSTS	LOT	$ 12,746,866.36	$ 14,245,845.16	$ 26,992,711.52
PROJECT TOTAL	**LOT**	**$ 170,574,618.70**	**$ 131,703,925.37**	**$ 302,278,544.07**
PROJECT TOTAL	**COST / MILE**	**$ 47,242,655.62**	**$ 36,476,957.93**	**$ 83,719,613.55**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 2, 85%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 19,064
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 3.62
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 8/30/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 69-in High

GENERAL PROJECT SUMMARY

GEN-1	The 500 kV Golden to Mars UG Route 2, 85%DLF Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 19064-ft for a (1)-Circuit, (5)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (20)-8in power conduits with (6) smaller conduits with overall ductbank dimensions of 206-in Wide X 69-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (337)-total working days for duct bank trenching activities. (83)-total working days for splice vault installations. (90)-total working days for cable pulling. (195)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $874282 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $791250 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	500 kV		
PROJECT NAME:	Golden to Mars UG Route 2, 85%DLF	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE		
ROUTE LENGTH (ft):	19,064	NUMBER OF CIRCUITS:	1	PREPARED BY Akaylia Morgan	8/30/2024
ROUTE LENGTH (mile):	3.62	NUMBER OF CABLES PER PHASE:	5	CHECKED BY Gustavo Constreras	8/30/2024

POWER CABLE DUCT SIZE:	8	NUMBER OF OTHER DUCTS:	6
NUMBER OF POWER CABLE DUCTS:	20	TYPICAL DUCT BANK DIMENSIONS:	206-in Wide X 69-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 301860-ft, with an additional spare cable length of 2000-ft. The accessories to be installed include: (30)- 500 kV Open Air Terminators, with (1)-Spare 500 kV Open Air Terminators. (165)-500 kV Cable Splice, with (1)-Spare 500 kV Cable Splice. (30)-500 kV Lightning Arrester, with (1)-Spare 500
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.35% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 1700-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (180)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 18608-ft with an average duct bank depth of cover of 4.47 feet, with a further breakdown
CIV-2	A total of 7362-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 7346-Cubic Yards of rock were assumed for open cut trenching and 16-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 18608-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (20)-8-inch power conduits as well as (6)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 206-in Wide X 69-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 68484-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 500-linear feet. Surface restoration costs also included (2)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (33) splice vaults as well as excavation for (33) splice vaults. Assumed splice vault dimensions were: 15-ft width by 40-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (33)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in
CIV-9	This cost estimate included material and installation for (13)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (20)-power conduits for (12)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (8)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 18564-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 14801-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.64% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (1058)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 2, 100%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 19,064
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 3.62
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 8/30/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	500 kV 5000 kcmil Cu XLPE Cable	L.F.	303,360	$ 265.25	$ 80,466,240.00	$ 25.47	$ 7,726,579.20	$ 88,192,819.20
U02	Spare 500 kV 5000 kcmil Cu XLPE Cable	L.F.	2,000	$ 265.25	$ 530,500.00	$ -	$ -	$ 530,500.00
U03	500 kV Open Air Terminators	EA.	30	$ 38,196.00	$ 1,145,880.00	$ 53,050.00	$ 1,591,500.00	$ 2,737,380.00
U04	Spare 500 kV Open Air Terminators	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U05	500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	500 kV Cable Splice	EA.	165	$ 41,379.00	$ 6,827,535.00	$ 53,050.00	$ 8,753,250.00	$ 15,580,785.00
U08	Spare 500 kV Cable Splice	EA.	1	$ 41,379.00	$ 41,379.00	$ -	$ -	$ 41,379.00
U09	500 kV Lightning Arrester	EA.	30	$ 7,427.00	$ 222,810.00	$ 3,713.50	$ 111,405.00	$ 334,215.00
U10	Spare 500 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	101,120	$ 12.74	$ 1,288,268.80	$ 8.49	$ 858,508.80	$ 2,146,777.60
U12	Link Box Without SVL's	EA.	60	$ 5,305.00	$ 318,300.00	$ 1,803.70	$ 108,222.00	$ 426,522.00
U13	Link Box With SVL's	EA.	60	$ 7,957.50	$ 477,450.00	$ 1,803.70	$ 108,222.00	$ 585,672.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
U16	Digital Temperature Monitoring System	EA.	1	$ 279,240.82	$ 279,240.82	$ 76,824.63	$ 76,824.63	$ 356,065.45
U17	Cable System Testing	L.S.	1	$ 177,043.98	$ 177,043.98	$ 711,300.21	$ 711,300.21	$ 888,344.19
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 5,094.41	$ 5,094.41	$ 130,407.51	$ 130,407.51	$ 135,501.92
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 347,204.91	$ 347,204.91	$ 347,204.91
				SUBTOTAL	**$ 91,825,365.01**		**$ 20,523,424.26**	**$ 112,348,789.27**
			CONTINGENCY	**20.00%**	**$ 18,365,073.00**		**$ 4,104,684.85**	**$ 22,469,757.85**
				TOTAL	**$ 110,190,438.01**		**$ 24,628,109.11**	**$ 134,818,547.12**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	18,608	$ 151.16	$ 2,812,660.74	$ 361.12	$ 6,719,473.41	$ 9,532,134.15
C02	Rock Excavation (Trench & Vault)	C.Y.	8,394	$ -	$ -	$ 203.56	$ 1,708,696.05	$ 1,708,696.05
C03a	Concrete Encased Duct Bank	L.F.	18,608	$ 1,335.16	$ 24,844,657.28	$ 2,626.12	$ 48,866,840.96	$ 73,711,498.24
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	68,484	$ 135.39	$ 9,271,813.91	$ 22.92	$ 1,569,613.97	$ 10,841,427.88
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	500	$ 316.91	$ 158,454.49	$ 359.72	$ 179,861.89	$ 338,316.38
C07	Splice Vault Material	EA.	33	$ 91,292.60	$ 3,012,655.80	$ -	$ -	$ 3,012,655.80
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	33	$ 28,117.22	$ 927,868.26	$ 50,007.32	$ 1,650,241.56	$ 2,578,109.82
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 185,583.75	$ 185,583.75	$ 185,583.75	$ 185,583.75	$ 371,167.50
C10	Communication Handholes	EA.	13	$ 7,810.77	$ 101,540.01	$ 11,716.15	$ 152,309.95	$ 253,849.96
C11	Conduit Proofing (Civil)	L.S.	1	$ 112,474.99	$ 112,474.99	$ 787,324.99	$ 787,324.99	$ 899,799.98
C12	Substation Termination Structures	EA.	10	$ 61,651.75	$ 616,517.50	$ 71,354.68	$ 713,546.80	$ 1,330,064.30
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 541,835.50	$ 541,835.50	$ 460,450.43	$ 460,450.43	$ 1,002,285.93
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 13,715.63	$ 13,715.63	$ 348,817.88	$ 348,817.88	$ 362,533.51
C19	Grading and Access Road	L.F.	14,801	$ 63.13	$ 934,387.13	$ 94.69	$ 1,401,506.69	$ 2,335,893.82
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 38,903.13	$ 38,903.13	$ 5,662,938.57	$ 5,662,938.57	$ 5,701,841.70
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 5,314,088.96	$ 5,314,088.96	$ 5,314,088.96
C22	Dewatering	L.S.	1	$ 819,327.15	$ 819,327.15	$ 1,367,318.34	$ 1,367,318.34	$ 2,186,645.49
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 1,914,261.97	$ 1,914,261.97	$ 1,914,261.97
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 752,711.16	$ 752,711.16	$ 752,711.16
				SUBTOTAL	**$ 44,392,395.27**		**$ 79,755,587.33**	**$ 124,147,982.60**
			CONTINGENCY	**20.00%**	**$ 8,878,479.05**		**$ 15,951,117.47**	**$ 24,829,596.52**
				TOTAL	**$ 53,270,874.32**		**$ 95,706,704.80**	**$ 148,977,579.12**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 43,714.10	$ 43,714.10	$ 830,567.90	$ 830,567.90	$ 874,282.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 396,562.50	$ 396,562.50	$ 7,534,687.50	$ 7,534,687.50	$ 7,931,250.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 14,189,806.31	$ 14,189,806.31	$ 14,189,806.31	$ 14,189,806.31	$ 28,379,612.62
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 14,630,082.91**		**$ 22,555,061.71**	**$ 37,185,144.62**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 110,190,438.01	$ 24,628,109.11	$ 134,818,547.12
CIVIL WORKS	LOT	$ 53,270,874.32	$ 95,706,704.80	$ 148,977,579.12
PROJECT OVERHEAD COSTS	LOT	$ 14,630,082.91	$ 22,555,061.71	$ 37,185,144.62
PROJECT TOTAL	**LOT**	**$ 178,091,395.25**	**$ 142,889,875.62**	**$ 320,981,270.86**
PROJECT TOTAL	**COST / MILE**	**$ 49,324,515.68**	**$ 39,575,038.99**	**$ 88,899,554.67**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 2, 100%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 19,064
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 3.62
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 8/30/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 500 kV Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 19064-ft for a (1)-Circuit, (5)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (20)-8in power conduits with (6) smaller conduits with overall ductbank dimensions of 206-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (337)-total working days for duct bank trenching activities. (83)-total working days for splice vault installations. (90)-total working days for cable pulling. (195)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $874282 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $7931250 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	500 kV			
PROJECT NAME:	Golden to Mars UG Route 2, 100%DLF	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE			
ROUTE LENGTH (ft):	19,064	NUMBER OF CIRCUITS:	1	PREPARED BY	Akaylia Morgan	8/30/2024
ROUTE LENGTH (mile):	3.62	NUMBER OF CABLES PER PHASE:	5	CHECKED BY	Gustavo Constreras	8/30/2024

POWER CABLE DUCT SIZE:	8	NUMBER OF OTHER DUCTS:	6
NUMBER OF POWER CABLE DUCTS:	20	TYPICAL DUCT BANK DIMENSIONS:	206-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 303360-ft, with an additional spare cable length of 2000-ft. The accessories to be installed include: (30)- 500 kV Open Air Terminators, with (1)-Spare 500 kV Open Air Terminators. (165)-500 kV Cable Splice, with (1)-Spare 500 kV Cable Splice. (30)-500 kV Lightning Arrester, with (1)-Spare 500
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.31% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 1700-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (180)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 18608-ft with an average duct bank depth of cover of 4.47 feet, with a further breakdown
CIV-2	A total of 8394-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 8378-Cubic Yards of rock were assumed for open cut trenching and 16-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 18608-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (20)-8-inch power conduits as well as (6)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 206-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 68484-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 500-linear feet. Surface restoration costs also included (2)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (33) splice vaults as well as excavation for (33) splice vaults. Assumed splice vault dimensions were: 15-ft width by 40-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (33)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in
CIV-9	This cost estimate included material and installation for (13)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (20)-power conduits for (12)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (10)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 18564-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 14801-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.61% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (1058)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route 3
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 15,539
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 2.95
NUMBER OF CABLES PER PHASE: 4
CHECKED BY Gustavo Constreras 8/30/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	230 kV 5000 kcmil Cu XLPE Cable	L.F.	195,588	$ 212.20	$ 41,503,773.60	$ 25.47	$ 4,981,626.36	$ 46,485,399.96
U02	Spare 230 kV 5000 kcmil Cu XLPE Cable	L.F.	2,800	$ 212.20	$ 594,160.00	$ -	$ -	$ 594,160.00
U03	230 kV Open Air Terminators	EA.	24	$ 19,098.00	$ 458,352.00	$ 26,525.00	$ 636,600.00	$ 1,094,952.00
U04	Spare 230 kV Open Air Terminators	EA.	1	$ 19,098.00	$ 19,098.00	$ -	$ -	$ 19,098.00
U05	230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	230 kV Cable Splice	EA.	72	$ 20,689.50	$ 1,489,644.00	$ 26,525.00	$ 1,909,800.00	$ 3,399,444.00
U08	Spare 230 kV Cable Splice	EA.	1	$ 20,689.50	$ 20,689.50	$ -	$ -	$ 20,689.50
U09	230 kV Lightning Arrester	EA.	24	$ 7,427.00	$ 178,248.00	$ 3,713.50	$ 89,124.00	$ 267,372.00
U10	Spare 230 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	65,196	$ 12.74	$ 830,597.04	$ 8.49	$ 553,514.04	$ 1,384,111.08
U12	Link Box Without SVL's	EA.	28	$ 5,305.00	$ 148,540.00	$ 1,803.70	$ 50,503.60	$ 199,043.60
U13	Link Box With SVL's	EA.	28	$ 7,957.50	$ 222,810.00	$ 1,803.70	$ 50,503.60	$ 273,313.60
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	16,299	$ 4.34	$ 70,713.13	$ 5.42	$ 88,349.82	$ 159,062.95
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 124,972.22	$ 124,972.22	$ 512,011.18	$ 512,011.18	$ 636,983.40
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 3,788.15	$ 3,788.15	$ 96,969.69	$ 96,969.69	$ 100,757.84
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 234,959.80	$ 234,959.80	$ 234,959.80
				SUBTOTAL	**$ 45,672,812.64**		**$ 9,203,962.09**	**$ 54,876,774.73**
			CONTINGENCY	**20.00%**	**$ 9,134,562.53**		**$ 1,840,792.42**	**$ 10,975,354.95**
				TOTAL	**$ 54,807,375.17**		**$ 11,044,754.51**	**$ 65,852,129.68**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 5
NUMBER OF POWER CABLE DUCTS: 16
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	15,374	$ 205.06	$ 3,152,623.09	$ 354.58	$ 5,451,374.42	$ 8,603,997.51
C02	Rock Excavation (Trench & Vault)	C.Y.	7,142	$ -	$ -	$ 203.55	$ 1,453,666.18	$ 1,453,666.18
C03a	Concrete Encased Duct Bank	L.F.	15,374	$ 786.17	$ 12,086,577.58	$ 2,047.10	$ 31,472,115.40	$ 43,558,692.98
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	29,622	$ 135.39	$ 4,010,421.00	$ 22.92	$ 678,919.24	$ 4,689,340.24
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	1,020	$ 141.95	$ 144,785.61	$ 173.48	$ 176,946.94	$ 321,732.55
C07	Splice Vault Material	EA.	12	$ 75,671.08	$ 908,052.96	$ -	$ -	$ 908,052.96
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	12	$ 26,692.85	$ 320,314.20	$ 43,289.75	$ 519,477.00	$ 839,791.20
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 67,485.00	$ 67,485.00	$ 67,485.00	$ 67,485.00	$ 134,970.00
C10	Communication Handholes	EA.	8	$ 7,810.77	$ 62,486.16	$ 11,716.15	$ 93,729.20	$ 156,215.36
C11	Conduit Proofing (Civil)	L.S.	1	$ 52,488.33	$ 52,488.33	$ 367,418.33	$ 367,418.33	$ 419,906.66
C12	Substation Termination Structures	EA.	8	$ 31,170.30	$ 249,362.40	$ 35,999.98	$ 287,999.84	$ 537,362.24
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 425,391.13	$ 425,391.13	$ 361,368.21	$ 361,368.21	$ 786,759.34
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 39,318.13	$ 39,318.13	$ 999,944.58	$ 999,944.58	$ 1,039,262.71
C19	Grading and Access Road	L.F.	3,760	$ 63.13	$ 237,368.80	$ 94.69	$ 356,034.40	$ 593,403.20
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 32,142.78	$ 32,142.78	$ 3,431,338.49	$ 3,431,338.49	$ 3,463,481.27
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 3,143,109.87	$ 3,143,109.87	$ 3,143,109.87
C22	Dewatering	L.S.	1	$ 668,304.75	$ 668,304.75	$ 1,115,474.86	$ 1,115,474.86	$ 1,783,779.61
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 899,487.55	$ 899,487.55	$ 899,487.55
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 454,664.67	$ 454,664.67	$ 454,664.67
				SUBTOTAL	**$ 22,457,121.92**		**$ 51,330,554.18**	**$ 73,787,676.10**
			CONTINGENCY	**20.00%**	**$ 4,491,424.38**		**$ 10,266,110.84**	**$ 14,757,535.22**
				TOTAL	**$ 26,948,546.30**		**$ 61,596,665.02**	**$ 88,545,211.32**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 39,526.60	$ 39,526.60	$ 751,005.40	$ 751,005.40	$ 790,532.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 281,812.50	$ 281,812.50	$ 5,354,437.50	$ 5,354,437.50	$ 5,636,250.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 7,719,867.05	$ 7,719,867.05	$ 7,719,867.05	$ 7,719,867.05	$ 15,439,734.10
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 8,041,206.15**		**$ 13,825,309.95**	**$ 21,866,516.10**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 54,807,375.17	$ 11,044,754.51	$ 65,852,129.68
CIVIL WORKS	LOT	$ 26,948,546.30	$ 61,596,665.02	$ 88,545,211.32
PROJECT OVERHEAD COSTS	LOT	$ 8,041,206.15	$ 13,825,309.95	$ 21,866,516.10
PROJECT TOTAL	**LOT**	**$ 89,797,127.62**	**$ 86,466,729.47**	**$ 176,263,857.10**
PROJECT TOTAL	**COST / MILE**	**$ 30,512,184.43**	**$ 29,380,547.76**	**$ 59,892,732.19**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route 3
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 15,539
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 2.95
NUMBER OF CABLES PER PHASE: 4
CHECKED BY Gustavo Constreras 8/30/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 5
NUMBER OF POWER CABLE DUCTS: 16
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 230 kV Golden to Mars UG Route 3 Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 15539-ft for a (1)-Circuit, (4)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (16)-8in power conduits with (5) smaller conduits with overall ductbank dimensions of 86-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (333)-total working days for duct bank trenching activities. (30)-total working days for splice vault installations. (42)-total working days for cable pulling. (96)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $790532 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $5636250 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	230 kV			
PROJECT NAME:	Golden to Mars UG Route 3	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE			
ROUTE LENGTH (ft):	15,539	NUMBER OF CIRCUITS:	1	PREPARED BY	Akaylia Morgan	8/30/2024
ROUTE LENGTH (mile):	2.95	NUMBER OF CABLES PER PHASE:	4	CHECKED BY	Gustavo Constreras	8/30/2024

POWER CABLE DUCT SIZE:	8	NUMBER OF OTHER DUCTS:	5
NUMBER OF POWER CABLE DUCTS:	16	TYPICAL DUCT BANK DIMENSIONS:	86-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 195588-ft, with an additional spare cable length of 2800-ft. The accessories to be installed include: (24)- 230 kV Open Air Terminators, with (1)-Spare 230 kV Open Air Terminators. (72)-230 kV Cable Splice, with (1)-Spare 230 kV Cable Splice. (24)-230 kV Lightning Arrester, with (1)-Spare 230 kV
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.43% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 2400-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (84)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 15374-ft with an average duct bank depth of cover of 5.37 feet, with a further breakdown
CIV-2	A total of 7142-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 7126-Cubic Yards of rock were assumed for open cut trenching and 15-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 15374-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (16)-8-inch power conduits as well as (5)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 86-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 29622-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 1020-linear feet. Surface restoration costs also included (2)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (12) splice vaults as well as excavation for (12) splice vaults. Assumed splice vault dimensions were: 10-ft width by 26-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (12)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in
CIV-9	This cost estimate included material and installation for (8)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (16)-power conduits for (7)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (8)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 14519-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 3760-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.62% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (439)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 3, 85%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 13,445
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 2.55
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 8/30/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	500 kV 5000 kcmil Cu XLPE Cable	L.F.	216,375	$ 265.25	$ 57,393,468.75	$ 25.47	$ 5,511,071.25	$ 62,904,540.00
U02	Spare 500 kV 5000 kcmil Cu XLPE Cable	L.F.	2,000	$ 265.25	$ 530,500.00	$ -	$ -	$ 530,500.00
U03	500 kV Open Air Terminators	EA.	30	$ 38,196.00	$ 1,145,880.00	$ 53,050.00	$ 1,591,500.00	$ 2,737,380.00
U04	Spare 500 kV Open Air Terminators	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U05	500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	500 kV Cable Splice	EA.	120	$ 38,196.00	$ 4,583,520.00	$ 53,050.00	$ 6,366,000.00	$ 10,949,520.00
U08	Spare 500 kV Cable Splice	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U09	500 kV Lightning Arrester	EA.	30	$ 7,427.00	$ 222,810.00	$ 3,713.50	$ 111,405.00	$ 334,215.00
U10	Spare 500 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	72,125	$ 12.74	$ 918,872.50	$ 8.49	$ 612,341.25	$ 1,531,213.75
U12	Link Box Without SVL's	EA.	45	$ 5,305.00	$ 238,725.00	$ 1,803.70	$ 81,166.50	$ 319,891.50
U13	Link Box With SVL's	EA.	45	$ 7,957.50	$ 358,087.50	$ 1,803.70	$ 81,166.50	$ 439,254.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	14,425	$ 4.34	$ 62,582.79	$ 5.42	$ 78,191.68	$ 140,774.47
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 177,043.98	$ 177,043.98	$ 683,181.46	$ 683,181.46	$ 860,225.44
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 18,026.39	$ 18,026.39	$ 461,441.96	$ 461,441.96	$ 479,468.35
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 349,636.45	$ 349,636.45	$ 349,636.45
				SUBTOTAL	**$ 65,733,335.91**		**$ 15,927,102.05**	**$ 81,660,437.96**
			CONTINGENCY	**20.00%**	**$ 13,146,667.18**		**$ 3,185,420.41**	**$ 16,332,087.59**
				TOTAL	**$ 78,880,003.09**		**$ 19,112,522.46**	**$ 97,992,525.55**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 2
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 69-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	13,113	$ 201.50	$ 2,642,249.89	$ 415.19	$ 5,444,429.74	$ 8,086,679.63
C02	Rock Excavation (Trench & Vault)	C.Y.	11,175	$ -	$ -	$ 203.53	$ 2,274,502.73	$ 2,274,502.73
C03a	Concrete Encased Duct Bank	L.F.	13,113	$ 1,151.00	$ 15,093,063.00	$ 2,469.76	$ 32,385,962.88	$ 47,479,025.88
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	56,203	$ 135.39	$ 7,609,131.44	$ 22.92	$ 1,288,140.50	$ 8,897,271.94
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	1,700	$ 155.21	$ 263,858.11	$ 337.90	$ 574,431.69	$ 838,289.80
C07	Splice Vault Material	EA.	24	$ 91,292.60	$ 2,191,022.40	$ -	$ -	$ 2,191,022.40
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	24	$ 28,117.22	$ 674,813.28	$ 49,728.08	$ 1,193,473.92	$ 1,868,287.20
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 134,970.00	$ 134,970.00	$ 134,970.00	$ 134,970.00	$ 269,940.00
C10	Communication Handholes	EA.	10	$ 7,810.77	$ 78,107.70	$ 11,716.15	$ 117,161.50	$ 195,269.20
C11	Conduit Proofing (Civil)	L.S.	1	$ 84,356.25	$ 84,356.25	$ 590,493.74	$ 590,493.74	$ 674,849.99
C12	Substation Termination Structures	EA.	10	$ 61,651.75	$ 616,517.50	$ 71,354.68	$ 713,546.80	$ 1,330,064.30
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 340,673.74	$ 340,673.74	$ 289,672.44	$ 289,672.44	$ 630,346.18
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 39,840.63	$ 39,840.63	$ 1,013,232.88	$ 1,013,232.88	$ 1,053,073.51
C19	Grading and Access Road	L.F.	3,414	$ 63.13	$ 215,525.82	$ 94.69	$ 323,271.66	$ 538,797.48
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 27,415.65	$ 27,415.65	$ 3,991,836.98	$ 3,991,836.98	$ 4,019,252.63
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 3,745,997.14	$ 3,745,997.14	$ 3,745,997.14
C22	Dewatering	L.S.	1	$ 580,730.10	$ 580,730.10	$ 969,992.81	$ 969,992.81	$ 1,550,722.91
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 1,586,522.33	$ 1,586,522.33	$ 1,586,522.33
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 758,900.26	$ 758,900.26	$ 758,900.26
				SUBTOTAL	**$ 30,592,275.51**		**$ 57,396,540.00**	**$ 87,988,815.51**
			CONTINGENCY	**20.00%**	**$ 6,118,455.10**		**$ 11,479,308.00**	**$ 17,597,763.10**
				TOTAL	**$ 36,710,730.61**		**$ 68,875,848.00**	**$ 105,586,578.61**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 38,945.35	$ 38,945.35	$ 739,961.65	$ 739,961.65	$ 778,907.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 316,125.00	$ 316,125.00	$ 6,006,375.00	$ 6,006,375.00	$ 6,322,500.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 9,362,350.83	$ 9,362,350.83	$ 9,362,350.83	$ 9,362,350.83	$ 18,724,701.66
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 9,717,421.18**		**$ 16,108,687.48**	**$ 25,826,108.66**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 78,880,003.09	$ 19,112,522.46	$ 97,992,525.55
CIVIL WORKS	LOT	$ 36,710,730.61	$ 68,875,848.00	$ 105,586,578.61
PROJECT OVERHEAD COSTS	LOT	$ 9,717,421.18	$ 16,108,687.48	$ 25,826,108.66
PROJECT TOTAL	**LOT**	**$ 125,308,154.88**	**$ 104,097,057.94**	**$ 229,405,212.82**
PROJECT TOTAL	**COST / MILE**	**$ 49,209,896.45**	**$ 40,880,064.40**	**$ 90,089,960.86**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 3, 85%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 13,445
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 2.55
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 8/30/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 2
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 69-in High

GENERAL PROJECT SUMMARY

GEN-1	The 500 kV Golden to Mars UG Route 3, 85%DLF Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 13445-ft for a (1)-Circuit, (5)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (20)-8in power conduits with (2) smaller conduits with overall ductbank dimensions of 206-in Wide X 69-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (284)-total working days for duct bank trenching activities. (60)-total working days for splice vault installations. (68)-total working days for cable pulling. (150)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $778907 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $6322500 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	500 kV			
PROJECT NAME:	Golden to Mars UG Route 3, 85%DLF	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE			
ROUTE LENGTH (ft):	13,445	NUMBER OF CIRCUITS:	1	PREPARED BY	Akaylia Morgan	8/30/2024
ROUTE LENGTH (mile):	2.55	NUMBER OF CABLES PER PHASE:	5	CHECKED BY	Gustavo Constreras	8/30/2024

POWER CABLE DUCT SIZE:	8	NUMBER OF OTHER DUCTS:	2
NUMBER OF POWER CABLE DUCTS:	20	TYPICAL DUCT BANK DIMENSIONS:	206-in Wide X 69-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 216375-ft, with an additional spare cable length of 2000-ft. The accessories to be installed include: (30)- 500 kV Open Air Terminators, with (1)-Spare 500 kV Open Air Terminators. (120)-500 kV Cable Splice, with (1)-Spare 500 kV Cable Splice. (30)-500 kV Lightning Arrester, with (1)-Spare 500
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.43% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 1700-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (135)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 13113-ft with an average duct bank depth of cover of 5.37 feet, with a further breakdown
CIV-2	A total of 11175-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 11143-Cubic Yards of rock were assumed for open cut trenching and 32-Cubic Yards of rock
CIV-3	This cost estimate included an assumed total installation length of 13113-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (20)-8-inch power conduits as well as (2)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 206-in Wide X 69-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 56203-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 1700-linear feet. Surface restoration costs also included (2)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (24) splice vaults as well as excavation for (24) splice vaults. Assumed splice vault dimensions were: 15-ft width by 40-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (24)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in
CIV-9	This cost estimate included material and installation for (10)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (20)-power conduits for (9)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (10)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 11745-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 3414-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.87% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (896)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 3, 100%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 13,445
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 2.55
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 8/30/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	500 kV 5000 kcmil Cu XLPE Cable	L.F.	216,375	$ 265.25	$ 57,393,468.75	$ 25.47	$ 5,511,071.25	$ 62,904,540.00
U02	Spare 500 kV 5000 kcmil Cu XLPE Cable	L.F.	2,000	$ 265.25	$ 530,500.00	$ -	$ -	$ 530,500.00
U03	500 kV Open Air Terminators	EA.	30	$ 38,196.00	$ 1,145,880.00	$ 53,050.00	$ 1,591,500.00	$ 2,737,380.00
U04	Spare 500 kV Open Air Terminators	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U05	500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	500 kV Cable Splice	EA.	120	$ 41,379.00	$ 4,965,480.00	$ 53,050.00	$ 6,366,000.00	$ 11,331,480.00
U08	Spare 500 kV Cable Splice	EA.	1	$ 41,379.00	$ 41,379.00	$ -	$ -	$ 41,379.00
U09	500 kV Lightning Arrester	EA.	30	$ 7,427.00	$ 222,810.00	$ 3,713.50	$ 111,405.00	$ 334,215.00
U10	Spare 500 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	72,125	$ 12.74	$ 918,872.50	$ 8.49	$ 612,341.25	$ 1,531,213.75
U12	Link Box Without SVL's	EA.	45	$ 5,305.00	$ 238,725.00	$ 1,803.70	$ 81,166.50	$ 319,891.50
U13	Link Box With SVL's	EA.	45	$ 7,957.50	$ 358,087.50	$ 1,803.70	$ 81,166.50	$ 439,254.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	14,425	$ 4.34	$ 62,582.79	$ 5.42	$ 78,191.68	$ 140,774.47
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 177,043.98	$ 177,043.98	$ 631,109.71	$ 631,109.71	$ 808,153.69
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 18,026.39	$ 18,026.39	$ 461,441.96	$ 461,441.96	$ 479,468.35
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 351,068.65	$ 351,068.65	$ 351,068.65
				SUBTOTAL	**$ 66,118,478.91**		**$ 15,876,462.50**	**$ 81,994,941.41**
			CONTINGENCY	**20.00%**	**$ 13,223,695.78**		**$ 3,175,292.50**	**$ 16,398,988.28**
				TOTAL	**$ 79,342,174.69**		**$ 19,051,755.00**	**$ 98,393,929.69**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 2
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	13,113	$ 205.06	$ 2,688,985.64	$ 434.27	$ 5,694,570.71	$ 8,383,556.35
C02	Rock Excavation (Trench & Vault)	C.Y.	12,639	$ -	$ -	$ 203.54	$ 2,572,613.04	$ 2,572,613.04
C03a	Concrete Encased Duct Bank	L.F.	13,113	$ 1,305.94	$ 17,124,791.22	$ 2,501.55	$ 32,802,825.15	$ 49,927,616.37
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	56,203	$ 135.39	$ 7,609,131.44	$ 22.92	$ 1,288,140.50	$ 8,897,271.94
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	1,700	$ 155.21	$ 263,858.11	$ 337.90	$ 574,431.69	$ 838,289.80
C07	Splice Vault Material	EA.	24	$ 91,292.60	$ 2,191,022.40	$ -	$ -	$ 2,191,022.40
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	24	$ 28,117.22	$ 674,813.28	$ 49,728.08	$ 1,193,473.92	$ 1,868,287.20
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 134,970.00	$ 134,970.00	$ 134,970.00	$ 134,970.00	$ 269,940.00
C10	Communication Handholes	EA.	10	$ 7,810.77	$ 78,107.70	$ 11,716.15	$ 117,161.50	$ 195,269.20
C11	Conduit Proofing (Civil)	L.S.	1	$ 84,356.25	$ 84,356.25	$ 590,493.74	$ 590,493.74	$ 674,849.99
C12	Substation Termination Structures	EA.	10	$ 61,651.75	$ 616,517.50	$ 71,354.68	$ 713,546.80	$ 1,330,064.30
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 340,673.74	$ 340,673.74	$ 289,672.44	$ 289,672.44	$ 630,346.18
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 39,840.63	$ 39,840.63	$ 1,013,232.88	$ 1,013,232.88	$ 1,053,073.51
C19	Grading and Access Road	L.F.	3,414	$ 63.13	$ 215,525.82	$ 94.69	$ 323,271.66	$ 538,797.48
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 27,415.65	$ 27,415.65	$ 4,141,209.68	$ 4,141,209.68	$ 4,168,625.33
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 3,895,369.83	$ 3,895,369.83	$ 3,895,369.83
C22	Dewatering	L.S.	1	$ 580,730.10	$ 580,730.10	$ 969,992.81	$ 969,992.81	$ 1,550,722.91
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 1,586,522.33	$ 1,586,522.33	$ 1,586,522.33
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 751,749.58	$ 751,749.58	$ 751,749.58
				SUBTOTAL	**$ 32,670,739.48**		**$ 58,653,248.26**	**$ 91,323,987.74**
			CONTINGENCY	**20.00%**	**$ 6,534,147.90**		**$ 11,730,649.65**	**$ 18,264,797.55**
				TOTAL	**$ 39,204,887.38**		**$ 70,383,897.91**	**$ 109,588,785.29**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 38,945.35	$ 38,945.35	$ 739,961.65	$ 739,961.65	$ 778,907.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 316,125.00	$ 316,125.00	$ 6,006,375.00	$ 6,006,375.00	$ 6,322,500.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 10,399,135.75	$ 10,399,135.75	$ 10,399,135.75	$ 10,399,135.75	$ 20,798,271.50
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 10,754,206.10**		**$ 17,145,472.40**	**$ 27,899,678.50**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 79,342,174.69	$ 19,051,755.00	$ 98,393,929.69
CIVIL WORKS	LOT	$ 39,204,887.38	$ 70,383,897.91	$ 109,588,785.29
PROJECT OVERHEAD COSTS	LOT	$ 10,754,206.10	$ 17,145,472.40	$ 27,899,678.50
PROJECT TOTAL	**LOT**	**$ 129,301,268.17**	**$ 106,581,125.31**	**$ 235,882,393.48**
PROJECT TOTAL	**COST / MILE**	**$ 50,778,036.14**	**$ 41,855,585.10**	**$ 92,633,621.24**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 3, 100%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 13,445
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 2.55
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 8/30/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 2
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 500 kV Golden to Mars UG Route 3, 100%DLF Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 13445-ft for a (1)-Circuit, (5)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (20)-8in power conduits with (2) smaller conduits with overall ductbank dimensions of 206-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (284)-total working days for duct bank trenching activities. (60)-total working days for splice vault installations. (68)-total working days for cable pulling. (150)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $778907 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $6322500 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	500 kV			
PROJECT NAME:	Golden to Mars UG Route 3, 100%DLF	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE			
ROUTE LENGTH (ft):	13,445	NUMBER OF CIRCUITS:	1	PREPARED BY	Akaylia Morgan	8/30/2024
ROUTE LENGTH (mile):	2.55	NUMBER OF CABLES PER PHASE:	5	CHECKED BY	Gustavo Constreras	8/30/2024

POWER CABLE DUCT SIZE:	8	NUMBER OF OTHER DUCTS:	2
NUMBER OF POWER CABLE DUCTS:	20	TYPICAL DUCT BANK DIMENSIONS:	206-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 216375-ft, with an additional spare cable length of 2000-ft. The accessories to be installed include: (30)- 500 kV Open Air Terminators, with (1)-Spare 500 kV Open Air Terminators. (120)-500 kV Cable Splice, with (1)-Spare 500 kV Cable Splice. (30)-500 kV Lightning Arrester, with (1)-Spare 500
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.43% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 1700-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (135)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 13113-ft with an average duct bank depth of cover of 5.37 feet, with a further breakdown
CIV-2	A total of 12639-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 12607-Cubic Yards of rock were assumed for open cut trenching and 32-Cubic Yards of rock
CIV-3	This cost estimate included an assumed total installation length of 13113-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (20)-8-inch power conduits as well as (2)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 206-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 56203-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 1700-linear feet. Surface restoration costs also included (2)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (24) splice vaults as well as excavation for (24) splice vaults. Assumed splice vault dimensions were: 15-ft width by 40-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (24)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in
CIV-9	This cost estimate included material and installation for (10)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (20)-power conduits for (9)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (10)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 11745-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 3414-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.83% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (896)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy

VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route 4

CABLE SIZE/TYPE: 5000 kcmil Cu XLPE

ROUTE LENGTH (ft): 15,894

NUMBER OF CIRCUITS: 1

PREPARED BY Juan Morales 12/1/2024

ROUTE LENGTH (mile): 3.02

NUMBER OF CABLES PER PHASE: 4

CHECKED BY Gustavo Constreras 12/2/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	230 kV 5000 kcmil Cu XLPE Cable	L.F.	200,568	$ 212.20	$ 42,560,529.60	$ 25.47	$ 5,108,466.96	$ 47,668,996.56
U02	Spare 230 kV 5000 kcmil Cu XLPE Cable	L.F.	2,800	$ 212.20	$ 594,160.00	$ -	$ -	$ 594,160.00
U03	230 kV Open Air Terminators	EA.	24	$ 19,098.00	$ 458,352.00	$ 26,525.00	$ 636,600.00	$ 1,094,952.00
U04	Spare 230 kV Open Air Terminators	EA.	1	$ 19,098.00	$ 19,098.00	$ -	$ -	$ 19,098.00
U05	230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	230 kV Cable Splice	EA.	84	$ 20,689.50	$ 1,737,918.00	$ 26,525.00	$ 2,228,100.00	$ 3,966,018.00
U08	Spare 230 kV Cable Splice	EA.	1	$ 20,689.50	$ 20,689.50	$ -	$ -	$ 20,689.50
U09	230 kV Lightning Arrester	EA.	24	$ 7,427.00	$ 178,248.00	$ 3,713.50	$ 89,124.00	$ 267,372.00
U10	Spare 230 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	66,856	$ 12.74	$ 851,745.44	$ 8.49	$ 567,607.44	$ 1,419,352.88
U12	Link Box Without SVL's	EA.	32	$ 5,305.00	$ 169,760.00	$ 1,803.70	$ 57,718.40	$ 227,478.40
U13	Link Box With SVL's	EA.	32	$ 7,957.50	$ 254,640.00	$ 1,803.70	$ 57,718.40	$ 312,358.40
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	16,714	$ 4.34	$ 72,513.61	$ 5.42	$ 90,599.36	$ 163,112.97
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 124,972.22	$ 124,972.22	$ 519,509.52	$ 519,509.52	$ 644,481.74
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 1,567.51	$ 1,567.51	$ 40,125.39	$ 40,125.39	$ 41,692.90
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 242,722.92	$ 242,722.92	$ 242,722.92
				SUBTOTAL	**$ 47,051,620.88**		**$ 9,638,292.39**	**$ 56,689,913.27**
			CONTINGENCY	**20.00%**	**$ 9,410,324.18**		**$ 1,927,658.48**	**$ 11,337,982.65**
				TOTAL	**$ 56,461,945.06**		**$ 11,565,950.87**	**$ 68,027,895.92**

POWER CABLE DUCT SIZE: 8

NUMBER OF OTHER DUCTS: 5

NUMBER OF POWER CABLE DUCTS: 16

TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	15,702	$ 125.65	$ 1,972,872.42	$ 243.58	$ 3,824,591.78	$ 5,797,464.20
C02	Rock Excavation (Trench & Vault)	C.Y.	6,509	$ -	$ -	$ 203.55	$ 1,324,963.63	$ 1,324,963.63
C03a	Concrete Encased Duct Bank	L.F.	15,702	$ 786.17	$ 12,344,441.34	$ 2,047.10	$ 32,143,564.20	$ 44,488,005.54
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	23,842	$ 135.39	$ 3,227,886.62	$ 22.92	$ 546,444.95	$ 3,774,331.57
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	350	$ 288.58	$ 101,002.07	$ 203.11	$ 71,090.24	$ 172,092.31
C07	Splice Vault Material	EA.	14	$ 75,671.08	$ 1,059,395.12	$ -	$ -	$ 1,059,395.12
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	14	$ 26,692.85	$ 373,699.90	$ 43,289.75	$ 606,056.50	$ 979,756.40
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 78,732.50	$ 78,732.50	$ 78,732.50	$ 78,732.50	$ 157,465.00
C10	Communication Handholes	EA.	9	$ 7,810.77	$ 70,296.93	$ 11,716.15	$ 105,445.35	$ 175,742.28
C11	Conduit Proofing (Civil)	L.S.	1	$ 59,986.67	$ 59,986.67	$ 419,906.66	$ 419,906.66	$ 479,893.33
C12	Substation Termination Structures	EA.	8	$ 31,170.30	$ 249,362.40	$ 35,999.98	$ 287,999.84	$ 537,362.24
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 454,640.69	$ 454,640.69	$ 386,277.24	$ 386,277.24	$ 840,917.93
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 1,045.00	$ 1,045.00	$ 26,576.60	$ 26,576.60	$ 27,621.60
C19	Grading and Access Road	L.F.	15,352	$ 63.13	$ 969,171.76	$ 94.69	$ 1,453,680.88	$ 2,422,852.64
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 32,827.49	$ 32,827.49	$ 3,348,878.40	$ 3,348,878.40	$ 3,381,705.89
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 3,054,509.88	$ 3,054,509.88	$ 3,054,509.88
C22	Dewatering	L.S.	1	$ 688,354.30	$ 688,354.30	$ 1,150,339.41	$ 1,150,339.41	$ 1,838,693.71
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 744,522.00	$ 744,522.00	$ 744,522.00
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 441,795.23	$ 441,795.23	$ 441,795.23
				SUBTOTAL	**$ 21,683,715.21**		**$ 50,015,375.29**	**$ 71,699,090.50**
			CONTINGENCY	**20.00%**	**$ 4,336,743.04**		**$ 10,003,075.06**	**$ 14,339,818.10**
				TOTAL	**$ 26,020,458.25**		**$ 60,018,450.35**	**$ 86,038,908.60**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 39,626.60	$ 39,626.60	$ 752,905.40	$ 752,905.40	$ 792,532.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 278,276.90	$ 278,276.90	$ 5,287,261.10	$ 5,287,261.10	$ 5,565,538.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 7,703,340.23	$ 7,703,340.23	$ 7,703,340.23	$ 7,703,340.23	$ 15,406,680.46
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 8,021,243.73**		**$ 13,743,506.73**	**$ 21,764,750.46**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 56,461,945.06	$ 11,565,950.87	$ 68,027,895.92
CIVIL WORKS	LOT	$ 26,020,458.25	$ 60,018,450.35	$ 86,038,908.60
PROJECT OVERHEAD COSTS	LOT	$ 8,021,243.73	$ 13,743,506.73	$ 21,764,750.46
PROJECT TOTAL	**LOT**	**$ 90,503,647.04**	**$ 85,327,907.95**	**$ 175,831,554.98**
PROJECT TOTAL	**COST / MILE**	**$ 30,065,386.71**	**$ 28,346,001.88**	**$ 58,411,388.59**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route 4
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 15,894
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 3.02
NUMBER OF CABLES PER PHASE: 4
CHECKED BY Gustavo Constreras 12/2/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 5
NUMBER OF POWER CABLE DUCTS: 16
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 230 kV Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 15894-ft for a (1)-Circuit, (4)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (16)-8in power conduits with (5) smaller conduits with overall ductbank dimensions of 86-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (259)-total working days for duct bank trenching activities. (35)-total working days for splice vault installations. (48)-total working days for cable pulling. (108)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $792532 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $5565538 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 4, 85%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 15,894
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 3.02
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 12/2/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	500 kV 5000 kcmil Cu XLPE Cable	L.F.	254,910	$ 265.25	$ 67,614,877.50	$ 25.47	$ 6,492,557.70	$ 74,107,435.20
U02	Spare 500 kV 5000 kcmil Cu XLPE Cable	L.F.	2,000	$ 265.25	$ 530,500.00	$ -	$ -	$ 530,500.00
U03	500 kV Open Air Terminators	EA.	30	$ 38,196.00	$ 1,145,880.00	$ 53,050.00	$ 1,591,500.00	$ 2,737,380.00
U04	Spare 500 kV Open Air Terminators	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U05	500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	500 kV Cable Splice	EA.	150	$ 41,379.00	$ 6,206,850.00	$ 53,050.00	$ 7,957,500.00	$ 14,164,350.00
U08	Spare 500 kV Cable Splice	EA.	1	$ 41,379.00	$ 41,379.00	$ -	$ -	$ 41,379.00
U09	500 kV Lightning Arrester	EA.	30	$ 7,427.00	$ 222,810.00	$ 3,713.50	$ 111,405.00	$ 334,215.00
U10	Spare 500 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	84,970	$ 12.74	$ 1,082,517.80	$ 8.49	$ 721,395.30	$ 1,803,913.10
U12	Link Box Without SVL's	EA.	55	$ 5,305.00	$ 291,775.00	$ 1,803.70	$ 99,203.50	$ 390,978.50
U13	Link Box With SVL's	EA.	55	$ 7,957.50	$ 437,662.50	$ 1,803.70	$ 99,203.50	$ 536,866.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	16,994	$ 4.34	$ 73,728.39	$ 5.42	$ 92,117.11	$ 165,845.50
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 177,043.98	$ 177,043.98	$ 701,927.30	$ 701,927.30	$ 878,971.28
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 3,918.78	$ 3,918.78	$ 100,313.47	$ 100,313.47	$ 104,232.25
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 335,445.91	$ 335,445.91	$ 335,445.91
				SUBTOTAL	**$ 77,874,565.95**		**$ 18,302,568.79**	**$ 96,177,134.74**
			CONTINGENCY	**20.00%**	**$ 15,574,913.19**		**$ 3,660,513.76**	**$ 19,235,426.95**
				TOTAL	**$ 93,449,479.14**		**$ 21,963,082.55**	**$ 115,412,561.69**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 69-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	15,479	$ 122.08	$ 1,889,667.40	$ 296.21	$ 4,585,023.75	$ 6,474,691.15
C02	Rock Excavation (Trench & Vault)	C.Y.	11,745	$ -	$ -	$ 203.53	$ 2,390,399.40	$ 2,390,399.40
C03a	Concrete Encased Duct Bank	L.F.	15,479	$ 1,180.21	$ 18,268,470.59	$ 2,594.33	$ 40,157,634.07	$ 58,426,104.66
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	52,283	$ 135.39	$ 7,078,416.08	$ 22.92	$ 1,198,296.35	$ 8,276,712.43
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	350	$ 415.19	$ 145,314.96	$ 373.75	$ 130,813.48	$ 276,128.44
C07	Splice Vault Material	EA.	30	$ 91,292.60	$ 2,738,778.00	$ -	$ -	$ 2,738,778.00
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	30	$ 28,117.22	$ 843,516.60	$ 49,728.08	$ 1,491,842.40	$ 2,335,359.00
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 168,712.50	$ 168,712.50	$ 168,712.50	$ 168,712.50	$ 337,425.00
C10	Communication Handholes	EA.	12	$ 7,810.77	$ 93,729.24	$ 11,716.15	$ 140,593.80	$ 234,323.04
C11	Conduit Proofing (Civil)	L.S.	1	$ 103,102.08	$ 103,102.08	$ 721,714.57	$ 721,714.57	$ 824,816.65
C12	Substation Termination Structures	EA.	10	$ 61,651.75	$ 616,517.50	$ 71,354.68	$ 713,546.80	$ 1,330,064.30
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 454,640.69	$ 454,640.69	$ 386,277.24	$ 386,277.24	$ 840,917.93
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 1,306.25	$ 1,306.25	$ 33,220.75	$ 33,220.75	$ 34,527.00
C19	Grading and Access Road	L.F.	15,138	$ 63.13	$ 955,661.94	$ 94.69	$ 1,433,417.22	$ 2,389,079.16
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 32,362.30	$ 32,362.30	$ 4,555,533.05	$ 4,555,533.05	$ 4,587,895.35
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 4,265,335.91	$ 4,265,335.91	$ 4,265,335.91
C22	Dewatering	L.S.	1	$ 688,502.45	$ 688,502.45	$ 1,150,582.84	$ 1,150,582.84	$ 1,839,085.29
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 1,450,927.47	$ 1,450,927.47	$ 1,450,927.47
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 633,936.45	$ 633,936.45	$ 633,936.45
				SUBTOTAL	**$ 34,078,698.58**		**$ 65,607,808.05**	**$ 99,686,506.63**
			CONTINGENCY	**20.00%**	**$ 6,815,739.72**		**$ 13,121,561.61**	**$ 19,937,301.33**
				TOTAL	**$ 40,894,438.30**		**$ 78,729,369.66**	**$ 119,623,807.96**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 41,626.60	$ 41,626.60	$ 790,905.40	$ 790,905.40	$ 832,532.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 363,683.40	$ 363,683.40	$ 6,909,984.60	$ 6,909,984.60	$ 7,273,668.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 10,790,047.14	$ 10,790,047.14	$ 10,790,047.14	$ 10,790,047.14	$ 21,580,094.28
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 11,195,357.14**		**$ 18,490,937.14**	**$ 29,686,294.28**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 93,449,479.14	$ 21,963,082.55	$ 115,412,561.69
CIVIL WORKS	LOT	$ 40,894,438.30	$ 78,729,369.66	$ 119,623,807.96
PROJECT OVERHEAD COSTS	LOT	$ 11,195,357.14	$ 18,490,937.14	$ 29,686,294.28
PROJECT TOTAL	**LOT**	**$ 145,539,274.58**	**$ 119,183,389.35**	**$ 264,722,663.92**
PROJECT TOTAL	**COST / MILE**	**$ 48,348,267.88**	**$ 39,592,820.92**	**$ 87,941,088.81**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 4, 85%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 15,894
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 3.02
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 12/2/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 69-in High

GENERAL PROJECT SUMMARY

GEN-1	The 500 kV Golden to Mars UG Route 4, 85%DLF Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 15894-ft for a (1)-Circuit, (5)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (20)-8in power conduits with (6) smaller conduits with overall ductbank dimensions of 206-in Wide X 69-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (255)-total working days for duct bank trenching activities. (75)-total working days for splice vault installations. (83)-total working days for cable pulling. (180)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $832532 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $7273668 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	500 kV		
PROJECT NAME:	Golden to Mars UG Route 4, 85%DLF	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE		
ROUTE LENGTH (ft):	15,894	NUMBER OF CIRCUITS:	1	PREPARED BY Juan Morales	12/1/2024
ROUTE LENGTH (mile):	3.02	NUMBER OF CABLES PER PHASE:	5	CHECKED BY Gustavo Constreras	12/2/2024

POWER CABLE DUCT SIZE: 8 — NUMBER OF OTHER DUCTS: 6

NUMBER OF POWER CABLE DUCTS: 20 — TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 69-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 254910-ft, with an additional spare cable length of 2000-ft. The accessories to be installed include: (30)-500 kV Open Air Terminators, with (1)-Spare 500 kV Open Air Terminators. (150)-500 kV Cable Splice, with (1)-Spare 500 kV Cable Splice. (30)-500 kV Lightning Arrester, with (1)-Spare 500 kV
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.35% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 1700-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (165)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 15479-ft with an average duct bank depth of cover of 4.02 feet, with a further breakdown
CIV-2	A total of 11745-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 11713-Cubic Yards of rock were assumed for open cut trenching and 32-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 15479-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (20)-8-inch power conduits as well as (6)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 206-in Wide X 69-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 52283-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 350-linear feet. Surface restoration costs also included (2)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (30) splice vaults as well as excavation for (30) splice vaults. Assumed splice vault dimensions were: 15-ft width by 40-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (30)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in this
CIV-9	This cost estimate included material and installation for (12)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (20)-power conduits for (11)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (10)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 15544-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 15138-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall route
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.64% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (792)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to C15 &
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 4, 100%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 15,894
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 3.02
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 12/2/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	500 kV 5000 kcmil Cu XLPE Cable	L.F.	254,910	$ 265.25	$ 67,614,877.50	$ 25.47	$ 6,492,557.70	$ 74,107,435.20
U02	Spare 500 kV 5000 kcmil Cu XLPE Cable	L.F.	2,000	$ 265.25	$ 530,500.00	$ -	$ -	$ 530,500.00
U03	500 kV Open Air Terminators	EA.	30	$ 38,196.00	$ 1,145,880.00	$ 53,050.00	$ 1,591,500.00	$ 2,737,380.00
U04	Spare 500 kV Open Air Terminators	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U05	500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	500 kV Cable Splice	EA.	150	$ 41,379.00	$ 6,206,850.00	$ 53,050.00	$ 7,957,500.00	$ 14,164,350.00
U08	Spare 500 kV Cable Splice	EA.	1	$ 41,379.00	$ 41,379.00	$ -	$ -	$ 41,379.00
U09	500 kV Lightning Arrester	EA.	30	$ 7,427.00	$ 222,810.00	$ 3,713.50	$ 111,405.00	$ 334,215.00
U10	Spare 500 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	84,970	$ 12.74	$ 1,082,517.80	$ 8.49	$ 721,395.30	$ 1,803,913.10
U12	Link Box Without SVL's	EA.	55	$ 5,305.00	$ 291,775.00	$ 1,803.70	$ 99,203.50	$ 390,978.50
U13	Link Box With SVL's	EA.	55	$ 7,957.50	$ 437,662.50	$ 1,803.70	$ 99,203.50	$ 536,866.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
U16	Digital Temperature Monitoring System	EA.	1	$ 265,227.48	$ 265,227.48	$ 69,867.41	$ 69,867.41	$ 335,094.89
U17	Cable System Testing	L.S.	1	$ 177,043.98	$ 177,043.98	$ 701,927.30	$ 701,927.30	$ 878,971.28
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 3,918.78	$ 3,918.78	$ 100,313.47	$ 100,313.47	$ 104,232.25
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 297,633.91	$ 297,633.91	$ 297,633.91
				SUBTOTAL	**$ 78,066,065.04**		**$ 18,242,507.09**	**$ 96,308,572.13**
			CONTINGENCY	**20.00%**	**$ 15,613,213.01**		**$ 3,648,501.42**	**$ 19,261,714.43**
				TOTAL	**$ 93,679,278.05**		**$ 21,891,008.51**	**$ 115,570,286.56**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	15,479	$ 125.65	$ 1,944,910.06	$ 315.28	$ 4,880,223.76	$ 6,825,133.82
C02	Rock Excavation (Trench & Vault)	C.Y.	13,456	$ -	$ -	$ 203.55	$ 2,738,873.91	$ 2,738,873.91
C03a	Concrete Encased Duct Bank	L.F.	15,479	$ 1,335.16	$ 20,666,941.64	$ 2,626.12	$ 40,649,711.48	$ 61,316,653.12
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	52,283	$ 135.39	$ 7,078,416.08	$ 22.92	$ 1,198,296.35	$ 8,276,712.43
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	350	$ 415.19	$ 145,314.96	$ 373.75	$ 130,813.48	$ 276,128.44
C07	Splice Vault Material	EA.	30	$ 91,292.60	$ 2,738,778.00	$ -	$ -	$ 2,738,778.00
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	30	$ 28,117.22	$ 843,516.60	$ 49,728.08	$ 1,491,842.40	$ 2,335,359.00
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 168,712.50	$ 168,712.50	$ 168,712.50	$ 168,712.50	$ 337,425.00
C10	Communication Handholes	EA.	12	$ 7,810.77	$ 93,729.24	$ 11,716.15	$ 140,593.80	$ 234,323.04
C11	Conduit Proofing (Civil)	L.S.	1	$ 103,102.08	$ 103,102.08	$ 721,714.57	$ 721,714.57	$ 824,816.65
C12	Substation Termination Structures	EA.	10	$ 61,651.75	$ 616,517.50	$ 71,354.68	$ 713,546.80	$ 1,330,064.30
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 454,640.69	$ 454,640.69	$ 386,277.24	$ 386,277.24	$ 840,917.93
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 1,306.25	$ 1,306.25	$ 33,220.75	$ 33,220.75	$ 34,527.00
C19	Grading and Access Road	L.F.	15,138	$ 63.13	$ 955,661.94	$ 94.69	$ 1,433,417.22	$ 2,389,079.16
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 32,362.30	$ 32,362.30	$ 4,731,696.84	$ 4,731,696.84	$ 4,764,059.14
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 4,441,499.71	$ 4,441,499.71	$ 4,441,499.71
C22	Dewatering	L.S.	1	$ 688,502.45	$ 688,502.45	$ 1,150,582.84	$ 1,150,582.84	$ 1,839,085.29
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 1,450,927.47	$ 1,450,927.47	$ 1,450,927.47
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 628,265.62	$ 628,265.62	$ 628,265.62
				SUBTOTAL	**$ 36,532,412.29**		**$ 67,090,216.74**	**$ 103,622,629.03**
			CONTINGENCY	**20.00%**	**$ 7,306,482.46**		**$ 13,418,043.35**	**$ 20,724,525.81**
				TOTAL	**$ 43,838,894.75**		**$ 80,508,260.09**	**$ 124,347,154.84**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 41,626.60	$ 41,626.60	$ 790,905.40	$ 790,905.40	$ 832,532.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 363,683.40	$ 363,683.40	$ 6,909,984.60	$ 6,909,984.60	$ 7,273,668.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 11,995,872.07	$ 11,995,872.07	$ 11,995,872.07	$ 11,995,872.07	$ 23,991,744.14
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 12,401,182.07**		**$ 19,696,762.07**	**$ 32,097,944.14**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 93,679,278.05	$ 21,891,008.51	$ 115,570,286.56
CIVIL WORKS	LOT	$ 43,838,894.75	$ 80,508,260.09	$ 124,347,154.84
PROJECT OVERHEAD COSTS	LOT	$ 12,401,182.07	$ 19,696,762.07	$ 32,097,944.14
PROJECT TOTAL	**LOT**	**$ 149,919,354.87**	**$ 122,096,030.67**	**$ 272,015,385.53**
PROJECT TOTAL	**COST / MILE**	**$ 49,803,334.19**	**$ 40,560,402.79**	**$ 90,363,736.98**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 4, 100%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 15,894
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 3.02
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 12/2/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 500 kV Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 15894-ft for a (1)-Circuit, (5)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (20)-8in power conduits with (6) smaller conduits with overall ductbank dimensions of 206-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (255)-total working days for duct bank trenching activities. (75)-total working days for splice vault installations. (83)-total working days for cable pulling. (180)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $832532 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $7273668 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	500 kV		
PROJECT NAME:	Golden to Mars UG Route 4, 100%DLF	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE		
ROUTE LENGTH (ft):	15,894	NUMBER OF CIRCUITS:	1	PREPARED BY Juan Morales	12/1/2024
ROUTE LENGTH (mile):	3.02	NUMBER OF CABLES PER PHASE:	5	CHECKED BY Gustavo Constreras	12/2/2024

POWER CABLE DUCT SIZE: 8 — NUMBER OF OTHER DUCTS: 6

NUMBER OF POWER CABLE DUCTS: 20 — TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 254910-ft, with an additional spare cable length of 2000-ft. The accessories to be installed include: (30)-500 kV Open Air Terminators, with (1)-Spare 500 kV Open Air Terminators. (150)-500 kV Cable Splice, with (1)-Spare 500 kV Cable Splice. (30)-500 kV Lightning Arrester, with (1)-Spare 500 kV
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.31% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 1700-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (165)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 15479-ft with an average duct bank depth of cover of 4.02 feet, with a further breakdown
CIV-2	A total of 13456-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 13424-Cubic Yards of rock were assumed for open cut trenching and 32-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 15479-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (20)-8-inch power conduits as well as (6)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 206-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 52283-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 350-linear feet. Surface restoration costs also included (2)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (30) splice vaults as well as excavation for (30) splice vaults. Assumed splice vault dimensions were: 15-ft width by 40-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (30)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in this
CIV-9	This cost estimate included material and installation for (12)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (20)-power conduits for (11)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (10)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 15544-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 15138-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall route
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.61% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (792)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to C15 &
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route 5
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 15,841
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 3.01
NUMBER OF CABLES PER PHASE: 4
CHECKED BY Gustavo Constreras 12/2/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	230 kV 5000 kcmil Cu XLPE Cable	L.F.	199,932	$ 212.20	$ 42,425,570.40	$ 25.47	$ 5,092,268.04	$ 47,517,838.44
U02	Spare 230 kV 5000 kcmil Cu XLPE Cable	L.F.	2,800	$ 212.20	$ 594,160.00	$ -	$ -	$ 594,160.00
U03	230 kV Open Air Terminators	EA.	24	$ 19,098.00	$ 458,352.00	$ 26,525.00	$ 636,600.00	$ 1,094,952.00
U04	Spare 230 kV Open Air Terminators	EA.	1	$ 19,098.00	$ 19,098.00	$ -	$ -	$ 19,098.00
U05	230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	230 kV Cable Splice	EA.	84	$ 20,689.50	$ 1,737,918.00	$ 26,525.00	$ 2,228,100.00	$ 3,966,018.00
U08	Spare 230 kV Cable Splice	EA.	1	$ 20,689.50	$ 20,689.50	$ -	$ -	$ 20,689.50
U09	230 kV Lightning Arrester	EA.	24	$ 7,427.00	$ 178,248.00	$ 3,713.50	$ 89,124.00	$ 267,372.00
U10	Spare 230 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	66,644	$ 12.74	$ 849,044.56	$ 8.49	$ 565,807.56	$ 1,414,852.12
U12	Link Box Without SVL's	EA.	32	$ 5,305.00	$ 169,760.00	$ 1,803.70	$ 57,718.40	$ 227,478.40
U13	Link Box With SVL's	EA.	32	$ 7,957.50	$ 254,640.00	$ 1,803.70	$ 57,718.40	$ 312,358.40
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	16,661	$ 4.34	$ 72,283.67	$ 5.42	$ 90,312.07	$ 162,595.74
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 124,972.22	$ 124,972.22	$ 519,509.52	$ 519,509.52	$ 644,481.74
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 26,125.20	$ 26,125.20	$ 668,756.46	$ 668,756.46	$ 694,881.66
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 244,860.07	$ 244,860.07	$ 244,860.07
				SUBTOTAL	**$ 46,938,288.55**		**$ 10,250,774.52**	**$ 57,189,063.07**
			CONTINGENCY	**20.00%**	**$ 9,387,657.71**		**$ 2,050,154.90**	**$ 11,437,812.61**
				TOTAL	**$ 56,325,946.26**		**$ 12,300,929.42**	**$ 68,626,875.68**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 5
NUMBER OF POWER CABLE DUCTS: 16
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	15,649	$ 125.65	$ 1,966,180.52	$ 243.78	$ 3,814,811.67	$ 5,780,992.19
C02	Rock Excavation (Trench & Vault)	C.Y.	6,311	$ -	$ -	$ 203.54	$ 1,284,469.04	$ 1,284,469.04
C03a	Concrete Encased Duct Bank	L.F.	15,649	$ 786.17	$ 12,302,774.33	$ 2,047.10	$ 32,035,067.90	$ 44,337,842.23
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	23,761	$ 135.39	$ 3,216,920.31	$ 22.92	$ 544,588.48	$ 3,761,508.79
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	6,263	$ 77.89	$ 487,794.31	$ 160.98	$ 1,008,248.77	$ 1,496,043.08
C07	Splice Vault Material	EA.	14	$ 75,671.08	$ 1,059,395.12	$ -	$ -	$ 1,059,395.12
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	14	$ 26,692.85	$ 373,699.90	$ 43,289.75	$ 606,056.50	$ 979,756.40
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 78,732.50	$ 78,732.50	$ 78,732.50	$ 78,732.50	$ 157,465.00
C10	Communication Handholes	EA.	9	$ 7,810.77	$ 70,296.93	$ 11,716.15	$ 105,445.35	$ 175,742.28
C11	Conduit Proofing (Civil)	L.S.	1	$ 59,986.67	$ 59,986.67	$ 419,906.66	$ 419,906.66	$ 479,893.33
C12	Substation Termination Structures	EA.	8	$ 31,170.30	$ 249,362.40	$ 35,999.98	$ 287,999.84	$ 537,362.24
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 280,996.33	$ 280,996.33	$ 238,676.10	$ 238,676.10	$ 519,672.43
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 17,503.75	$ 17,503.75	$ 445,158.05	$ 445,158.05	$ 462,661.80
C19	Grading and Access Road	L.F.	9,386	$ 63.13	$ 592,538.18	$ 94.69	$ 888,760.34	$ 1,481,298.52
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 32,716.68	$ 32,716.68	$ 3,361,442.01	$ 3,361,442.01	$ 3,394,158.69
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 3,068,067.13	$ 3,068,067.13	$ 3,068,067.13
C22	Dewatering	L.S.	1	$ 686,135.33	$ 686,135.33	$ 1,146,653.24	$ 1,146,653.24	$ 1,832,788.57
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 741,397.70	$ 741,397.70	$ 741,397.70
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 443,613.19	$ 443,613.19	$ 443,613.19
				SUBTOTAL	**$ 21,475,033.26**		**$ 50,519,094.47**	**$ 71,994,127.73**
			CONTINGENCY	**20.00%**	**$ 4,295,006.65**		**$ 10,103,818.89**	**$ 14,398,825.55**
				TOTAL	**$ 25,770,039.91**		**$ 60,622,913.36**	**$ 86,392,953.28**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 39,207.85	$ 39,207.85	$ 744,949.15	$ 744,949.15	$ 784,157.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 277,348.95	$ 277,348.95	$ 5,269,630.05	$ 5,269,630.05	$ 5,546,979.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 7,750,991.45	$ 7,750,991.45	$ 7,750,991.45	$ 7,750,991.45	$ 15,501,982.90
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 8,067,548.25**		**$ 13,765,570.65**	**$ 21,833,118.90**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 56,325,946.26	$ 12,300,929.42	$ 68,626,875.68
CIVIL WORKS	LOT	$ 25,770,039.91	$ 60,622,913.36	$ 86,392,953.28
PROJECT OVERHEAD COSTS	LOT	$ 8,067,548.25	$ 13,765,570.65	$ 21,833,118.90
PROJECT TOTAL	**LOT**	**$ 90,163,534.42**	**$ 86,689,413.44**	**$ 176,852,947.86**
PROJECT TOTAL	**COST / MILE**	**$ 30,052,614.21**	**$ 28,894,646.99**	**$ 58,947,261.20**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route 5
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 15,841
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 3.01
NUMBER OF CABLES PER PHASE: 4
CHECKED BY Gustavo Constreras 12/2/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 5
NUMBER OF POWER CABLE DUCTS: 16
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 230 kV Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 15841-ft for a (1)-Circuit, (4)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (16)-8in power conduits with (5) smaller conduits with overall ductbank dimensions of 86-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (258)-total working days for duct bank trenching activities. (35)-total working days for splice vault installations. (48)-total working days for cable pulling. (108)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $784157 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $5546979 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	230 kV		
PROJECT NAME:	Golden to Mars UG Route 5	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE		
ROUTE LENGTH (ft):	15,841	NUMBER OF CIRCUITS:	1	PREPARED BY Juan Morales	12/1/2024
ROUTE LENGTH (mile):	3.01	NUMBER OF CABLES PER PHASE:	4	CHECKED BY Gustavo Constreras	12/2/2024

POWER CABLE DUCT SIZE: 8 — NUMBER OF OTHER DUCTS: 5

NUMBER OF POWER CABLE DUCTS: 16 — TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 199932-ft, with an additional spare cable length of 2800-ft. The accessories to be installed include: (24)-230 kV Open Air Terminators, with (1)-Spare 230 kV Open Air Terminators. (84)-230 kV Cable Splice, with (1)-Spare 230 kV Cable Splice. (24)-230 kV Lightning Arrester, with (1)-Spare 230 kV
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.43% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2800-ft and standard splice vault spacing of 2400-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (96)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 15649-ft with an average duct bank depth of cover of 4.02 feet, with a further breakdown
CIV-2	A total of 6311-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 6295-Cubic Yards of rock were assumed for open cut trenching and 15-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 15649-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (16)-8-inch power conduits as well as (5)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 86-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 23761-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 6263-linear feet. Surface restoration costs also included (2)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (14) splice vaults as well as excavation for (14) splice vaults. Assumed splice vault dimensions were: 10-ft width by 26-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (14)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in this
CIV-9	This cost estimate included material and installation for (9)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (16)-power conduits for (8)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (8)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 9578-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 9386-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall route
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.62% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (334)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to C15 &
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 5, 85%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 15,841
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 3.01
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 12/2/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	500 kV 5000 kcmil Cu XLPE Cable	L.F.	254,115	$ 265.25	$ 67,404,003.75	$ 25.47	$ 6,472,309.05	$ 73,876,312.80
U02	Spare 500 kV 5000 kcmil Cu XLPE Cable	L.F.	2,000	$ 265.25	$ 530,500.00	$ -	$ -	$ 530,500.00
U03	500 kV Open Air Terminators	EA.	30	$ 38,196.00	$ 1,145,880.00	$ 53,050.00	$ 1,591,500.00	$ 2,737,380.00
U04	Spare 500 kV Open Air Terminators	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U05	500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	500 kV Cable Splice	EA.	150	$ 41,379.00	$ 6,206,850.00	$ 53,050.00	$ 7,957,500.00	$ 14,164,350.00
U08	Spare 500 kV Cable Splice	EA.	1	$ 41,379.00	$ 41,379.00	$ -	$ -	$ 41,379.00
U09	500 kV Lightning Arrester	EA.	30	$ 7,427.00	$ 222,810.00	$ 3,713.50	$ 111,405.00	$ 334,215.00
U10	Spare 500 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	84,705	$ 12.74	$ 1,079,141.70	$ 8.49	$ 719,145.45	$ 1,798,287.15
U12	Link Box Without SVL's	EA.	55	$ 5,305.00	$ 291,775.00	$ 1,803.70	$ 99,203.50	$ 390,978.50
U13	Link Box With SVL's	EA.	55	$ 7,957.50	$ 437,662.50	$ 1,803.70	$ 99,203.50	$ 536,866.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	16,941	$ 4.34	$ 73,498.45	$ 5.42	$ 91,829.82	$ 165,328.27
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 177,043.98	$ 177,043.98	$ 701,927.30	$ 701,927.30	$ 878,971.28
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 69,754.29	$ 69,754.29	$ 1,785,579.75	$ 1,785,579.75	$ 1,855,334.04
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 340,744.34	$ 340,744.34	$ 340,744.34
				SUBTOTAL	**$ 77,725,921.67**		**$ 19,970,347.71**	**$ 97,696,269.38**
			CONTINGENCY	**20.00%**	**$ 15,545,184.33**		**$ 3,994,069.54**	**$ 19,539,253.88**
				TOTAL	**$ 93,271,106.00**		**$ 23,964,417.25**	**$ 117,235,523.26**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 69-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	15,426	$ 122.08	$ 1,883,201.42	$ 296.65	$ 4,576,112.10	$ 6,459,313.52
C02	Rock Excavation (Trench & Vault)	C.Y.	11,317	$ -	$ -	$ 203.53	$ 2,303,368.27	$ 2,303,368.27
C03a	Concrete Encased Duct Bank	L.F.	15,426	$ 1,180.21	$ 18,205,919.46	$ 2,594.33	$ 40,020,134.58	$ 58,226,054.04
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	52,104	$ 135.39	$ 7,054,181.88	$ 22.92	$ 1,194,193.77	$ 8,248,375.65
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	6,263	$ 106.17	$ 664,955.18	$ 331.64	$ 2,077,060.73	$ 2,742,015.91
C07	Splice Vault Material	EA.	30	$ 91,292.60	$ 2,738,778.00	$ -	$ -	$ 2,738,778.00
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	30	$ 28,117.22	$ 843,516.60	$ 49,728.08	$ 1,491,842.40	$ 2,335,359.00
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 168,712.50	$ 168,712.50	$ 168,712.50	$ 168,712.50	$ 337,425.00
C10	Communication Handholes	EA.	12	$ 7,810.77	$ 93,729.24	$ 11,716.15	$ 140,593.80	$ 234,323.04
C11	Conduit Proofing (Civil)	L.S.	1	$ 103,102.08	$ 103,102.08	$ 721,714.57	$ 721,714.57	$ 824,816.65
C12	Substation Termination Structures	EA.	10	$ 61,651.75	$ 616,517.50	$ 71,354.68	$ 713,546.80	$ 1,330,064.30
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 280,996.33	$ 280,996.33	$ 238,676.10	$ 238,676.10	$ 519,672.43
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 21,422.50	$ 21,422.50	$ 544,820.30	$ 544,820.30	$ 566,242.80
C19	Grading and Access Road	L.F.	9,327	$ 63.13	$ 588,813.51	$ 94.69	$ 883,173.63	$ 1,471,987.14
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 32,251.49	$ 32,251.49	$ 4,624,645.85	$ 4,624,645.85	$ 4,656,897.34
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 4,335,442.35	$ 4,335,442.35	$ 4,335,442.35
C22	Dewatering	L.S.	1	$ 686,283.48	$ 686,283.48	$ 1,146,896.67	$ 1,146,896.67	$ 1,833,180.15
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 1,446,241.01	$ 1,446,241.01	$ 1,446,241.01
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 643,901.16	$ 643,901.16	$ 643,901.16
				SUBTOTAL	**$ 33,982,381.17**		**$ 67,271,076.59**	**$ 101,253,457.76**
			CONTINGENCY	**20.00%**	**$ 6,796,476.23**		**$ 13,454,215.32**	**$ 20,250,691.55**
				TOTAL	**$ 40,778,857.40**		**$ 80,725,291.91**	**$ 121,504,149.31**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 41,626.60	$ 41,626.60	$ 790,905.40	$ 790,905.40	$ 832,532.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 363,683.40	$ 363,683.40	$ 6,909,984.60	$ 6,909,984.60	$ 7,273,668.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 10,960,020.93	$ 10,960,020.93	$ 10,960,020.93	$ 10,960,020.93	$ 21,920,041.86
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 11,365,330.93**		**$ 18,660,910.93**	**$ 30,026,241.86**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 93,271,106.00	$ 23,964,417.25	$ 117,235,523.26
CIVIL WORKS	LOT	$ 40,778,857.40	$ 80,725,291.91	$ 121,504,149.31
PROJECT OVERHEAD COSTS	LOT	$ 11,365,330.93	$ 18,660,910.93	$ 30,026,241.86
PROJECT TOTAL	**LOT**	**$ 145,415,294.34**	**$ 123,350,620.09**	**$ 268,765,914.43**
PROJECT TOTAL	**COST / MILE**	**$ 48,468,704.89**	**$ 41,114,277.76**	**$ 89,582,982.65**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 5, 85%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 15,841
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 3.01
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 12/2/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 69-in High

GENERAL PROJECT SUMMARY

GEN-1	The 500 kV Golden to Mars UG Route 5, 85%DLF Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 15841-ft for a (1)-Circuit, (5)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (20)-8in power conduits with (6) smaller conduits with overall ductbank dimensions of 206-in Wide X 69-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (254)-total working days for duct bank trenching activities. (75)-total working days for splice vault installations. (83)-total working days for cable pulling. (180)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $832532 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $7273668 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	500 kV		
PROJECT NAME:	Golden to Mars UG Route 5, 85%DLF	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE		
ROUTE LENGTH (ft):	15,841	NUMBER OF CIRCUITS:	1	PREPARED BY Juan Morales	12/1/2024
ROUTE LENGTH (mile):	3.01	NUMBER OF CABLES PER PHASE:	5	CHECKED BY Gustavo Constreras	12/2/2024

POWER CABLE DUCT SIZE: 8 — NUMBER OF OTHER DUCTS: 6

NUMBER OF POWER CABLE DUCTS: 20 — TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 69-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 254115-ft, with an additional spare cable length of 2000-ft. The accessories to be installed include: (30)-500 kV Open Air Terminators, with (1)-Spare 500 kV Open Air Terminators. (150)-500 kV Cable Splice, with (1)-Spare 500 kV Cable Splice. (30)-500 kV Lightning Arrester, with (1)-Spare 500 kV
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.35% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 1700-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (165)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 15426-ft with an average duct bank depth of cover of 4.02 feet, with a further breakdown
CIV-2	A total of 11317-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 11285-Cubic Yards of rock were assumed for open cut trenching and 32-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 15426-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (20)-8-inch power conduits as well as (6)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 206-in Wide X 69-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 52104-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 6263-linear feet. Surface restoration costs also included (2)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (30) splice vaults as well as excavation for (30) splice vaults. Assumed splice vault dimensions were: 15-ft width by 40-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (30)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in this
CIV-9	This cost estimate included material and installation for (12)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (20)-power conduits for (11)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (10)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 9578-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 9327-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall route
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.64% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (789)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to C15 &
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 5, 100%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 15,841
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 3.01
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 12/2/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	500 kV 5000 kcmil Cu XLPE Cable	L.F.	254,115	$ 265.25	$ 67,404,003.75	$ 25.47	$ 6,472,309.05	$ 73,876,312.80
U02	Spare 500 kV 5000 kcmil Cu XLPE Cable	L.F.	2,000	$ 265.25	$ 530,500.00	$ -	$ -	$ 530,500.00
U03	500 kV Open Air Terminators	EA.	30	$ 38,196.00	$ 1,145,880.00	$ 53,050.00	$ 1,591,500.00	$ 2,737,380.00
U04	Spare 500 kV Open Air Terminators	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U05	500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	500 kV Cable Splice	EA.	150	$ 41,379.00	$ 6,206,850.00	$ 53,050.00	$ 7,957,500.00	$ 14,164,350.00
U08	Spare 500 kV Cable Splice	EA.	1	$ 41,379.00	$ 41,379.00	$ -	$ -	$ 41,379.00
U09	500 kV Lightning Arrester	EA.	30	$ 7,427.00	$ 222,810.00	$ 3,713.50	$ 111,405.00	$ 334,215.00
U10	Spare 500 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	84,705	$ 12.74	$ 1,079,141.70	$ 8.49	$ 719,145.45	$ 1,798,287.15
U12	Link Box Without SVL's	EA.	55	$ 5,305.00	$ 291,775.00	$ 1,803.70	$ 99,203.50	$ 390,978.50
U13	Link Box With SVL's	EA.	55	$ 7,957.50	$ 437,662.50	$ 1,803.70	$ 99,203.50	$ 536,866.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
U16	Digital Temperature Monitoring System	EA.	1	$ 264,997.54	$ 264,997.54	$ 69,753.26	$ 69,753.26	$ 334,750.80
U17	Cable System Testing	L.S.	1	$ 177,043.98	$ 177,043.98	$ 701,927.30	$ 701,927.30	$ 878,971.28
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 69,754.29	$ 69,754.29	$ 1,785,579.75	$ 1,785,579.75	$ 1,855,334.04
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 302,327.34	$ 302,327.34	$ 302,327.34
				SUBTOTAL	$ 77,917,420.76		$ 19,909,854.15	$ 97,827,274.91
			CONTINGENCY	20.00%	$ 15,583,484.15		$ 3,981,970.83	$ 19,565,454.98
				TOTAL	$ 93,500,904.91		$ 23,891,824.98	$ 117,392,729.89

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	15,426	$ 125.65	$ 1,938,247.22	$ 315.72	$ 4,870,309.06	$ 6,808,556.28
C02	Rock Excavation (Trench & Vault)	C.Y.	13,022	$ -	$ -	$ 203.54	$ 2,650,511.64	$ 2,650,511.64
C03a	Concrete Encased Duct Bank	L.F.	15,426	$ 1,335.16	$ 20,596,178.16	$ 2,626.12	$ 40,510,527.12	$ 61,106,705.28
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	52,104	$ 135.39	$ 7,054,181.88	$ 22.92	$ 1,194,193.77	$ 8,248,375.65
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	6,263	$ 106.17	$ 664,955.18	$ 331.64	$ 2,077,060.73	$ 2,742,015.91
C07	Splice Vault Material	EA.	30	$ 91,292.60	$ 2,738,778.00	$ -	$ -	$ 2,738,778.00
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	30	$ 28,117.22	$ 843,516.60	$ 49,728.08	$ 1,491,842.40	$ 2,335,359.00
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 168,712.50	$ 168,712.50	$ 168,712.50	$ 168,712.50	$ 337,425.00
C10	Communication Handholes	EA.	12	$ 7,810.77	$ 93,729.24	$ 11,716.15	$ 140,593.80	$ 234,323.04
C11	Conduit Proofing (Civil)	L.S.	1	$ 103,102.08	$ 103,102.08	$ 721,714.57	$ 721,714.57	$ 824,816.65
C12	Substation Termination Structures	EA.	10	$ 61,651.75	$ 616,517.50	$ 71,354.68	$ 713,546.80	$ 1,330,064.30
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 280,996.33	$ 280,996.33	$ 238,676.10	$ 238,676.10	$ 519,672.43
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 21,422.50	$ 21,422.50	$ 544,820.30	$ 544,820.30	$ 566,242.80
C19	Grading and Access Road	L.F.	9,327	$ 63.13	$ 588,813.51	$ 94.69	$ 883,173.63	$ 1,471,987.14
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 32,251.49	$ 32,251.49	$ 4,800,199.69	$ 4,800,199.69	$ 4,832,451.18
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 4,510,996.19	$ 4,510,996.19	$ 4,510,996.19
C22	Dewatering	L.S.	1	$ 686,283.48	$ 686,283.48	$ 1,146,896.67	$ 1,146,896.67	$ 1,833,180.15
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 1,446,241.01	$ 1,446,241.01	$ 1,446,241.01
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 637,679.98	$ 637,679.98	$ 637,679.98
				SUBTOTAL	$ 36,427,685.67		$ 68,747,695.96	$ 105,175,381.63
			CONTINGENCY	20.00%	$ 7,285,537.13		$ 13,749,539.19	$ 21,035,076.33
				TOTAL	$ 43,713,222.80		$ 82,497,235.15	$ 126,210,457.96

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 41,626.60	$ 41,626.60	$ 790,905.40	$ 790,905.40	$ 832,532.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 363,683.40	$ 363,683.40	$ 6,909,984.60	$ 6,909,984.60	$ 7,273,668.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 12,180,159.39	$ 12,180,159.39	$ 12,180,159.39	$ 12,180,159.39	$ 24,360,318.78
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	$ 12,585,469.39		$ 19,881,049.39	$ 32,466,518.78

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 93,500,904.91	$ 23,891,824.98	$ 117,392,729.89
CIVIL WORKS	LOT	$ 43,713,222.80	$ 82,497,235.15	$ 126,210,457.96
PROJECT OVERHEAD COSTS	LOT	$ 12,585,469.39	$ 19,881,049.39	$ 32,466,518.78
PROJECT TOTAL	**LOT**	**$ 149,799,597.11**	**$ 126,270,109.52**	**$ 276,069,706.63**
PROJECT TOTAL	**COST / MILE**	**$ 49,930,046.89**	**$ 42,087,379.48**	**$ 92,017,426.36**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 5, 100%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 15,841
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 3.01
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 12/2/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 500 kV Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 15841-ft for a (1)-Circuit, (5)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (20)-8in power conduits with (6) smaller conduits with overall ductbank dimensions of 206-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (254)-total working days for duct bank trenching activities. (75)-total working days for splice vault installations. (83)-total working days for cable pulling. (180)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $832532 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $7273668 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	500 kV		
PROJECT NAME:	Golden to Mars UG Route 5, 100%DLF	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE		
ROUTE LENGTH (ft):	15,841	NUMBER OF CIRCUITS:	1	PREPARED BY Juan Morales	12/1/2024
ROUTE LENGTH (mile):	3.01	NUMBER OF CABLES PER PHASE:	5	CHECKED BY Gustavo Constreras	12/2/2024

POWER CABLE DUCT SIZE: 8 — NUMBER OF OTHER DUCTS: 6

NUMBER OF POWER CABLE DUCTS: 20 — TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 254115-ft, with an additional spare cable length of 2000-ft. The accessories to be installed include: (30)-500 kV Open Air Terminators, with (1)-Spare 500 kV Open Air Terminators. (150)-500 kV Cable Splice, with (1)-Spare 500 kV Cable Splice. (30)-500 kV Lightning Arrester, with (1)-Spare 500 kV
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.31% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 1700-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (165)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 15426-ft with an average duct bank depth of cover of 4.02 feet, with a further breakdown
CIV-2	A total of 13022-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 12990-Cubic Yards of rock were assumed for open cut trenching and 32-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 15426-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (20)-8-inch power conduits as well as (6)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 206-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 52104-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 6263-linear feet. Surface restoration costs also included (2)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (30) splice vaults as well as excavation for (30) splice vaults. Assumed splice vault dimensions were: 15-ft width by 40-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (30)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in this
CIV-9	This cost estimate included material and installation for (12)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (20)-power conduits for (11)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (10)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 9578-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 9327-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall route
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.61% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (789)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to C15 &
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route 6
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 17,970
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 3.41
NUMBER OF CABLES PER PHASE: 4
CHECKED BY Gustavo Constreras 8/30/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	230 kV 5000 kcmil Cu XLPE Cable	L.F.	225,480	$ 212.20	$ 47,846,856.00	$ 25.47	$ 5,742,975.60	$ 53,589,831.60
U02	Spare 230 kV 5000 kcmil Cu XLPE Cable	L.F.	2,800	$ 212.20	$ 594,160.00	$ -	$ -	$ 594,160.00
U03	230 kV Open Air Terminators	EA.	24	$ 19,098.00	$ 458,352.00	$ 26,525.00	$ 636,600.00	$ 1,094,952.00
U04	Spare 230 kV Open Air Terminators	EA.	1	$ 19,098.00	$ 19,098.00	$ -	$ -	$ 19,098.00
U05	230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	230 kV Cable Splice	EA.	84	$ 20,689.50	$ 1,737,918.00	$ 26,525.00	$ 2,228,100.00	$ 3,966,018.00
U08	Spare 230 kV Cable Splice	EA.	1	$ 20,689.50	$ 20,689.50	$ -	$ -	$ 20,689.50
U09	230 kV Lightning Arrester	EA.	24	$ 7,427.00	$ 178,248.00	$ 3,713.50	$ 89,124.00	$ 267,372.00
U10	Spare 230 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	75,160	$ 12.74	$ 957,538.40	$ 8.49	$ 638,108.40	$ 1,595,646.80
U12	Link Box Without SVL's	EA.	32	$ 5,305.00	$ 169,760.00	$ 1,803.70	$ 57,718.40	$ 227,478.40
U13	Link Box With SVL's	EA.	32	$ 7,957.50	$ 254,640.00	$ 1,803.70	$ 57,718.40	$ 312,358.40
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	18,790	$ 4.34	$ 81,520.32	$ 5.42	$ 101,852.45	$ 183,372.77
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 124,972.22	$ 124,972.22	$ 519,509.52	$ 519,509.52	$ 644,481.74
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 21,422.66	$ 21,422.66	$ 548,380.30	$ 548,380.30	$ 569,802.96
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 239,752.22	$ 239,752.22	$ 239,752.22
				SUBTOTAL	**$ 52,472,602.10**		**$ 10,859,839.29**	**$ 63,332,441.39**
			CONTINGENCY	**20.00%**	**$ 10,494,520.42**		**$ 2,171,967.86**	**$ 12,666,488.28**
				TOTAL	**$ 62,967,122.52**		**$ 13,031,807.15**	**$ 75,998,929.67**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 5
NUMBER OF POWER CABLE DUCTS: 16
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	17,778	$ 205.65	$ 3,655,905.20	$ 355.57	$ 6,321,191.90	$ 9,977,097.10
C02	Rock Excavation (Trench & Vault)	C.Y.	8,131	$ -	$ -	$ 203.56	$ 1,655,139.71	$ 1,655,139.71
C03a	Concrete Encased Duct Bank	L.F.	17,778	$ 786.17	$ 13,976,530.26	$ 2,047.10	$ 36,393,343.80	$ 50,369,874.06
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	34,360	$ 135.39	$ 4,651,882.57	$ 22.92	$ 787,511.48	$ 5,439,394.05
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	5,800	$ 78.84	$ 457,273.10	$ 160.88	$ 933,085.46	$ 1,390,358.56
C07	Splice Vault Material	EA.	14	$ 75,671.08	$ 1,059,395.12	$ -	$ -	$ 1,059,395.12
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	14	$ 26,692.85	$ 373,699.90	$ 43,289.75	$ 606,056.50	$ 979,756.40
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 78,732.50	$ 78,732.50	$ 78,732.50	$ 78,732.50	$ 157,465.00
C10	Communication Handholes	EA.	9	$ 7,810.77	$ 70,296.93	$ 11,716.15	$ 105,445.35	$ 175,742.28
C11	Conduit Proofing (Civil)	L.S.	1	$ 59,986.67	$ 59,986.67	$ 419,906.66	$ 419,906.66	$ 479,893.33
C12	Substation Termination Structures	EA.	8	$ 31,170.30	$ 249,362.40	$ 35,999.98	$ 287,999.84	$ 537,362.24
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 354,417.32	$ 354,417.32	$ 301,245.76	$ 301,245.76	$ 655,663.08
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 53,686.88	$ 53,686.88	$ 1,365,372.83	$ 1,365,372.83	$ 1,419,059.71
C19	Grading and Access Road	L.F.	0	$ -	$ -	$ -	$ -	$ -
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 37,167.83	$ 37,167.83	$ 3,979,597.88	$ 3,979,597.88	$ 4,016,765.71
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 3,646,308.94	$ 3,646,308.94	$ 3,646,308.94
C22	Dewatering	L.S.	1	$ 770,066.06	$ 770,066.06	$ 1,284,499.68	$ 1,284,499.68	$ 2,054,565.74
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 1,043,205.60	$ 1,043,205.60	$ 1,043,205.60
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 450,802.35	$ 450,802.35	$ 450,802.35
				SUBTOTAL	**$ 25,848,402.74**		**$ 59,659,446.24**	**$ 85,507,848.98**
			CONTINGENCY	**20.00%**	**$ 5,169,680.55**		**$ 11,931,889.25**	**$ 17,101,569.80**
				TOTAL	**$ 31,018,083.29**		**$ 71,591,335.49**	**$ 102,609,418.78**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 41,314.10	$ 41,314.10	$ 784,967.90	$ 784,967.90	$ 826,282.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 324,562.50	$ 324,562.50	$ 6,166,687.50	$ 6,166,687.50	$ 6,491,250.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 8,930,417.42	$ 8,930,417.42	$ 8,930,417.42	$ 8,930,417.42	$ 17,860,834.84
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 9,296,294.02**		**$ 15,882,072.82**	**$ 25,178,366.84**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 62,967,122.52	$ 13,031,807.15	$ 75,998,929.67
CIVIL WORKS	LOT	$ 31,018,083.29	$ 71,591,335.49	$ 102,609,418.78
PROJECT OVERHEAD COSTS	LOT	$ 9,296,294.02	$ 15,882,072.82	$ 25,178,366.84
PROJECT TOTAL	**LOT**	**$ 103,281,499.83**	**$ 100,505,215.46**	**$ 203,786,715.28**
PROJECT TOTAL	**COST / MILE**	**$ 30,346,484.09**	**$ 29,530,747.78**	**$ 59,877,231.87**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route 6
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 17,970
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 3.41
NUMBER OF CABLES PER PHASE: 4
CHECKED BY Gustavo Constreras 8/30/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 5
NUMBER OF POWER CABLE DUCTS: 16
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 230 kV Golden to Mars UG Route 6 Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 17970-ft for a (1)-Circuit, (4)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (16)-8in power conduits with (5) smaller conduits with overall ductbank dimensions of 86-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (386)-total working days for duct bank trenching activities. (35)-total working days for splice vault installations. (48)-total working days for cable pulling. (108)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $826282 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $6491250 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	230 kV			
PROJECT NAME:	Golden to Mars UG Route 6	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE			
ROUTE LENGTH (ft):	17,970	NUMBER OF CIRCUITS:	1	PREPARED BY	Akaylia Morgan	8/30/2024
ROUTE LENGTH (mile):	3.41	NUMBER OF CABLES PER PHASE:	4	CHECKED BY	Gustavo Constreras	8/30/2024

POWER CABLE DUCT SIZE:	8	NUMBER OF OTHER DUCTS:	5
NUMBER OF POWER CABLE DUCTS:	16	TYPICAL DUCT BANK DIMENSIONS:	86-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 225480-ft, with an additional spare cable length of 2800-ft. The accessories to be installed include: (24)- 230 kV Open Air Terminators, with (1)-Spare 230 kV Open Air Terminators. (84)-230 kV Cable Splice, with (1)-Spare 230 kV Cable Splice. (24)-230 kV Lightning Arrester, with (1)-Spare 230 kV
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.38% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2800-ft and standard splice vault spacing of 2400-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (96)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 17778-ft with an average duct bank depth of cover of 5.39 feet, with a further breakdown
CIV-2	A total of 8131-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 8116-Cubic Yards of rock were assumed for open cut trenching and 15-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 17778-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (16)-8-inch power conduits as well as (5)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 86-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 34360-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 5800-linear feet. Surface restoration costs also included (2)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (14) splice vaults as well as excavation for (14) splice vaults. Assumed splice vault dimensions were: 10-ft width by 26-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (14)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in
CIV-9	This cost estimate included material and installation for (9)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (16)-power conduits for (8)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (8)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 12170-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	Not Used
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.53% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (509)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 6, 85%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 13,325
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 2.53
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 8/30/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	500 kV 5000 kcmil Cu XLPE Cable	L.F.	214,575	$ 265.25	$ 56,916,018.75	$ 25.47	$ 5,465,225.25	$ 62,381,244.00
U02	Spare 500 kV 5000 kcmil Cu XLPE Cable	L.F.	2,000	$ 265.25	$ 530,500.00	$ -	$ -	$ 530,500.00
U03	500 kV Open Air Terminators	EA.	30	$ 38,196.00	$ 1,145,880.00	$ 53,050.00	$ 1,591,500.00	$ 2,737,380.00
U04	Spare 500 kV Open Air Terminators	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U05	500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	500 kV Cable Splice	EA.	120	$ 41,379.00	$ 4,965,480.00	$ 53,050.00	$ 6,366,000.00	$ 11,331,480.00
U08	Spare 500 kV Cable Splice	EA.	1	$ 41,379.00	$ 41,379.00	$ -	$ -	$ 41,379.00
U09	500 kV Lightning Arrester	EA.	30	$ 7,427.00	$ 222,810.00	$ 3,713.50	$ 111,405.00	$ 334,215.00
U10	Spare 500 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	71,525	$ 12.74	$ 911,228.50	$ 8.49	$ 607,247.25	$ 1,518,475.75
U12	Link Box Without SVL's	EA.	45	$ 5,305.00	$ 238,725.00	$ 1,803.70	$ 81,166.50	$ 319,891.50
U13	Link Box With SVL's	EA.	45	$ 7,957.50	$ 358,087.50	$ 1,803.70	$ 81,166.50	$ 439,254.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	14,305	$ 4.34	$ 62,062.17	$ 5.42	$ 77,541.21	$ 139,603.38
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 177,043.98	$ 177,043.98	$ 683,181.46	$ 683,181.46	$ 860,225.44
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 37,228.41	$ 37,228.41	$ 952,977.95	$ 952,977.95	$ 990,206.36
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 506,350.76	$ 506,350.76	$ 506,350.76
				SUBTOTAL	**$ 65,652,066.31**		**$ 16,523,761.88**	**$ 82,175,828.19**
			CONTINGENCY	**20.00%**	**$ 13,130,413.26**		**$ 3,304,752.38**	**$ 16,435,165.64**
				TOTAL	**$ 78,782,479.57**		**$ 19,828,514.26**	**$ 98,610,993.83**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 2
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 69-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	12,993	$ 201.86	$ 2,622,746.27	$ 415.93	$ 5,404,155.10	$ 8,026,901.37
C02	Rock Excavation (Trench & Vault)	C.Y.	10,964	$ -	$ -	$ 203.53	$ 2,231,483.37	$ 2,231,483.37
C03a	Concrete Encased Duct Bank	L.F.	12,993	$ 1,151.00	$ 14,954,943.00	$ 2,469.76	$ 32,089,591.68	$ 47,044,534.68
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	55,776	$ 135.39	$ 7,551,321.37	$ 22.92	$ 1,278,353.90	$ 8,829,675.27
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	3,500	$ 120.56	$ 421,967.50	$ 333.23	$ 1,166,316.57	$ 1,588,284.07
C07	Splice Vault Material	EA.	24	$ 91,292.60	$ 2,191,022.40	$ -	$ -	$ 2,191,022.40
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	24	$ 28,117.22	$ 674,813.28	$ 49,728.08	$ 1,193,473.92	$ 1,868,287.20
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 134,970.00	$ 134,970.00	$ 134,970.00	$ 134,970.00	$ 269,940.00
C10	Communication Handholes	EA.	10	$ 7,810.77	$ 78,107.70	$ 11,716.15	$ 117,161.50	$ 195,269.20
C11	Conduit Proofing (Civil)	L.S.	1	$ 84,356.25	$ 84,356.25	$ 590,493.74	$ 590,493.74	$ 674,849.99
C12	Substation Termination Structures	EA.	10	$ 61,651.75	$ 616,517.50	$ 71,354.68	$ 713,546.80	$ 1,330,064.30
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 288,215.57	$ 288,215.57	$ 244,810.20	$ 244,810.20	$ 533,025.77
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 53,556.25	$ 53,556.25	$ 1,362,050.75	$ 1,362,050.75	$ 1,415,607.00
C19	Grading and Access Road	L.F.	0	$ -	$ -	$ -	$ -	$ -
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 27,164.77	$ 27,164.77	$ 3,983,281.92	$ 3,983,281.92	$ 4,010,446.69
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 3,739,691.81	$ 3,739,691.81	$ 3,739,691.81
C22	Dewatering	L.S.	1	$ 575,670.60	$ 575,670.60	$ 961,577.20	$ 961,577.20	$ 1,537,247.80
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 1,568,088.93	$ 1,568,088.93	$ 1,568,088.93
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 757,373.45	$ 757,373.45	$ 757,373.45
				SUBTOTAL	**$ 30,275,372.46**		**$ 57,536,420.84**	**$ 87,811,793.30**
			CONTINGENCY	**20.00%**	**$ 6,055,074.49**		**$ 11,507,284.17**	**$ 17,562,358.66**
				TOTAL	**$ 36,330,446.95**		**$ 69,043,705.01**	**$ 105,374,151.96**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 45,545.35	$ 45,545.35	$ 865,361.65	$ 865,361.65	$ 910,907.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 315,000.00	$ 315,000.00	$ 5,985,000.00	$ 5,985,000.00	$ 6,300,000.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 8,499,381.07	$ 8,499,381.07	$ 8,499,381.07	$ 8,499,381.07	$ 16,998,762.14
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 8,859,926.42**		**$ 15,349,742.72**	**$ 24,209,669.14**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 78,782,479.57	$ 19,828,514.26	$ 98,610,993.83
CIVIL WORKS	LOT	$ 36,330,446.95	$ 69,043,705.01	$ 105,374,151.96
PROJECT OVERHEAD COSTS	LOT	$ 8,859,926.42	$ 15,349,742.72	$ 24,209,669.14
PROJECT TOTAL	**LOT**	**$ 123,972,852.94**	**$ 104,221,961.98**	**$ 228,194,814.93**
PROJECT TOTAL	**COST / MILE**	**$ 49,123,952.24**	**$ 41,297,708.01**	**$ 90,421,660.25**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 6, 85%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 13,325
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 2.53
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 8/30/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 2
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 69-in High

GENERAL PROJECT SUMMARY

GEN-1	The 500 kV Golden to Mars UG Route 6, 85%DLF Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 13325-ft for a (1)-Circuit, (5)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (20)-8in power conduits with (2) smaller conduits with overall ductbank dimensions of 206-in Wide X 69-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (282)-total working days for duct bank trenching activities. (60)-total working days for splice vault installations. (68)-total working days for cable pulling. (150)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $910907 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $6300000 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	500 kV			
PROJECT NAME:	Golden to Mars UG Route 6, 85%DLF	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE			
ROUTE LENGTH (ft):	13,325	NUMBER OF CIRCUITS:	1	PREPARED BY	Akaylia Morgan	8/30/2024
ROUTE LENGTH (mile):	2.53	NUMBER OF CABLES PER PHASE:	5	CHECKED BY	Gustavo Constreras	8/30/2024

POWER CABLE DUCT SIZE:	8	NUMBER OF OTHER DUCTS:	2
NUMBER OF POWER CABLE DUCTS:	20	TYPICAL DUCT BANK DIMENSIONS:	206-in Wide X 69-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 214575-ft, with an additional spare cable length of 2000-ft. The accessories to be installed include: (30)- 500 kV Open Air Terminators, with (1)-Spare 500 kV Open Air Terminators. (120)-500 kV Cable Splice, with (1)-Spare 500 kV Cable Splice. (30)-500 kV Lightning Arrester, with (1)-Spare 500
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.62% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 1700-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (135)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 12993-ft with an average duct bank depth of cover of 5.38 feet, with a further breakdown
CIV-2	A total of 10964-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 10932-Cubic Yards of rock were assumed for open cut trenching and 32-Cubic Yards of rock
CIV-3	This cost estimate included an assumed total installation length of 12993-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (20)-8-inch power conduits as well as (2)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 206-in Wide X 69-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 55776-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 3500-linear feet. Surface restoration costs also included (2)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (24) splice vaults as well as excavation for (24) splice vaults. Assumed splice vault dimensions were: 15-ft width by 40-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (24)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in
CIV-9	This cost estimate included material and installation for (10)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (20)-power conduits for (9)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (10)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 9825-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	Not Used
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.87% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (889)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 6, 100%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 13,325
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 2.53
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 8/30/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	500 kV 5000 kcmil Cu XLPE Cable	L.F.	214,575	$ 265.25	$ 56,916,018.75	$ 25.47	$ 5,465,225.25	$ 62,381,244.00
U02	Spare 500 kV 5000 kcmil Cu XLPE Cable	L.F.	2,000	$ 265.25	$ 530,500.00	$ -	$ -	$ 530,500.00
U03	500 kV Open Air Terminators	EA.	30	$ 38,196.00	$ 1,145,880.00	$ 53,050.00	$ 1,591,500.00	$ 2,737,380.00
U04	Spare 500 kV Open Air Terminators	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U05	500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	500 kV Cable Splice	EA.	120	$ 41,379.00	$ 4,965,480.00	$ 53,050.00	$ 6,366,000.00	$ 11,331,480.00
U08	Spare 500 kV Cable Splice	EA.	1	$ 41,379.00	$ 41,379.00	$ -	$ -	$ 41,379.00
U09	500 kV Lightning Arrester	EA.	30	$ 7,427.00	$ 222,810.00	$ 3,713.50	$ 111,405.00	$ 334,215.00
U10	Spare 500 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	71,525	$ 12.74	$ 911,228.50	$ 8.49	$ 607,247.25	$ 1,518,475.75
U12	Link Box Without SVL's	EA.	45	$ 5,305.00	$ 238,725.00	$ 1,803.70	$ 81,166.50	$ 319,891.50
U13	Link Box With SVL's	EA.	45	$ 7,957.50	$ 358,087.50	$ 1,803.70	$ 81,166.50	$ 439,254.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	14,305	$ 4.34	$ 62,062.17	$ 5.42	$ 77,541.21	$ 139,603.38
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 177,043.98	$ 177,043.98	$ 631,109.71	$ 631,109.71	$ 808,153.69
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 37,228.41	$ 37,228.41	$ 952,977.95	$ 952,977.95	$ 990,206.36
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 350,954.84	$ 350,954.84	$ 350,954.84
				SUBTOTAL	**$ 65,652,066.31**		**$ 16,316,294.21**	**$ 81,968,360.52**
			CONTINGENCY	**20.00%**	**$ 13,130,413.26**		**$ 3,263,258.84**	**$ 16,393,672.10**
				TOTAL	**$ 78,782,479.57**		**$ 19,579,553.05**	**$ 98,362,032.62**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 2
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	12,993	$ 205.42	$ 2,669,045.23	$ 435.00	$ 5,652,016.07	$ 8,321,061.30
C02	Rock Excavation (Trench & Vault)	C.Y.	12,415	$ -	$ -	$ 203.54	$ 2,526,886.55	$ 2,526,886.55
C03a	Concrete Encased Duct Bank	L.F.	12,993	$ 1,305.94	$ 16,968,078.42	$ 2,501.55	$ 32,502,639.15	$ 49,470,717.57
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	55,776	$ 135.39	$ 7,551,321.37	$ 22.92	$ 1,278,353.90	$ 8,829,675.27
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	3,500	$ 120.56	$ 421,967.50	$ 333.23	$ 1,166,316.57	$ 1,588,284.07
C07	Splice Vault Material	EA.	24	$ 91,292.60	$ 2,191,022.40	$ -	$ -	$ 2,191,022.40
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	24	$ 28,117.22	$ 674,813.28	$ 49,728.08	$ 1,193,473.92	$ 1,868,287.20
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 134,970.00	$ 134,970.00	$ 134,970.00	$ 134,970.00	$ 269,940.00
C10	Communication Handholes	EA.	10	$ 7,810.77	$ 78,107.70	$ 11,716.15	$ 117,161.50	$ 195,269.20
C11	Conduit Proofing (Civil)	L.S.	1	$ 84,356.25	$ 84,356.25	$ 590,493.74	$ 590,493.74	$ 674,849.99
C12	Substation Termination Structures	EA.	10	$ 61,651.75	$ 616,517.50	$ 71,354.68	$ 713,546.80	$ 1,330,064.30
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 288,215.57	$ 288,215.57	$ 244,810.20	$ 244,810.20	$ 533,025.77
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 53,556.25	$ 53,556.25	$ 1,362,050.75	$ 1,362,050.75	$ 1,415,607.00
C19	Grading and Access Road	L.F.	0	$ -	$ -	$ -	$ -	$ -
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 27,164.77	$ 27,164.77	$ 4,131,288.71	$ 4,131,288.71	$ 4,158,453.48
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 3,887,698.59	$ 3,887,698.59	$ 3,887,698.59
C22	Dewatering	L.S.	1	$ 575,670.60	$ 575,670.60	$ 961,577.20	$ 961,577.20	$ 1,537,247.80
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 1,568,088.93	$ 1,568,088.93	$ 1,568,088.93
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 759,075.91	$ 759,075.91	$ 759,075.91
				SUBTOTAL	**$ 32,334,806.84**		**$ 58,790,448.49**	**$ 91,125,255.33**
			CONTINGENCY	**20.00%**	**$ 6,466,961.37**		**$ 11,758,089.70**	**$ 18,225,051.07**
				TOTAL	**$ 38,801,768.21**		**$ 70,548,538.19**	**$ 109,350,306.40**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 45,545.35	$ 45,545.35	$ 865,361.65	$ 865,361.65	$ 910,907.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 315,000.00	$ 315,000.00	$ 5,985,000.00	$ 5,985,000.00	$ 6,300,000.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 10,385,616.95	$ 10,385,616.95	$ 10,385,616.95	$ 10,385,616.95	$ 20,771,233.90
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 10,746,162.30**		**$ 17,235,978.60**	**$ 27,982,140.90**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 78,782,479.57	$ 19,579,553.05	$ 98,362,032.62
CIVIL WORKS	LOT	$ 38,801,768.21	$ 70,548,538.19	$ 109,350,306.40
PROJECT OVERHEAD COSTS	LOT	$ 10,746,162.30	$ 17,235,978.60	$ 27,982,140.90
PROJECT TOTAL	**LOT**	**$ 128,330,410.08**	**$ 107,364,069.84**	**$ 235,694,479.92**
PROJECT TOTAL	**COST / MILE**	**$ 50,850,624.03**	**$ 42,542,760.88**	**$ 93,393,384.91**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 6, 100%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 13,325
NUMBER OF CIRCUITS: 1
PREPARED BY Akaylia Morgan 8/30/2024
ROUTE LENGTH (mile): 2.53
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 8/30/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 2
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 500 kV Golden to Mars UG Route 6, 100%DLF Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 13325-ft for a (1)-Circuit, (5)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (20)-8in power conduits with (2) smaller conduits with overall ductbank dimensions of 206-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (282)-total working days for duct bank trenching activities. (60)-total working days for splice vault installations. (68)-total working days for cable pulling. (150)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $910907 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $6300000 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	500 kV			
PROJECT NAME:	Golden to Mars UG Route 6, 100%DLF	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE			
ROUTE LENGTH (ft):	13,325	NUMBER OF CIRCUITS:	1	PREPARED BY	Akaylia Morgan	8/30/2024
ROUTE LENGTH (mile):	2.53	NUMBER OF CABLES PER PHASE:	5	CHECKED BY	Gustavo Constreras	8/30/2024

POWER CABLE DUCT SIZE:	8	NUMBER OF OTHER DUCTS:	2
NUMBER OF POWER CABLE DUCTS:	20	TYPICAL DUCT BANK DIMENSIONS:	206-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 214575-ft, with an additional spare cable length of 2000-ft. The accessories to be installed include: (30)- 500 kV Open Air Terminators, with (1)-Spare 500 kV Open Air Terminators. (120)-500 kV Cable Splice, with (1)-Spare 500 kV Cable Splice. (30)-500 kV Lightning Arrester, with (1)-Spare 500
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.43% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 1700-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (135)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 12993-ft with an average duct bank depth of cover of 5.38 feet, with a further breakdown
CIV-2	A total of 12415-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 12383-Cubic Yards of rock were assumed for open cut trenching and 32-Cubic Yards of rock
CIV-3	This cost estimate included an assumed total installation length of 12993-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (20)-8-inch power conduits as well as (2)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 206-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 55776-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 3500-linear feet. Surface restoration costs also included (2)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (24) splice vaults as well as excavation for (24) splice vaults. Assumed splice vault dimensions were: 15-ft width by 40-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (24)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in
CIV-9	This cost estimate included material and installation for (10)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (20)-power conduits for (9)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (10)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 9825-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	Not Used
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.84% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (889)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route 7
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 16,195
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 3.07
NUMBER OF CABLES PER PHASE: 4
CHECKED BY Gustavo Constreras 12/2/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	230 kV 5000 kcmil Cu XLPE Cable	L.F.	204,180	$ 212.20	$ 43,326,996.00	$ 25.47	$ 5,200,464.60	$ 48,527,460.60
U02	Spare 230 kV 5000 kcmil Cu XLPE Cable	L.F.	2,800	$ 212.20	$ 594,160.00	$ -	$ -	$ 594,160.00
U03	230 kV Open Air Terminators	EA.	24	$ 19,098.00	$ 458,352.00	$ 26,525.00	$ 636,600.00	$ 1,094,952.00
U04	Spare 230 kV Open Air Terminators	EA.	1	$ 19,098.00	$ 19,098.00	$ -	$ -	$ 19,098.00
U05	230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	230 kV Cable Splice	EA.	84	$ 20,689.50	$ 1,737,918.00	$ 26,525.00	$ 2,228,100.00	$ 3,966,018.00
U08	Spare 230 kV Cable Splice	EA.	1	$ 20,689.50	$ 20,689.50	$ -	$ -	$ 20,689.50
U09	230 kV Lightning Arrester	EA.	24	$ 7,427.00	$ 178,248.00	$ 3,713.50	$ 89,124.00	$ 267,372.00
U10	Spare 230 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	68,060	$ 12.74	$ 867,084.40	$ 8.49	$ 577,829.40	$ 1,444,913.80
U12	Link Box Without SVL's	EA.	32	$ 5,305.00	$ 169,760.00	$ 1,803.70	$ 57,718.40	$ 227,478.40
U13	Link Box With SVL's	EA.	32	$ 7,957.50	$ 254,640.00	$ 1,803.70	$ 57,718.40	$ 312,358.40
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	17,015	$ 4.34	$ 73,819.50	$ 5.42	$ 92,230.95	$ 166,050.45
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 124,972.22	$ 124,972.22	$ 519,509.52	$ 519,509.52	$ 644,481.74
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 15,152.62	$ 15,152.62	$ 387,878.75	$ 387,878.75	$ 403,031.37
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 248,090.61	$ 248,090.61	$ 248,090.61
				SUBTOTAL	**$ 47,848,317.24**		**$ 10,095,264.63**	**$ 57,943,581.87**
			CONTINGENCY	**20.00%**	**$ 9,569,663.45**		**$ 2,019,052.93**	**$ 11,588,716.37**
				TOTAL	**$ 57,417,980.69**		**$ 12,114,317.56**	**$ 69,532,298.24**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 5
NUMBER OF POWER CABLE DUCTS: 16
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	16,003	$ 190.28	$ 3,045,003.57	$ 335.01	$ 5,361,071.14	$ 8,406,074.71
C02	Rock Excavation (Trench & Vault)	C.Y.	7,366	$ -	$ -	$ 203.56	$ 1,499,394.93	$ 1,499,394.93
C03a	Concrete Encased Duct Bank	L.F.	16,003	$ 786.17	$ 12,581,078.51	$ 2,047.10	$ 32,759,741.30	$ 45,340,819.81
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	30,930	$ 135.39	$ 4,187,506.63	$ 22.92	$ 708,897.85	$ 4,896,404.48
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	3,664	$ 88.15	$ 322,966.31	$ 166.97	$ 611,765.40	$ 934,731.71
C07	Splice Vault Material	EA.	14	$ 75,671.08	$ 1,059,395.12	$ -	$ -	$ 1,059,395.12
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	14	$ 26,692.85	$ 373,699.90	$ 43,289.75	$ 606,056.50	$ 979,756.40
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 78,732.50	$ 78,732.50	$ 78,732.50	$ 78,732.50	$ 157,465.00
C10	Communication Handholes	EA.	7	$ 7,810.77	$ 54,675.39	$ 11,716.15	$ 82,013.05	$ 136,688.44
C11	Conduit Proofing (Civil)	L.S.	1	$ 59,986.67	$ 59,986.67	$ 419,906.66	$ 419,906.66	$ 479,893.33
C12	Substation Termination Structures	EA.	8	$ 31,170.30	$ 249,362.40	$ 35,999.98	$ 287,999.84	$ 537,362.24
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 367,516.38	$ 367,516.38	$ 312,174.54	$ 312,174.54	$ 679,690.92
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 55,123.75	$ 55,123.75	$ 1,401,915.65	$ 1,401,915.65	$ 1,457,039.40
C19	Grading and Access Road	L.F.	0	$ -	$ -	$ -	$ -	$ -
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 33,456.80	$ 33,456.80	$ 3,566,874.77	$ 3,566,874.77	$ 3,600,331.57
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 3,266,863.16	$ 3,266,863.16	$ 3,266,863.16
C22	Dewatering	L.S.	1	$ 695,751.32	$ 695,751.32	$ 1,161,047.72	$ 1,161,047.72	$ 1,856,799.04
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 944,165.12	$ 944,165.12	$ 944,165.12
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 472,643.83	$ 472,643.83	$ 472,643.83
				SUBTOTAL	**$ 23,164,255.25**		**$ 53,541,263.96**	**$ 76,705,519.21**
			CONTINGENCY	**20.00%**	**$ 4,632,851.05**		**$ 10,708,252.79**	**$ 15,341,103.84**
				TOTAL	**$ 27,797,106.30**		**$ 64,249,516.75**	**$ 92,046,623.05**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 39,307.85	$ 39,307.85	$ 746,849.15	$ 746,849.15	$ 786,157.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 326,103.55	$ 326,103.55	$ 6,195,967.45	$ 6,195,967.45	$ 6,522,071.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 8,078,946.06	$ 8,078,946.06	$ 8,078,946.06	$ 8,078,946.06	$ 16,157,892.12
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 8,444,357.46**		**$ 15,021,762.66**	**$ 23,466,120.12**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 57,417,980.69	$ 12,114,317.56	$ 69,532,298.24
CIVIL WORKS	LOT	$ 27,797,106.30	$ 64,249,516.75	$ 92,046,623.05
PROJECT OVERHEAD COSTS	LOT	$ 8,444,357.46	$ 15,021,762.66	$ 23,466,120.12
PROJECT TOTAL	**LOT**	**$ 93,659,444.45**	**$ 91,385,596.97**	**$ 185,045,041.42**
PROJECT TOTAL	**COST / MILE**	**$ 30,535,465.68**	**$ 29,794,131.03**	**$ 60,329,596.71**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route 7
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 16,195
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 3.07
NUMBER OF CABLES PER PHASE: 4
CHECKED BY Gustavo Constreras 12/2/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 5
NUMBER OF POWER CABLE DUCTS: 16
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 230 kV Golden to Mars UG Route 7 Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 16195-ft for a (1)-Circuit, (4)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (16)-8in power conduits with (5) smaller conduits with overall ductbank dimensions of 86-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (348)-total working days for duct bank trenching activities. (35)-total working days for splice vault installations. (48)-total working days for cable pulling. (108)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $786157 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $6522071 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	230 kV		
PROJECT NAME:	Golden to Mars UG Route 7	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE		
ROUTE LENGTH (ft):	16,195	NUMBER OF CIRCUITS:	1	PREPARED BY Juan Morales	12/1/2024
ROUTE LENGTH (mile):	3.07	NUMBER OF CABLES PER PHASE:	4	CHECKED BY Gustavo Constreras	12/2/2024

POWER CABLE DUCT SIZE: 8 — NUMBER OF OTHER DUCTS: 5

NUMBER OF POWER CABLE DUCTS: 16 — TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 204180-ft, with an additional spare cable length of 2800-ft. The accessories to be installed include: (24)-230 kV Open Air Terminators, with (1)-Spare 230 kV Open Air Terminators. (84)-230 kV Cable Splice, with (1)-Spare 230 kV Cable Splice. (24)-230 kV Lightning Arrester, with (1)-Spare 230 kV
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.43% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2800-ft and standard splice vault spacing of 2400-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (96)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 16003-ft with an average duct bank depth of cover of 5.39 feet, with a further breakdown
CIV-2	A total of 7366-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 7351-Cubic Yards of rock were assumed for open cut trenching and 15-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 16003-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (16)-8-inch power conduits as well as (5)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 86-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 30930-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 3664-linear feet. Surface restoration costs also included (4)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (14) splice vaults as well as excavation for (14) splice vaults. Assumed splice vault dimensions were: 10-ft width by 26-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (14)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in this
CIV-9	This cost estimate included material and installation for (7)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (16)-power conduits for (8)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (8)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 12531-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	Not Used
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall route
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.62% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (458)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to C15 &
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars, UG Route 7, 85%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 13,323
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 2.53
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 12/2/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	500 kV 5000 kcmil Cu XLPE Cable	L.F.	214,545	$ 265.25	$ 56,908,061.25	$ 25.47	$ 5,464,461.15	$ 62,372,522.40
U02	Spare 500 kV 5000 kcmil Cu XLPE Cable	L.F.	2,000	$ 265.25	$ 530,500.00	$ -	$ -	$ 530,500.00
U03	500 kV Open Air Terminators	EA.	30	$ 38,196.00	$ 1,145,880.00	$ 53,050.00	$ 1,591,500.00	$ 2,737,380.00
U04	Spare 500 kV Open Air Terminators	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U05	500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	500 kV Cable Splice	EA.	120	$ 41,379.00	$ 4,965,480.00	$ 53,050.00	$ 6,366,000.00	$ 11,331,480.00
U08	Spare 500 kV Cable Splice	EA.	1	$ 41,379.00	$ 41,379.00	$ -	$ -	$ 41,379.00
U09	500 kV Lightning Arrester	EA.	30	$ 7,427.00	$ 222,810.00	$ 3,713.50	$ 111,405.00	$ 334,215.00
U10	Spare 500 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	71,515	$ 12.74	$ 911,101.10	$ 8.49	$ 607,162.35	$ 1,518,263.45
U12	Link Box Without SVL's	EA.	45	$ 5,305.00	$ 238,725.00	$ 1,803.70	$ 81,166.50	$ 319,891.50
U13	Link Box With SVL's	EA.	45	$ 7,957.50	$ 358,087.50	$ 1,803.70	$ 81,166.50	$ 439,254.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	14,303	$ 4.34	$ 62,053.50	$ 5.42	$ 77,530.37	$ 139,583.87
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 177,043.98	$ 177,043.98	$ 683,181.46	$ 683,181.46	$ 860,225.44
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 39,057.18	$ 39,057.18	$ 999,790.91	$ 999,790.91	$ 1,038,848.09
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 506,596.83	$ 506,596.83	$ 506,596.83
				SUBTOTAL	**$ 65,645,801.51**		**$ 16,569,961.07**	**$ 82,215,762.58**
			CONTINGENCY	**20.00%**	**$ 13,129,160.30**		**$ 3,313,992.21**	**$ 16,443,152.52**
				TOTAL	**$ 78,774,961.81**		**$ 19,883,953.28**	**$ 98,658,915.10**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 69-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	12,991	$ 186.71	$ 2,425,608.25	$ 395.84	$ 5,142,302.88	$ 7,567,911.13
C02	Rock Excavation (Trench & Vault)	C.Y.	10,960	$ -	$ -	$ 203.53	$ 2,230,653.22	$ 2,230,653.22
C03a	Concrete Encased Duct Bank	L.F.	12,991	$ 1,180.21	$ 15,332,108.11	$ 2,594.33	$ 33,702,941.03	$ 49,035,049.14
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	55,855	$ 135.39	$ 7,562,016.91	$ 22.92	$ 1,280,164.54	$ 8,842,181.45
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	3,664	$ 120.52	$ 441,579.02	$ 337.30	$ 1,235,856.37	$ 1,677,435.39
C07	Splice Vault Material	EA.	24	$ 91,292.60	$ 2,191,022.40	$ -	$ -	$ 2,191,022.40
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	24	$ 24,148.00	$ 579,552.00	$ 43,150.63	$ 1,035,615.12	$ 1,615,167.12
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 134,970.00	$ 134,970.00	$ 134,970.00	$ 134,970.00	$ 269,940.00
C10	Communication Handholes	EA.	10	$ 7,810.77	$ 78,107.70	$ 11,716.15	$ 117,161.50	$ 195,269.20
C11	Conduit Proofing (Civil)	L.S.	1	$ 84,356.25	$ 84,356.25	$ 590,493.74	$ 590,493.74	$ 674,849.99
C12	Substation Termination Structures	EA.	10	$ 61,651.75	$ 616,517.50	$ 71,354.68	$ 713,546.80	$ 1,330,064.30
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 281,812.07	$ 281,812.07	$ 239,491.83	$ 239,491.83	$ 521,303.90
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 50,421.25	$ 50,421.25	$ 1,282,320.95	$ 1,282,320.95	$ 1,332,742.20
C19	Grading and Access Road	L.F.	0	$ -	$ -	$ -	$ -	$ -
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 27,160.58	$ 27,160.58	$ 4,046,292.23	$ 4,046,292.23	$ 4,073,452.81
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 3,802,739.61	$ 3,802,739.61	$ 3,802,739.61
C22	Dewatering	L.S.	1	$ 575,803.74	$ 575,803.74	$ 961,864.19	$ 961,864.19	$ 1,537,667.93
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 1,571,213.23	$ 1,571,213.23	$ 1,571,213.23
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 769,677.37	$ 769,677.37	$ 769,677.37
				SUBTOTAL	**$ 30,381,035.78**		**$ 58,857,304.61**	**$ 89,238,340.39**
			CONTINGENCY	**20.00%**	**$ 6,076,207.16**		**$ 11,771,460.92**	**$ 17,847,668.08**
				TOTAL	**$ 36,457,242.94**		**$ 70,628,765.53**	**$ 107,086,008.47**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 38,357.85	$ 38,357.85	$ 728,799.15	$ 728,799.15	$ 767,157.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 325,219.45	$ 325,219.45	$ 6,179,169.55	$ 6,179,169.55	$ 6,504,389.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 9,465,088.55	$ 9,465,088.55	$ 9,465,088.55	$ 9,465,088.55	$ 18,930,177.10
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 9,828,665.85**		**$ 16,373,057.25**	**$ 26,201,723.10**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 78,774,961.81	$ 19,883,953.28	$ 98,658,915.10
CIVIL WORKS	LOT	$ 36,457,242.94	$ 70,628,765.53	$ 107,086,008.47
PROJECT OVERHEAD COSTS	LOT	$ 9,828,665.85	$ 16,373,057.25	$ 26,201,723.10
PROJECT TOTAL	**LOT**	**$ 125,060,870.60**	**$ 106,885,776.07**	**$ 231,946,646.66**
PROJECT TOTAL	**COST / MILE**	**$ 49,562,515.71**	**$ 42,359,596.01**	**$ 91,922,111.72**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars, UG Route 7, 85%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 13,323
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 2.53
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 12/2/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 69-in High

GENERAL PROJECT SUMMARY

GEN-1	The 500 kV Golden to Mars, UG Route 7, 85%DLF Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 13323-ft for a (1)-Circuit, (5)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (20)-8in power conduits with (6) smaller conduits with overall ductbank dimensions of 206-in Wide X 69-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (282)-total working days for duct bank trenching activities. (48)-total working days for splice vault installations. (68)-total working days for cable pulling. (150)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $767157 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $6504389 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	500 kV		
PROJECT NAME:	Golden to Mars, UG Route 7, 85%DLF	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE		
ROUTE LENGTH (ft):	13,323	NUMBER OF CIRCUITS:	1	PREPARED BY Juan Morales	12/1/2024
ROUTE LENGTH (mile):	2.53	NUMBER OF CABLES PER PHASE:	5	CHECKED BY Gustavo Constreras	12/2/2024

POWER CABLE DUCT SIZE: 8 NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20 TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 69-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 214545-ft, with an additional spare cable length of 2000-ft. The accessories to be installed include: (30)-500 kV Open Air Terminators, with (1)-Spare 500 kV Open Air Terminators. (120)-500 kV Cable Splice, with (1)-Spare 500 kV Cable Splice. (30)-500 kV Lightning Arrester, with (1)-Spare 500 kV
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.62% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 1700-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (135)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 12991-ft with an average duct bank depth of cover of 5.39 feet, with a further breakdown
CIV-2	A total of 10960-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 10928-Cubic Yards of rock were assumed for open cut trenching and 32-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 12991-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (20)-8-inch power conduits as well as (6)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 206-in Wide X 69-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 55855-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 3664-linear feet. Surface restoration costs also included (4)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (24) splice vaults as well as excavation for (24) splice vaults. Assumed splice vault dimensions were: 15-ft width by 40-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (24)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in this
CIV-9	This cost estimate included material and installation for (10)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (20)-power conduits for (9)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (10)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 9659-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	Not Used
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall route
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.87% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (891)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to C15 &
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 7, 100%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 13,323
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 2.53
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 12/2/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	500 kV 5000 kcmil Cu XLPE Cable	L.F.	214,545	$ 265.25	$ 56,908,061.25	$ 25.47	$ 5,464,461.15	$ 62,372,522.40
U02	Spare 500 kV 5000 kcmil Cu XLPE Cable	L.F.	2,000	$ 265.25	$ 530,500.00	$ -	$ -	$ 530,500.00
U03	500 kV Open Air Terminators	EA.	30	$ 38,196.00	$ 1,145,880.00	$ 53,050.00	$ 1,591,500.00	$ 2,737,380.00
U04	Spare 500 kV Open Air Terminators	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U05	500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	500 kV Cable Splice	EA.	120	$ 41,379.00	$ 4,965,480.00	$ 53,050.00	$ 6,366,000.00	$ 11,331,480.00
U08	Spare 500 kV Cable Splice	EA.	1	$ 41,379.00	$ 41,379.00	$ -	$ -	$ 41,379.00
U09	500 kV Lightning Arrester	EA.	30	$ 7,427.00	$ 222,810.00	$ 3,713.50	$ 111,405.00	$ 334,215.00
U10	Spare 500 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	71,515	$ 12.74	$ 911,101.10	$ 8.49	$ 607,162.35	$ 1,518,263.45
U12	Link Box Without SVL's	EA.	45	$ 5,305.00	$ 238,725.00	$ 1,803.70	$ 81,166.50	$ 319,891.50
U13	Link Box With SVL's	EA.	45	$ 7,957.50	$ 358,087.50	$ 1,803.70	$ 81,166.50	$ 439,254.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	14,303	$ 4.34	$ 62,053.50	$ 5.42	$ 77,530.37	$ 139,583.87
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 177,043.98	$ 177,043.98	$ 683,181.46	$ 683,181.46	$ 860,225.44
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 39,057.18	$ 39,057.18	$ 999,790.91	$ 999,790.91	$ 1,038,848.09
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 506,596.83	$ 506,596.83	$ 506,596.83
				SUBTOTAL	**$ 65,645,801.51**		**$ 16,569,961.07**	**$ 82,215,762.58**
			CONTINGENCY	**20.00%**	**$ 13,129,160.30**		**$ 3,313,992.21**	**$ 16,443,152.52**
				TOTAL	**$ 78,774,961.81**		**$ 19,883,953.28**	**$ 98,658,915.10**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	12,991	$ 190.28	$ 2,471,952.05	$ 414.91	$ 5,390,073.73	$ 7,862,025.78
C02	Rock Excavation (Trench & Vault)	C.Y.	12,410	$ -	$ -	$ 203.54	$ 2,526,032.94	$ 2,526,032.94
C03a	Concrete Encased Duct Bank	L.F.	12,991	$ 1,335.16	$ 17,345,063.56	$ 2,626.12	$ 34,115,924.92	$ 51,460,988.48
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	55,855	$ 135.39	$ 7,562,016.91	$ 22.92	$ 1,280,164.54	$ 8,842,181.45
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	3,664	$ 121.23	$ 444,182.60	$ 339.43	$ 1,243,667.14	$ 1,687,849.74
C07	Splice Vault Material	EA.	24	$ 91,292.60	$ 2,191,022.40	$ -	$ -	$ 2,191,022.40
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	24	$ 24,148.00	$ 579,552.00	$ 43,150.63	$ 1,035,615.12	$ 1,615,167.12
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 134,970.00	$ 134,970.00	$ 134,970.00	$ 134,970.00	$ 269,940.00
C10	Communication Handholes	EA.	10	$ 7,810.77	$ 78,107.70	$ 11,716.15	$ 117,161.50	$ 195,269.20
C11	Conduit Proofing (Civil)	L.S.	1	$ 84,356.25	$ 84,356.25	$ 590,493.74	$ 590,493.74	$ 674,849.99
C12	Substation Termination Structures	EA.	10	$ 61,651.75	$ 616,517.50	$ 71,354.68	$ 713,546.80	$ 1,330,064.30
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 281,812.07	$ 281,812.07	$ 239,491.83	$ 239,491.83	$ 521,303.90
C15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C16	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 50,421.25	$ 50,421.25	$ 1,282,320.95	$ 1,282,320.95	$ 1,332,742.20
C19	Grading and Access Road	L.F.	0	$ -	$ -	$ -	$ -	$ -
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 27,160.58	$ 27,160.58	$ 4,194,794.80	$ 4,194,794.80	$ 4,221,955.38
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 3,951,242.18	$ 3,951,242.18	$ 3,951,242.18
C22	Dewatering	L.S.	1	$ 575,803.74	$ 575,803.74	$ 961,864.19	$ 961,864.19	$ 1,537,667.93
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 1,571,213.23	$ 1,571,213.23	$ 1,571,213.23
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 798,586.19	$ 798,586.19	$ 798,586.19
				SUBTOTAL	**$ 32,442,938.61**		**$ 60,147,163.80**	**$ 92,590,102.41**
			CONTINGENCY	**20.00%**	**$ 6,488,587.72**		**$ 12,029,432.76**	**$ 18,518,020.48**
				TOTAL	**$ 38,931,526.33**		**$ 72,176,596.56**	**$ 111,108,122.89**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 38,357.85	$ 38,357.85	$ 728,799.15	$ 728,799.15	$ 767,157.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 325,219.45	$ 325,219.45	$ 6,179,169.55	$ 6,179,169.55	$ 6,504,389.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 10,488,351.90	$ 10,488,351.90	$ 10,488,351.90	$ 10,488,351.90	$ 20,976,703.80
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 10,851,929.20**		**$ 17,396,320.60**	**$ 28,248,249.80**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 78,774,961.81	$ 19,883,953.28	$ 98,658,915.10
CIVIL WORKS	LOT	$ 38,931,526.33	$ 72,176,596.56	$ 111,108,122.89
PROJECT OVERHEAD COSTS	LOT	$ 10,851,929.20	$ 17,396,320.60	$ 28,248,249.80
PROJECT TOTAL	**LOT**	**$ 128,558,417.34**	**$ 109,456,870.44**	**$ 238,015,287.79**
PROJECT TOTAL	**COST / MILE**	**$ 50,948,618.45**	**$ 43,378,539.06**	**$ 94,327,157.51**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route 7, 100%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 13,323
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 2.53
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 12/2/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 500 kV Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 13323-ft for a (1)-Circuit, (5)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (20)-8in power conduits with (6) smaller conduits with overall ductbank dimensions of 206-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (282)-total working days for duct bank trenching activities. (48)-total working days for splice vault installations. (68)-total working days for cable pulling. (150)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $767157 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $6504389 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	500 kV		
PROJECT NAME:	Golden to Mars UG Route 7, 100%DLF	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE		
ROUTE LENGTH (ft):	13,323	NUMBER OF CIRCUITS:	1	PREPARED BY Juan Morales	12/1/2024
ROUTE LENGTH (mile):	2.53	NUMBER OF CABLES PER PHASE:	5	CHECKED BY Gustavo Constreras	12/2/2024

POWER CABLE DUCT SIZE: 8 — NUMBER OF OTHER DUCTS: 6

NUMBER OF POWER CABLE DUCTS: 20 — TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 214545-ft, with an additional spare cable length of 2000-ft. The accessories to be installed include: (30)-500 kV Open Air Terminators, with (1)-Spare 500 kV Open Air Terminators. (120)-500 kV Cable Splice, with (1)-Spare 500 kV Cable Splice. (30)-500 kV Lightning Arrester, with (1)-Spare 500 kV
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.62% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 1700-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (135)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 12991-ft with an average duct bank depth of cover of 5.39 feet, with a further breakdown
CIV-2	A total of 12410-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 12379-Cubic Yards of rock were assumed for open cut trenching and 32-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 12991-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (20)-8-inch power conduits as well as (6)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 206-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 55855-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 3664-linear feet. Surface restoration costs also included (5)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (24) splice vaults as well as excavation for (24) splice vaults. Assumed splice vault dimensions were: 15-ft width by 40-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (24)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in this
CIV-9	This cost estimate included material and installation for (10)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (20)-power conduits for (9)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (10)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 9659-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	Not Used
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall route
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.87% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (891)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to C15 &
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route R1
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 22,089
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 4.19
NUMBER OF CABLES PER PHASE: 4
CHECKED BY Gustavo Constreras 12/2/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	230 kV 5000 kcmil Cu XLPE Cable	L.F.	276,348	$ 212.20	$ 58,641,045.60	$ 25.47	$ 7,038,583.56	$ 65,679,629.16
U02	Spare 230 kV 5000 kcmil Cu XLPE Cable	L.F.	2,800	$ 212.20	$ 594,160.00	$ -	$ -	$ 594,160.00
U03	230 kV Open Air Terminators	EA.	24	$ 19,098.00	$ 458,352.00	$ 26,525.00	$ 636,600.00	$ 1,094,952.00
U04	Spare 230 kV Open Air Terminators	EA.	1	$ 19,098.00	$ 19,098.00	$ -	$ -	$ 19,098.00
U05	230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	230 kV Cable Splice	EA.	108	$ 20,689.50	$ 2,234,466.00	$ 26,525.00	$ 2,864,700.00	$ 5,099,166.00
U08	Spare 230 kV Cable Splice	EA.	1	$ 20,689.50	$ 20,689.50	$ -	$ -	$ 20,689.50
U09	230 kV Lightning Arrester	EA.	24	$ 7,427.00	$ 178,248.00	$ 3,713.50	$ 89,124.00	$ 267,372.00
U10	Spare 230 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	92,116	$ 12.74	$ 1,173,557.84	$ 8.49	$ 782,064.84	$ 1,955,622.68
U12	Link Box Without SVL's	EA.	40	$ 5,305.00	$ 212,200.00	$ 1,803.70	$ 72,148.00	$ 284,348.00
U13	Link Box With SVL's	EA.	40	$ 7,957.50	$ 318,300.00	$ 1,803.70	$ 72,148.00	$ 390,448.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	23,029	$ 4.34	$ 99,911.21	$ 5.42	$ 124,830.24	$ 224,741.45
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 124,972.22	$ 124,972.22	$ 534,506.18	$ 534,506.18	$ 659,478.40
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 783.76	$ 783.76	$ 20,062.69	$ 20,062.69	$ 20,846.45
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 267,112.93	$ 267,112.93	$ 267,112.93
				SUBTOTAL	**$ 64,083,211.13**		**$ 12,501,880.44**	**$ 76,585,091.57**
			CONTINGENCY	**20.00%**	**$ 12,816,642.23**		**$ 2,500,376.09**	**$ 15,317,018.31**
				TOTAL	**$ 76,899,853.36**		**$ 15,002,256.53**	**$ 91,902,109.88**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 5
NUMBER OF POWER CABLE DUCTS: 16
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	20,212	$ 125.64	$ 2,539,455.43	$ 243.58	$ 4,923,096.96	$ 7,462,552.39
C02	Rock Excavation (Trench & Vault)	C.Y.	8,382	$ -	$ -	$ 203.56	$ 1,706,340.27	$ 1,706,340.27
C03a	Concrete Encased Duct Bank	L.F.	20,212	$ 786.17	$ 15,890,068.04	$ 2,047.10	$ 41,375,985.20	$ 57,266,053.24
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	30,690	$ 135.39	$ 4,155,013.86	$ 22.92	$ 703,397.18	$ 4,858,411.04
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	197	$ 435.42	$ 85,782.59	$ 158.29	$ 31,185.18	$ 116,967.77
C07	Splice Vault Material	EA.	18	$ 75,671.08	$ 1,362,079.44	$ -	$ -	$ 1,362,079.44
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	18	$ 26,692.85	$ 480,471.30	$ 43,289.75	$ 779,215.50	$ 1,259,686.80
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 101,227.50	$ 101,227.50	$ 101,227.50	$ 101,227.50	$ 202,455.00
C10	Communication Handholes	EA.	11	$ 7,810.77	$ 85,918.47	$ 11,716.15	$ 128,877.65	$ 214,796.12
C11	Conduit Proofing (Civil)	L.S.	1	$ 74,983.33	$ 74,983.33	$ 524,883.33	$ 524,883.33	$ 599,866.66
C12	Substation Termination Structures	EA.	8	$ 31,170.30	$ 249,362.40	$ 35,999.98	$ 287,999.84	$ 537,362.24
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 592,176.37	$ 592,176.37	$ 503,195.37	$ 503,195.37	$ 1,095,371.74
C15	Jack & Bore	L.F.	330	-	$ 188,900.00	-	$ 230,877.78	$ 419,777.78
C16	Horizontal Directional Drill	L.F.	1,300	-	$ 2,012,000.00	-	$ 2,459,111.11	$ 4,471,111.11
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 653.13	$ 653.13	$ 16,610.38	$ 16,610.38	$ 17,263.51
C19	Grading and Access Road	L.F.	20,012	$ 63.13	$ 1,263,357.56	$ 94.69	$ 1,894,936.28	$ 3,158,293.84
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 42,256.65	$ 42,256.65	$ 4,538,202.52	$ 4,538,202.52	$ 4,580,459.17
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 4,159,281.44	$ 4,159,281.44	$ 4,159,281.44
C22	Dewatering	L.S.	1	$ 879,583.93	$ 879,583.93	$ 1,468,010.85	$ 1,468,010.85	$ 2,347,594.78
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 957,287.20	$ 957,287.20	$ 957,287.20
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 532,361.56	$ 532,361.56	$ 532,361.56
				SUBTOTAL	**$ 30,003,290.00**		**$ 67,322,083.10**	**$ 97,325,373.10**
			CONTINGENCY	**20.00%**	**$ 6,000,658.00**		**$ 13,464,416.62**	**$ 19,465,074.62**
				TOTAL	**$ 36,003,948.00**		**$ 80,786,499.72**	**$ 116,790,447.72**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 50,376.60	$ 50,376.60	$ 957,155.40	$ 957,155.40	$ 1,007,532.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 539,240.80	$ 539,240.80	$ 10,245,575.20	$ 10,245,575.20	$ 10,784,816.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 10,434,627.88	$ 10,434,627.88	$ 10,434,627.88	$ 10,434,627.88	$ 20,869,255.76
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 11,024,245.28**		**$ 21,637,358.48**	**$ 32,661,603.76**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 76,899,853.36	$ 15,002,256.53	$ 91,902,109.88
CIVIL WORKS	LOT	$ 36,003,948.00	$ 80,786,499.72	$ 116,790,447.72
PROJECT OVERHEAD COSTS	LOT	$ 11,024,245.28	$ 21,637,358.48	$ 32,661,603.76
PROJECT TOTAL	**LOT**	**$ 123,928,046.64**	**$ 117,426,114.73**	**$ 241,354,161.36**
PROJECT TOTAL	**COST / MILE**	**$ 29,622,893.12**	**$ 28,068,716.82**	**$ 57,691,609.94**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route R1
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 22,089
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 4.19
NUMBER OF CABLES PER PHASE: 4
CHECKED BY Gustavo Constreras 12/2/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 5
NUMBER OF POWER CABLE DUCTS: 16
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 230 kV Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 22089-ft for a (1)-Circuit, (4)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (16)-8in power conduits with (5) smaller conduits with overall ductbank dimensions of 86-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (333)-total working days for duct bank trenching activities. (45)-total working days for splice vault installations. (60)-total working days for cable pulling. (132)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $1007532 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $10784816 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	230 kV		
PROJECT NAME:	Golden to Mars UG Route R1	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE		
ROUTE LENGTH (ft):	22,089	NUMBER OF CIRCUITS:	1	PREPARED BY Juan Morales	12/1/2024
ROUTE LENGTH (mile):	4.19	NUMBER OF CABLES PER PHASE:	4	CHECKED BY Gustavo Constreras	12/2/2024

POWER CABLE DUCT SIZE: 8 — NUMBER OF OTHER DUCTS: 5

NUMBER OF POWER CABLE DUCTS: 16 — TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 276348-ft, with an additional spare cable length of 2800-ft. The accessories to be installed include: (24)-230 kV Open Air Terminators, with (1)-Spare 230 kV Open Air Terminators. (108)-230 kV Cable Splice, with (1)-Spare 230 kV Cable Splice. (24)-230 kV Lightning Arrester, with (1)-Spare 230 kV
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.35% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2800-ft and standard splice vault spacing of 2400-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (120)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 20212-ft with an average duct bank depth of cover of 4.02 feet, with a further breakdown
CIV-2	A total of 8382-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 8367-Cubic Yards of rock were assumed for open cut trenching and 15-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 20212-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (16)-8-inch power conduits as well as (5)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 86-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 30690-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 197.01-linear feet. Surface restoration costs also included (0)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (18) splice vaults as well as excavation for (18) splice vaults. Assumed splice vault dimensions were: 10-ft width by 26-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (18)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in this
CIV-9	This cost estimate included material and installation for (11)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (16)-power conduits for (10)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (8)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 20274-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	This cost estimate included (4)-Jack & Bore with a total length of installation of 330-L.F.and an assumed bore diameter of 36-inches, including bore spacers and grouting. The assumed depth of bore sending and receiving pits were 30-feet below grade, with (0)pairs of sending and recieving pits.
CIV-14	This cost estimate included (4)-Horizontal Directional Drill with a total length of installation of 1300-L.F.and an assumed bore diameter of 36-inches, including bore spacers and grouting.
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 20012-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall route
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.55% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (432)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to C15 &
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route R1, 100%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 22,089
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 4.19
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 12/2/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	500 kV 5000 kcmil Cu XLPE Cable	L.F.	350,535	$ 265.25	$ 92,979,408.75	$ 25.47	$ 8,928,126.45	$ 101,907,535.20
U02	Spare 500 kV 5000 kcmil Cu XLPE Cable	L.F.	2,000	$ 265.25	$ 530,500.00	$ -	$ -	$ 530,500.00
U03	500 kV Open Air Terminators	EA.	30	$ 38,196.00	$ 1,145,880.00	$ 53,050.00	$ 1,591,500.00	$ 2,737,380.00
U04	Spare 500 kV Open Air Terminators	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U05	500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	500 kV Cable Splice	EA.	195	$ 41,379.00	$ 8,068,905.00	$ 53,050.00	$ 10,344,750.00	$ 18,413,655.00
U08	Spare 500 kV Cable Splice	EA.	1	$ 41,379.00	$ 41,379.00	$ -	$ -	$ 41,379.00
U09	500 kV Lightning Arrester	EA.	30	$ 7,427.00	$ 222,810.00	$ 3,713.50	$ 111,405.00	$ 334,215.00
U10	Spare 500 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	116,845	$ 12.74	$ 1,488,605.30	$ 8.49	$ 992,014.05	$ 2,480,619.35
U12	Link Box Without SVL's	EA.	70	$ 5,305.00	$ 371,350.00	$ 1,803.70	$ 126,259.00	$ 497,609.00
U13	Link Box With SVL's	EA.	70	$ 7,957.50	$ 557,025.00	$ 1,803.70	$ 126,259.00	$ 683,284.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
U16	Digital Temperature Monitoring System	EA.	1	$ 292,885.39	$ 292,885.39	$ 83,598.75	$ 83,598.75	$ 376,484.14
U17	Cable System Testing	L.S.	1	$ 177,043.98	$ 177,043.98	$ 730,046.05	$ 730,046.05	$ 907,090.03
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 2,220.64	$ 2,220.64	$ 56,844.30	$ 56,844.30	$ 59,064.94
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 451,550.54	$ 451,550.54	$ 451,550.54
				SUBTOTAL	**$ 105,923,636.06**		**$ 23,542,353.14**	**$ 129,465,989.20**
			CONTINGENCY	**20.00%**	**$ 21,184,727.21**		**$ 4,708,470.63**	**$ 25,893,197.84**
				TOTAL	**$ 127,108,363.27**		**$ 28,250,823.77**	**$ 155,359,187.04**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	19,920	$ 125.64	$ 2,502,775.82	$ 315.27	$ 6,279,996.86	$ 8,782,772.68
C02	Rock Excavation (Trench & Vault)	C.Y.	17,324	$ -	$ -	$ 203.56	$ 3,526,431.61	$ 3,526,431.61
C03a	Concrete Encased Duct Bank	L.F.	19,920	$ 1,335.16	$ 26,596,387.20	$ 2,626.12	$ 52,312,310.40	$ 78,908,697.60
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	67,282	$ 135.39	$ 9,109,079.26	$ 22.92	$ 1,542,064.82	$ 10,651,144.08
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	197	$ 642.86	$ 126,650.91	$ 328.63	$ 64,744.22	$ 191,395.13
C07	Splice Vault Material	EA.	39	$ 91,292.60	$ 3,560,411.40	$ -	$ -	$ 3,560,411.40
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	39	$ 28,117.22	$ 1,096,571.58	$ 49,728.08	$ 1,939,395.12	$ 3,035,966.70
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 219,326.24	$ 219,326.24	$ 219,326.25	$ 219,326.25	$ 438,652.49
C10	Communication Handholes	EA.	15	$ 7,810.77	$ 117,161.55	$ 11,716.15	$ 175,742.25	$ 292,903.80
C11	Conduit Proofing (Civil)	L.S.	1	$ 131,220.83	$ 131,220.83	$ 918,545.82	$ 918,545.82	$ 1,049,766.65
C12	Substation Termination Structures	EA.	10	$ 61,651.75	$ 616,517.50	$ 71,354.68	$ 713,546.80	$ 1,330,064.30
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 592,176.37	$ 592,176.37	$ 503,195.37	$ 503,195.37	$ 1,095,371.74
C15	Jack & Bore	L.F.	330	-	$ 236,125.00	-	$ 288,597.22	$ 524,722.22
C16	Horizontal Directional Drill	L.F.	1,300	-	$ 2,515,000.00	-	$ 3,073,888.89	$ 5,588,888.89
C17	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 783.75	$ 783.75	$ 19,932.45	$ 19,932.45	$ 20,716.20
C19	Grading and Access Road	L.F.	19,739	$ 63.13	$ 1,246,123.07	$ 94.69	$ 1,869,085.91	$ 3,115,208.98
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 41,646.16	$ 41,646.16	$ 6,366,514.16	$ 6,366,514.16	$ 6,408,160.32
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 5,993,067.44	$ 5,993,067.44	$ 5,993,067.44
C22	Dewatering	L.S.	1	$ 879,784.41	$ 879,784.41	$ 1,468,341.21	$ 1,468,341.21	$ 2,348,125.62
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 1,866,772.53	$ 1,866,772.53	$ 1,866,772.53
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 804,629.59	$ 804,629.59	$ 804,629.59
				SUBTOTAL	**$ 49,587,741.05**		**$ 89,946,128.92**	**$ 139,533,869.97**
			CONTINGENCY	**20.00%**	**$ 9,917,548.21**		**$ 17,989,225.78**	**$ 27,906,773.99**
				TOTAL	**$ 59,505,289.26**		**$ 107,935,354.71**	**$ 167,440,643.97**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 54,251.60	$ 54,251.60	$ 1,030,780.40	$ 1,030,780.40	$ 1,085,032.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 696,061.20	$ 696,061.20	$ 13,225,162.80	$ 13,225,162.80	$ 13,921,224.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 16,139,991.55	$ 16,139,991.55	$ 16,139,991.55	$ 16,139,991.55	$ 32,279,983.10
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 16,890,304.35**		**$ 30,395,934.75**	**$ 47,286,239.10**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 127,108,363.27	$ 28,250,823.77	$ 155,359,187.04
CIVIL WORKS	LOT	$ 59,505,289.26	$ 107,935,354.71	$ 167,440,643.97
PROJECT OVERHEAD COSTS	LOT	$ 16,890,304.35	$ 30,395,934.75	$ 47,286,239.10
PROJECT TOTAL	**LOT**	**$ 203,503,956.88**	**$ 166,582,113.22**	**$ 370,086,070.11**
PROJECT TOTAL	**COST / MILE**	**$ 48,644,161.91**	**$ 39,818,622.75**	**$ 88,462,784.65**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route R1, 100%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 22,089
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 4.19
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 12/2/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 500 kV Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 22089-ft for a (1)-Circuit, (5)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (20)-8in power conduits with (6) smaller conduits with overall ductbank dimensions of 206-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (328)-total working days for duct bank trenching activities. (98)-total working days for splice vault installations. (105)-total working days for cable pulling. (225)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $1085032 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $13921224 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	500 kV		
PROJECT NAME:	Golden to Mars UG Route R1, 100%DLF	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE		
ROUTE LENGTH (ft):	22,089	NUMBER OF CIRCUITS:	1	PREPARED BY Juan Morales	12/1/2024
ROUTE LENGTH (mile):	4.19	NUMBER OF CABLES PER PHASE:	5	CHECKED BY Gustavo Constreras	12/2/2024

POWER CABLE DUCT SIZE: 8 — NUMBER OF OTHER DUCTS: 6

NUMBER OF POWER CABLE DUCTS: 20 — TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 350535-ft, with an additional spare cable length of 2000-ft. The accessories to be installed include: (30)-500 kV Open Air Terminators, with (1)-Spare 500 kV Open Air Terminators. (195)-500 kV Cable Splice, with (1)-Spare 500 kV Cable Splice. (30)-500 kV Lightning Arrester, with (1)-Spare 500 kV
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.35% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 1700-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (210)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 19920-ft with an average duct bank depth of cover of 4.02 feet, with a further breakdown
CIV-2	A total of 17324-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 17292-Cubic Yards of rock were assumed for open cut trenching and 32-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 19920-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (20)-8-inch power conduits as well as (6)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 206-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 67282-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 197.01-linear feet. Surface restoration costs also included (0)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (39) splice vaults as well as excavation for (39) splice vaults. Assumed splice vault dimensions were: 15-ft width by 40-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (39)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in this
CIV-9	This cost estimate included material and installation for (15)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (20)-power conduits for (14)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (10)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 20274-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	This cost estimate included (5)-Jack & Bore with a total length of installation of 330-L.F.and an assumed bore diameter of 36-inches, including bore spacers and grouting. The assumed depth of bore sending and receiving pits were 30-feet below grade, with (0)pairs of sending and recieving pits.
CIV-14	This cost estimate included (5)-Horizontal Directional Drill with a total length of installation of 1300-L.F.and an assumed bore diameter of 36-inches, including bore spacers and grouting.
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 19739-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall route
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.58% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (1019)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to C15 &
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route R2
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 19,013
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 3.61
NUMBER OF CABLES PER PHASE: 4
CHECKED BY Gustavo Constreras 12/2/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	230 kV 5000 kcmil Cu XLPE Cable	L.F.	237,996	$ 212.20	$ 50,502,751.20	$ 25.47	$ 6,061,758.12	$ 56,564,509.32
U02	Spare 230 kV 5000 kcmil Cu XLPE Cable	L.F.	2,800	$ 212.20	$ 594,160.00	$ -	$ -	$ 594,160.00
U03	230 kV Open Air Terminators	EA.	24	$ 19,098.00	$ 458,352.00	$ 26,525.00	$ 636,600.00	$ 1,094,952.00
U04	Spare 230 kV Open Air Terminators	EA.	1	$ 19,098.00	$ 19,098.00	$ -	$ -	$ 19,098.00
U05	230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	230 kV Cable Splice	EA.	84	$ 20,689.50	$ 1,737,918.00	$ 26,525.00	$ 2,228,100.00	$ 3,966,018.00
U08	Spare 230 kV Cable Splice	EA.	1	$ 20,689.50	$ 20,689.50	$ -	$ -	$ 20,689.50
U09	230 kV Lightning Arrester	EA.	24	$ 7,427.00	$ 178,248.00	$ 3,713.50	$ 89,124.00	$ 267,372.00
U10	Spare 230 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	79,332	$ 12.74	$ 1,010,689.68	$ 8.49	$ 673,528.68	$ 1,684,218.36
U12	Link Box Without SVL's	EA.	32	$ 5,305.00	$ 169,760.00	$ 1,803.70	$ 57,718.40	$ 227,478.40
U13	Link Box With SVL's	EA.	32	$ 7,957.50	$ 254,640.00	$ 1,803.70	$ 57,718.40	$ 312,358.40
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	19,833	$ 4.34	$ 86,045.38	$ 5.42	$ 107,506.10	$ 193,551.48
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 124,972.22	$ 124,972.22	$ 519,509.52	$ 519,509.52	$ 644,481.74
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 12,801.35	$ 12,801.35	$ 327,690.67	$ 327,690.67	$ 340,492.02
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 230,778.82	$ 230,778.82	$ 230,778.82
				SUBTOTAL	**$ 55,177,552.33**		**$ 10,990,032.71**	**$ 66,167,585.04**
			CONTINGENCY	**20.00%**	**$ 11,035,510.47**		**$ 2,198,006.54**	**$ 13,233,517.01**
				TOTAL	**$ 66,213,062.80**		**$ 13,188,039.25**	**$ 79,401,102.05**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 5
NUMBER OF POWER CABLE DUCTS: 16
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	17,741	$ 180.02	$ 3,193,722.23	$ 319.90	$ 5,675,161.11	$ 8,868,883.34
C02	Rock Excavation (Trench & Vault)	C.Y.	7,939	$ -	$ -	$ 203.56	$ 1,616,060.95	$ 1,616,060.95
C03a	Concrete Encased Duct Bank	L.F.	17,741	$ 786.17	$ 13,947,441.97	$ 2,047.10	$ 36,317,601.10	$ 50,265,043.07
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	32,250	$ 135.39	$ 4,366,216.91	$ 22.92	$ 739,151.49	$ 5,105,368.40
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	3,577	$ 87.19	$ 311,876.19	$ 162.42	$ 580,957.37	$ 892,833.56
C07	Splice Vault Material	EA.	14	$ 75,671.08	$ 1,059,395.12	$ -	$ -	$ 1,059,395.12
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	14	$ 26,692.85	$ 373,699.90	$ 43,289.75	$ 606,056.50	$ 979,756.40
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 78,732.50	$ 78,732.50	$ 78,732.50	$ 78,732.50	$ 157,465.00
C10	Communication Handholes	EA.	9	$ 7,810.77	$ 70,296.93	$ 11,716.15	$ 105,445.35	$ 175,742.28
C11	Conduit Proofing (Civil)	L.S.	1	$ 59,986.67	$ 59,986.67	$ 419,906.66	$ 419,906.66	$ 479,893.33
C12	Substation Termination Structures	EA.	8	$ 31,170.30	$ 249,362.40	$ 35,999.98	$ 287,999.84	$ 537,362.24
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 420,465.66	$ 420,465.66	$ 357,527.87	$ 357,527.87	$ 777,993.53
C15	Jack & Bore R2_TC1	L.F.	330	-	$ 188,900.00	-	$ 230,877.78	$ 419,777.78
C16	Jack & Bore R2_TC6	L.F.	100	-	$ 85,400.00	-	$ 104,377.78	$ 189,777.78
C17	Guided Jack & Bore Route 606	L.F.	650	-	$ 332,900.00	-	$ 406,877.78	$ 739,777.78
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 11,756.25	$ 11,756.25	$ 298,986.75	$ 298,986.75	$ 310,743.00
C19	Grading and Access Road	L.F.	14,101	$ 63.13	$ 890,196.13	$ 94.69	$ 1,335,223.69	$ 2,225,419.82
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 37,090.47	$ 37,090.47	$ 4,003,693.16	$ 4,003,693.16	$ 4,040,783.63
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 3,671,097.88	$ 3,671,097.88	$ 3,671,097.88
C22	Dewatering	L.S.	1	$ 770,676.90	$ 770,676.90	$ 1,286,169.91	$ 1,286,169.91	$ 2,056,846.81
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 985,405.95	$ 985,405.95	$ 985,405.95
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 470,554.85	$ 470,554.85	$ 470,554.85
				SUBTOTAL	**$ 26,448,116.23**		**$ 59,577,866.26**	**$ 86,025,982.49**
			CONTINGENCY	**20.00%**	**$ 5,289,623.25**		**$ 11,915,573.25**	**$ 17,205,196.50**
				TOTAL	**$ 31,737,739.48**		**$ 71,493,439.52**	**$ 103,231,178.99**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 50,039.10	$ 50,039.10	$ 950,742.90	$ 950,742.90	$ 1,000,782.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 495,635.30	$ 495,635.30	$ 9,417,070.70	$ 9,417,070.70	$ 9,912,706.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 9,131,614.05	$ 9,131,614.05	$ 9,131,614.05	$ 9,131,614.05	$ 18,263,228.10
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 9,677,288.45**		**$ 19,499,427.65**	**$ 29,176,716.10**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 66,213,062.80	$ 13,188,039.25	$ 79,401,102.05
CIVIL WORKS	LOT	$ 31,737,739.48	$ 71,493,439.52	$ 103,231,178.99
PROJECT OVERHEAD COSTS	LOT	$ 9,677,288.45	$ 19,499,427.65	$ 29,176,716.10
PROJECT TOTAL	**LOT**	**$ 107,628,090.72**	**$ 104,180,906.42**	**$ 211,808,997.14**
PROJECT TOTAL	**COST / MILE**	**$ 29,888,829.70**	**$ 28,931,530.32**	**$ 58,820,360.01**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route R2
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 19,013
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 3.61
NUMBER OF CABLES PER PHASE: 4
CHECKED BY Gustavo Constreras 12/2/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 5
NUMBER OF POWER CABLE DUCTS: 16
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 230 kV Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 19013-ft for a (1)-Circuit, (4)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (16)-8in power conduits with (5) smaller conduits with overall ductbank dimensions of 86-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (340)-total working days for duct bank trenching activities. (35)-total working days for splice vault installations. (48)-total working days for cable pulling. (108)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $1000782 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $9912706 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	230 kV		
PROJECT NAME:	Golden to Mars UG Route R2	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE		
ROUTE LENGTH (ft):	19,013	NUMBER OF CIRCUITS:	1	PREPARED BY Juan Morales	12/1/2024
ROUTE LENGTH (mile):	3.61	NUMBER OF CABLES PER PHASE:	4	CHECKED BY Gustavo Constreras	12/2/2024

POWER CABLE DUCT SIZE: 8 — NUMBER OF OTHER DUCTS: 5

NUMBER OF POWER CABLE DUCTS: 16 — TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 237996-ft, with an additional spare cable length of 2800-ft. The accessories to be installed include: (24)-230 kV Open Air Terminators, with (1)-Spare 230 kV Open Air Terminators. (84)-230 kV Cable Splice, with (1)-Spare 230 kV Cable Splice. (24)-230 kV Lightning Arrester, with (1)-Spare 230 kV
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.35% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2800-ft and standard splice vault spacing of 2400-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (96)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 17741-ft with an average duct bank depth of cover of 5.01 feet, with a further breakdown
CIV-2	A total of 7939-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 7924-Cubic Yards of rock were assumed for open cut trenching and 15-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 17741-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (16)-8-inch power conduits as well as (5)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 86-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 32250-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 3576.82-linear feet. Surface restoration costs also included (2)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (14) splice vaults as well as excavation for (14) splice vaults. Assumed splice vault dimensions were: 10-ft width by 26-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (14)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in this
CIV-9	This cost estimate included material and installation for (9)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (16)-power conduits for (8)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (8)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 14500-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 14101-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall route
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.55% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (472)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to C15 &
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route R2, 100%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 19,013
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 3.61
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 12/2/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	500 kV 5000 kcmil Cu XLPE Cable	L.F.	300,795	$ 265.25	$ 79,785,873.75	$ 25.47	$ 7,661,248.65	$ 87,447,122.40
U02	Spare 500 kV 5000 kcmil Cu XLPE Cable	L.F.	2,000	$ 265.25	$ 530,500.00	$ -	$ -	$ 530,500.00
U03	500 kV Open Air Terminators	EA.	30	$ 38,196.00	$ 1,145,880.00	$ 53,050.00	$ 1,591,500.00	$ 2,737,380.00
U04	Spare 500 kV Open Air Terminators	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U05	500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	500 kV Cable Splice	EA.	135	$ 41,379.00	$ 5,586,165.00	$ 53,050.00	$ 7,161,750.00	$ 12,747,915.00
U08	Spare 500 kV Cable Splice	EA.	1	$ 41,379.00	$ 41,379.00	$ -	$ -	$ 41,379.00
U09	500 kV Lightning Arrester	EA.	30	$ 7,427.00	$ 222,810.00	$ 3,713.50	$ 111,405.00	$ 334,215.00
U10	Spare 500 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	100,265	$ 12.74	$ 1,277,376.10	$ 8.49	$ 851,249.85	$ 2,128,625.95
U12	Link Box Without SVL's	EA.	50	$ 5,305.00	$ 265,250.00	$ 1,803.70	$ 90,185.00	$ 355,435.00
U13	Link Box With SVL's	EA.	50	$ 7,957.50	$ 397,875.00	$ 1,803.70	$ 90,185.00	$ 488,060.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
U16	Digital Temperature Monitoring System	EA.	1	$ 278,498.94	$ 278,498.94	$ 76,456.30	$ 76,456.30	$ 354,955.24
U17	Cable System Testing	L.S.	1	$ 177,043.98	$ 177,043.98	$ 692,554.38	$ 692,554.38	$ 869,598.36
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 30,566.49	$ 30,566.49	$ 782,445.06	$ 782,445.06	$ 813,011.55
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 381,128.37	$ 381,128.37	$ 381,128.37
				SUBTOTAL	**$ 89,784,841.26**		**$ 19,490,107.61**	**$ 109,274,948.87**
			CONTINGENCY	**20.00%**	**$ 17,956,968.25**		**$ 3,898,021.52**	**$ 21,854,989.77**
				TOTAL	**$ 107,741,809.51**		**$ 23,388,129.13**	**$ 131,129,938.64**

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	17,560	$ 180.02	$ 3,161,124.59	$ 397.49	$ 6,979,757.26	$ 10,140,881.85
C02	Rock Excavation (Trench & Vault)	C.Y.	16,374	$ -	$ -	$ 203.56	$ 3,333,063.57	$ 3,333,063.57
C03a	Concrete Encased Duct Bank	L.F.	17,560	$ 1,335.16	$ 23,445,409.60	$ 2,626.12	$ 46,114,667.20	$ 69,560,076.80
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	71,007	$ 135.39	$ 9,613,394.23	$ 22.92	$ 1,627,439.68	$ 11,240,833.91
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	3,577	$ 119.65	$ 427,976.25	$ 331.57	$ 1,185,962.81	$ 1,613,939.06
C07	Splice Vault Material	EA.	27	$ 91,292.60	$ 2,464,900.20	$ -	$ -	$ 2,464,900.20
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	27	$ 28,117.22	$ 759,164.94	$ 49,728.08	$ 1,342,658.16	$ 2,101,823.10
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 151,841.25	$ 151,841.25	$ 151,841.25	$ 151,841.25	$ 303,682.50
C10	Communication Handholes	EA.	11	$ 7,810.77	$ 85,918.47	$ 11,716.15	$ 128,877.65	$ 214,796.12
C11	Conduit Proofing (Civil)	L.S.	1	$ 93,729.16	$ 93,729.16	$ 656,104.16	$ 656,104.16	$ 749,833.32
C12	Substation Termination Structures	EA.	10	$ 61,651.75	$ 616,517.50	$ 71,354.68	$ 713,546.80	$ 1,330,064.30
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 420,465.66	$ 420,465.66	$ 357,527.87	$ 357,527.87	$ 777,993.53
C15	Jack & Bore R2_TC1	L.F.	330	-	$ 236,125.00	-	$ 288,597.22	$ 524,722.22
C16	Jack & Bore R2_TC6	L.F.	100	-	$ 106,750.00	-	$ 130,472.22	$ 237,222.22
C17	Jack & Bore Route 606	L.F.	650	-	$ 416,125.00	-	$ 508,597.22	$ 924,722.22
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 12,540.00	$ 12,540.00	$ 318,919.20	$ 318,919.20	$ 331,459.20
C19	Grading and Access Road	L.F.	14,198	$ 63.13	$ 896,319.74	$ 94.69	$ 1,344,408.62	$ 2,240,728.36
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 36,712.05	$ 36,712.05	$ 5,634,079.39	$ 5,634,079.39	$ 5,670,791.44
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 5,304,877.46	$ 5,304,877.46	$ 5,304,877.46
C22	Dewatering	L.S.	1	$ 770,772.72	$ 770,772.72	$ 1,286,326.39	$ 1,286,326.39	$ 2,057,099.11
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 1,996,118.78	$ 1,996,118.78	$ 1,996,118.78
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 714,093.85	$ 714,093.85	$ 714,093.85
				SUBTOTAL	**$ 43,715,786.36**		**$ 80,117,936.77**	**$ 123,833,723.13**
			CONTINGENCY	**20.00%**	**$ 8,743,157.27**		**$ 16,023,587.35**	**$ 24,766,744.63**
				TOTAL	**$ 52,458,943.63**		**$ 96,141,524.12**	**$ 148,600,467.75**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 54,351.60	$ 54,351.60	$ 1,032,680.40	$ 1,032,680.40	$ 1,087,032.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 638,489.30	$ 638,489.30	$ 12,131,296.70	$ 12,131,296.70	$ 12,769,786.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 13,986,520.32	$ 13,986,520.32	$ 13,986,520.32	$ 13,986,520.32	$ 27,973,040.64
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 14,679,361.22**		**$ 27,150,497.42**	**$ 41,829,858.64**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 107,741,809.51	$ 23,388,129.13	$ 131,129,938.64
CIVIL WORKS	LOT	$ 52,458,943.63	$ 96,141,524.12	$ 148,600,467.75
PROJECT OVERHEAD COSTS	LOT	$ 14,679,361.22	$ 27,150,497.42	$ 41,829,858.64
PROJECT TOTAL	**LOT**	**$ 174,880,114.36**	**$ 146,680,150.67**	**$ 321,560,265.04**
PROJECT TOTAL	**COST / MILE**	**$ 48,565,034.65**	**$ 40,733,771.40**	**$ 89,298,806.05**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route R2, 100%DLF
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
ROUTE LENGTH (ft): 19,013
NUMBER OF CIRCUITS: 1
PREPARED BY Juan Morales 12/1/2024
ROUTE LENGTH (mile): 3.61
NUMBER OF CABLES PER PHASE: 5
CHECKED BY Gustavo Constreras 12/2/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF OTHER DUCTS: 6
NUMBER OF POWER CABLE DUCTS: 20
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 500 kV Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 19013-ft for a (1)-Circuit, (5)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (20)-8in power conduits with (6) smaller conduits with overall ductbank dimensions of 206-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (337)-total working days for duct bank trenching activities. (68)-total working days for splice vault installations. (75)-total working days for cable pulling. (165)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $1087032 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $12769786 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS:	500 kV		
PROJECT NAME:	Golden to Mars UG Route R2, 100%DLF	CABLE SIZE/TYPE:	5000 kcmil Cu XLPE		
ROUTE LENGTH (ft):	19,013	NUMBER OF CIRCUITS:	1	PREPARED BY Juan Morales	12/1/2024
ROUTE LENGTH (mile):	3.61	NUMBER OF CABLES PER PHASE:	5	CHECKED BY Gustavo Constreras	12/2/2024

POWER CABLE DUCT SIZE: 8 — NUMBER OF OTHER DUCTS: 6

NUMBER OF POWER CABLE DUCTS: 20 — TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 300795-ft, with an additional spare cable length of 2000-ft. The accessories to be installed include: (30)-500 kV Open Air Terminators, with (1)-Spare 500 kV Open Air Terminators. (135)-500 kV Cable Splice, with (1)-Spare 500 kV Cable Splice. (30)-500 kV Lightning Arrester, with (1)-Spare 500 kV
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.35% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 1700-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (150)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 17560-ft with an average duct bank depth of cover of 5.01 feet, with a further breakdown
CIV-2	A total of 16374-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 16342-Cubic Yards of rock were assumed for open cut trenching and 32-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 17560-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (20)-8-inch power conduits as well as (6)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 206-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 71007-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 3576.82-linear feet. Surface restoration costs also included (2)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (27) splice vaults as well as excavation for (27) splice vaults. Assumed splice vault dimensions were: 15-ft width by 40-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (27)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in this
CIV-9	This cost estimate included material and installation for (11)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (20)-power conduits for (10)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (10)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 14500-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 14198-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall route
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.58% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (1119)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to C15 &
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy

VOLTAGE CLASS: 230 kV

BURNS McDONNELL

PROJECT NAME: Golden to Mars UG Route R3
ROUTE LENGTH (ft): 23,987
ROUTE LENGTH (mile): 4.55

CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
NUMBER OF CIRCUITS: 1
NUMBER OF CABLES PER PHASE: 4

PREPARED BY Juan Morales 12/1/2024
CHECKED BY Gustavo Constreras 12/2/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	230 kV 5000 kcmil Cu XLPE Cable	L.F.	300,564	$ 212.20	$ 63,779,680.80	$ 25.47	$ 7,655,365.08	$ 71,435,045.88
U02	Spare 230 kV 5000 kcmil Cu XLPE Cable	L.F.	2,800	$ 212.20	$ 594,160.00	$ -	$ -	$ 594,160.00
U03	230 kV Open Air Terminators	EA.	24	$ 19,098.00	$ 458,352.00	$ 26,525.00	$ 636,600.00	$ 1,094,952.00
U04	Spare 230 kV Open Air Terminators	EA.	1	$ 19,098.00	$ 19,098.00	$ -	$ -	$ 19,098.00
U05	230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	230 kV Cable Splice	EA.	132	$ 20,689.50	$ 2,731,014.00	$ 26,525.00	$ 3,501,300.00	$ 6,232,314.00
U08	Spare 230 kV Cable Splice	EA.	1	$ 20,689.50	$ 20,689.50	$ -	$ -	$ 20,689.50
U09	230 kV Lightning Arrester	EA.	24	$ 7,427.00	$ 178,248.00	$ 3,713.50	$ 89,124.00	$ 267,372.00
U10	Spare 230 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	100,188	$ 12.74	$ 1,276,395.12	$ 8.49	$ 850,596.12	$ 2,126,991.24
U12	Link Box Without SVL's	EA.	48	$ 5,305.00	$ 254,640.00	$ 1,803.70	$ 86,577.60	$ 341,217.60
U13	Link Box With SVL's	EA.	48	$ 7,957.50	$ 381,960.00	$ 1,803.70	$ 86,577.60	$ 468,537.60
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	25,047	$ 4.34	$ 108,666.29	$ 5.42	$ 135,768.94	$ 244,435.23
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 124,972.22	$ 124,972.22	$ 549,502.85	$ 549,502.85	$ 674,475.07
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 91,568.83	$ 91,568.83	$ 2,343,991.39	$ 2,343,991.39	$ 2,435,560.22
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 257,886.83	$ 257,886.83	$ 257,886.83
				SUBTOTAL	**$ 70,026,871.76**		**$ 16,193,290.41**	**$ 86,220,162.17**
			CONTINGENCY	**20.00%**	**$ 14,005,374.35**		**$ 3,238,658.08**	**$ 17,244,032.43**
				TOTAL	**$ 84,032,246.11**		**$ 19,431,948.49**	**$ 103,464,194.60**

POWER CABLE DUCT SIZE: 8
NUMBER OF POWER CABLE DUCTS: 16

NUMBER OF OTHER DUCTS: 5
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	23,685	$ 217.08	$ 5,141,433.41	$ 373.64	$ 8,849,547.63	$ 13,990,981.04
C02	Rock Excavation (Trench & Vault)	C.Y.	11,050	$ -	$ -	$ 203.58	$ 2,249,501.39	$ 2,249,501.39
C03a	Concrete Encased Duct Bank	L.F.	23,685	$ 786.17	$ 18,620,436.45	$ 2,047.10	$ 48,485,563.50	$ 67,105,999.95
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	50,649	$ 135.39	$ 6,857,194.42	$ 22.92	$ 1,160,846.01	$ 8,018,040.43
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	21,180	$ 69.73	$ 1,476,878.94	$ 161.18	$ 3,413,703.09	$ 4,890,582.03
C07	Splice Vault Material	EA.	22	$ 75,671.08	$ 1,664,763.76	$ -	$ -	$ 1,664,763.76
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	22	$ 26,692.85	$ 587,242.70	$ 43,289.75	$ 952,374.50	$ 1,539,617.20
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 123,722.50	$ 123,722.50	$ 123,722.50	$ 123,722.50	$ 247,445.00
C10	Communication Handholes	EA.	13	$ 7,810.77	$ 101,540.01	$ 11,716.15	$ 152,309.95	$ 253,849.96
C11	Conduit Proofing (Civil)	L.S.	1	$ 89,980.00	$ 89,980.00	$ 629,859.99	$ 629,859.99	$ 719,839.99
C12	Substation Termination Structures	EA.	8	$ 31,170.30	$ 249,362.40	$ 35,999.98	$ 287,999.84	$ 537,362.24
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 85,049.73	$ 85,049.73	$ 72,028.11	$ 72,028.11	$ 157,077.84
C15	Trenchless Crossing not Constructible, Re-Routing Required	TBD	TBD	-	-	-	-	-
C16	Not Used	TBD	0	-	-	-	-	-
C17	Not Used	TBD	0	-	-	-	-	-
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 79,811.88	$ 79,811.88	$ 2,029,787.83	$ 2,029,787.83	$ 2,109,599.71
C19	Grading and Access Road	L.F.	2,505	$ 63.13	$ 158,140.65	$ 94.69	$ 237,198.45	$ 395,339.10
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 49,517.73	$ 49,517.73	$ 5,542,254.80	$ 5,542,254.80	$ 5,591,772.53
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 5,098,222.63	$ 5,098,222.63	$ 5,098,222.63
C22	Dewatering	L.S.	1	$ 1,020,740.14	$ 1,020,740.14	$ 1,700,479.92	$ 1,700,479.92	$ 2,721,220.06
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 1,523,723.79	$ 1,523,723.79	$ 1,523,723.79
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 475,259.75	$ 475,259.75	$ 475,259.75
				SUBTOTAL	**$ 36,305,814.72**		**$ 82,984,383.68**	**$ 119,290,198.40**
			CONTINGENCY	**20.00%**	**$ 7,261,162.94**		**$ 16,596,876.74**	**$ 23,858,039.68**
				TOTAL	**$ 43,566,977.66**		**$ 99,581,260.42**	**$ 143,148,238.08**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 49,820.35	$ 49,820.35	$ 946,586.65	$ 946,586.65	$ 996,407.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 419,971.55	$ 419,971.55	$ 7,979,459.45	$ 7,979,459.45	$ 8,399,431.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 12,330,621.63	$ 12,330,621.63	$ 12,330,621.63	$ 12,330,621.63	$ 24,661,243.26
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 12,800,413.53**		**$ 21,256,667.73**	**$ 34,057,081.26**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 84,032,246.11	$ 19,431,948.49	$ 103,464,194.60
CIVIL WORKS	LOT	$ 43,566,977.66	$ 99,581,260.42	$ 143,148,238.08
PROJECT OVERHEAD COSTS	LOT	$ 12,800,413.53	$ 21,256,667.73	$ 34,057,081.26
PROJECT TOTAL	**LOT**	**$ 140,399,637.31**	**$ 140,269,876.64**	**$ 280,669,513.94**
PROJECT TOTAL	**COST / MILE**	**$ 30,904,660.23**	**$ 30,876,097.41**	**$ 61,780,757.64**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy

VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route R3
ROUTE LENGTH (ft): 23,987
ROUTE LENGTH (mile): 4.55

CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
NUMBER OF CIRCUITS: 1
NUMBER OF CABLES PER PHASE: 4

PREPARED BY Juan Morales 12/1/2024
CHECKED BY Gustavo Constreras 12/2/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF POWER CABLE DUCTS: 16

NUMBER OF OTHER DUCTS: 5
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 230 kV Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 23987-ft for a (1)-Circuit, (4)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (16)-8in power conduits with (5) smaller conduits with overall ductbank dimensions of 86-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (564)-total working days for duct bank trenching activities. (55)-total working days for splice vault installations. (72)-total working days for cable pulling. (156)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $996407 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $8399431 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS: 230 kV			
PROJECT NAME:	Golden to Mars UG Route R3	CABLE SIZE/TYPE: 5000 kcmil Cu XLPE			
ROUTE LENGTH (ft):	23,987	NUMBER OF CIRCUITS: 1	PREPARED BY Juan Morales	12/1/2024	
ROUTE LENGTH (mile):	4.55	NUMBER OF CABLES PER PHASE: 4	CHECKED BY Gustavo Constreras	12/2/2024	

POWER CABLE DUCT SIZE: 8 — NUMBER OF OTHER DUCTS: 5

NUMBER OF POWER CABLE DUCTS: 16 — TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 300564-ft, with an additional spare cable length of 2800-ft. The accessories to be installed include: (24)-230 kV Open Air Terminators, with (1)-Spare 230 kV Open Air Terminators. (132)-230 kV Cable Splice, with (1)-Spare 230 kV Cable Splice. (24)-230 kV Lightning Arrester, with (1)-Spare 230 kV Lightning
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-days
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.3% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2800-ft and standard splice vault spacing of 2400-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (144)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 23685-ft with an average duct bank depth of cover of 6.07 feet, with a further breakdown
CIV-2	A total of 11050-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 11034-Cubic Yards of rock were assumed for open cut trenching and 15-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 23685-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (16)-8-inch power conduits as well as (5)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 86-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 50649-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 21180-linear feet. Surface restoration costs also included (7)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (22) splice vaults as well as excavation for (22) splice vaults. Assumed splice vault dimensions were: 10-ft width by 26-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (22)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in this
CIV-9	This cost estimate included material and installation for (13)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (16)-power conduits for (12)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (8)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 2807-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 2505-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall route
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.4% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (764)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to C15 &
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
PROJECT NAME: Golden to Mars UG Route R3, 100%DLF
ROUTE LENGTH (ft): 23,987
ROUTE LENGTH (mile): 4.55

VOLTAGE CLASS: 500 kV
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
NUMBER OF CIRCUITS: 1
NUMBER OF CABLES PER PHASE: 5

PREPARED BY Juan Morales 12/1/2024
CHECKED BY Gustavo Constreras 12/2/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	500 kV 5000 kcmil Cu XLPE Cable	L.F.	380,805	$ 265.25	$ 101,008,526.25	$ 25.47	$ 9,699,103.35	$ 110,707,629.60
U02	Spare 500 kV 5000 kcmil Cu XLPE Cable	L.F.	2,000	$ 265.25	$ 530,500.00	$ -	$ -	$ 530,500.00
U03	500 kV Open Air Terminators	EA.	30	$ 38,196.00	$ 1,145,880.00	$ 53,050.00	$ 1,591,500.00	$ 2,737,380.00
U04	Spare 500 kV Open Air Terminators	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U05	500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	500 kV Cable Splice	EA.	225	$ 41,379.00	$ 9,310,275.00	$ 53,050.00	$ 11,936,250.00	$ 21,246,525.00
U08	Spare 500 kV Cable Splice	EA.	1	$ 41,379.00	$ 41,379.00	$ -	$ -	$ 41,379.00
U09	500 kV Lightning Arrester	EA.	30	$ 7,427.00	$ 222,810.00	$ 3,713.50	$ 111,405.00	$ 334,215.00
U10	Spare 500 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	126,935	$ 12.74	$ 1,617,151.90	$ 8.49	$ 1,077,678.15	$ 2,694,830.05
U12	Link Box Without SVL's	EA.	80	$ 5,305.00	$ 424,400.00	$ 1,803.70	$ 144,296.00	$ 568,696.00
U13	Link Box With SVL's	EA.	80	$ 7,957.50	$ 636,600.00	$ 1,803.70	$ 144,296.00	$ 780,896.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
U16	Digital Temperature Monitoring System	EA.	1	$ 301,640.47	$ 301,640.47	$ 87,945.39	$ 87,945.39	$ 389,585.86
U17	Cable System Testing	L.S.	1	$ 177,043.98	$ 177,043.98	$ 748,791.88	$ 748,791.88	$ 925,835.86
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 233,820.55	$ 233,820.55	$ 5,985,370.31	$ 5,985,370.31	$ 6,219,190.86
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 441,666.86	$ 441,666.86	$ 441,666.86
				SUBTOTAL	**$ 115,695,650.15**		**$ 31,968,302.94**	**$ 147,663,953.09**
			CONTINGENCY	**20.00%**	**$ 23,139,130.03**		**$ 6,393,660.59**	**$ 29,532,790.62**
				TOTAL	**$ 138,834,780.18**		**$ 38,361,963.53**	**$ 177,196,743.71**

POWER CABLE DUCT SIZE: 8
NUMBER OF POWER CABLE DUCTS: 20

NUMBER OF OTHER DUCTS: 6
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	23,365	$ 217.08	$ 5,071,949.68	$ 457.88	$ 10,698,088.19	$ 15,770,037.87
C02	Rock Excavation (Trench & Vault)	C.Y.	22,545	$ -	$ -	$ 203.58	$ 4,589,699.13	$ 4,589,699.13
C03a	Concrete Encased Duct Bank	L.F.	23,365	$ 1,335.16	$ 31,196,013.40	$ 2,626.12	$ 61,359,293.80	$ 92,555,307.20
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	111,145	$ 135.39	$ 15,047,540.41	$ 22.92	$ 2,547,379.60	$ 17,594,920.01
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	21,180	$ 93.90	$ 1,988,723.57	$ 331.67	$ 7,024,711.03	$ 9,013,434.60
C07	Splice Vault Material	EA.	45	$ 91,292.60	$ 4,108,167.00	$ -	$ -	$ 4,108,167.00
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	45	$ 28,117.22	$ 1,265,274.90	$ 49,728.08	$ 2,237,763.60	$ 3,503,038.50
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 253,068.74	$ 253,068.74	$ 253,068.75	$ 253,068.75	$ 506,137.49
C10	Communication Handholes	EA.	17	$ 7,810.77	$ 132,783.09	$ 11,716.15	$ 199,174.55	$ 331,957.64
C11	Conduit Proofing (Civil)	L.S.	1	$ 149,966.66	$ 149,966.66	$ 1,049,766.65	$ 1,049,766.65	$ 1,199,733.31
C12	Substation Termination Structures	EA.	10	$ 61,651.75	$ 616,517.50	$ 71,354.68	$ 713,546.80	$ 1,330,064.30
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 85,049.73	$ 85,049.73	$ 72,028.11	$ 72,028.11	$ 157,077.84
C15	Trenchless Crossing not Constructible, Re-Routing Required	TBD	TBD	-	-	-	-	-
C16	Not Used	TBD	0	-	-	-	-	-
C17	Not Used	TBD	0	-	-	-	-	-
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 92,090.63	$ 92,090.63	$ 2,342,062.88	$ 2,342,062.88	$ 2,434,153.51
C19	Grading and Access Road	L.F.	2,734	$ 63.13	$ 172,597.42	$ 94.69	$ 258,882.46	$ 431,479.88
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 48,848.70	$ 48,848.70	$ 7,972,743.06	$ 7,972,743.06	$ 8,021,591.76
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 7,534,710.18	$ 7,534,710.18	$ 7,534,710.18
C22	Dewatering	L.S.	1	$ 1,020,940.63	$ 1,020,940.63	$ 1,700,810.28	$ 1,700,810.28	$ 2,721,750.91
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 3,142,426.46	$ 3,142,426.46	$ 3,142,426.46
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 699,782.75	$ 699,782.75	$ 699,782.75
				SUBTOTAL	**$ 61,249,532.06**		**$ 114,395,938.28**	**$ 175,645,470.34**
			CONTINGENCY	**20.00%**	**$ 12,249,906.41**		**$ 22,879,187.66**	**$ 35,129,094.07**
				TOTAL	**$ 73,499,438.47**		**$ 137,275,125.94**	**$ 210,774,564.41**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 52,470.35	$ 52,470.35	$ 996,936.65	$ 996,936.65	$ 1,049,407.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 548,865.90	$ 548,865.90	$ 10,428,452.10	$ 10,428,452.10	$ 10,977,318.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 19,398,565.41	$ 19,398,565.41	$ 19,398,565.41	$ 19,398,565.41	$ 38,797,130.82
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 19,999,901.66**		**$ 30,823,954.16**	**$ 50,823,855.82**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 138,834,780.18	$ 38,361,963.53	$ 177,196,743.71
CIVIL WORKS	LOT	$ 73,499,438.47	$ 137,275,125.94	$ 210,774,564.41
PROJECT OVERHEAD COSTS	LOT	$ 19,999,901.66	$ 30,823,954.16	$ 50,823,855.82
PROJECT TOTAL	**LOT**	**$ 232,334,120.31**	**$ 206,461,043.62**	**$ 438,795,163.94**
PROJECT TOTAL	**COST / MILE**	**$ 51,141,207.96**	**$ 45,446,046.21**	**$ 96,587,254.16**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy

VOLTAGE CLASS: 500 kV

PROJECT NAME: Golden to Mars UG Route R3, 100%DLF
ROUTE LENGTH (ft): 23,987
ROUTE LENGTH (mile): 4.55

CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
NUMBER OF CIRCUITS: 1
NUMBER OF CABLES PER PHASE: 5

PREPARED BY Juan Morales 12/1/2024
CHECKED BY Gustavo Constreras 12/2/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF POWER CABLE DUCTS: 20

NUMBER OF OTHER DUCTS: 6
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 500 kV Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 23987-ft for a (1)-Circuit, (5)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (20)-8in power conduits with (6) smaller conduits with overall ductbank dimensions of 206-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (557)-total working days for duct bank trenching activities. (113)-total working days for splice vault installations. (120)-total working days for cable pulling. (255)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $1049407 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $10977318 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS: 500 kV			
PROJECT NAME:	Golden to Mars UG Route R3, 100%DLF	CABLE SIZE/TYPE: 5000 kcmil Cu XLPE			
ROUTE LENGTH (ft):	23,987	NUMBER OF CIRCUITS: 1	PREPARED BY Juan Morales	12/1/2024	
ROUTE LENGTH (mile):	4.55	NUMBER OF CABLES PER PHASE: 5	CHECKED BY Gustavo Constreras	12/2/2024	

POWER CABLE DUCT SIZE: 8 — NUMBER OF OTHER DUCTS: 6

NUMBER OF POWER CABLE DUCTS: 20 — TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 380805-ft, with an additional spare cable length of 2000-ft. The accessories to be installed include: (30)-500 kV Open Air Terminators, with (1)-Spare 500 kV Open Air Terminators. (225)-500 kV Cable Splice, with (1)-Spare 500 kV Cable Splice. (30)-500 kV Lightning Arrester, with (1)-Spare 500 kV
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.3% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 1700-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (240)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 23365-ft with an average duct bank depth of cover of 6.07 feet, with a further breakdown
CIV-2	A total of 22545-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 22513-Cubic Yards of rock were assumed for open cut trenching and 32-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 23365-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (20)-8-inch power conduits as well as (6)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 206-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 111145-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 21180-linear feet. Surface restoration costs also included (7)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (45) splice vaults as well as excavation for (45) splice vaults. Assumed splice vault dimensions were: 15-ft width by 40-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (45)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in
CIV-9	This cost estimate included material and installation for (17)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (20)-power conduits for (16)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (10)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 2807-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 2734-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall route
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 0.4% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (1804)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to C15
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy

VOLTAGE CLASS: 230 kV

BURNS McDONNELL

PROJECT NAME: Golden to Mars UG Route R4
ROUTE LENGTH (ft): 8,284
ROUTE LENGTH (mile): 1.57

CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
NUMBER OF CIRCUITS: 1
NUMBER OF CABLES PER PHASE: 4

PREPARED BY Juan Morales 12/1/2024
CHECKED BY Gustavo Constreras 12/2/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	230 kV 5000 kcmil Cu XLPE Cable	L.F.	106,368	$ 212.20	$ 22,571,289.60	$ 25.47	$ 2,709,192.96	$ 25,280,482.56
U02	Spare 230 kV 5000 kcmil Cu XLPE Cable	L.F.	2,800	$ 212.20	$ 594,160.00	$ -	$ -	$ 594,160.00
U03	230 kV Open Air Terminators	EA.	24	$ 19,098.00	$ 458,352.00	$ 26,525.00	$ 636,600.00	$ 1,094,952.00
U04	Spare 230 kV Open Air Terminators	EA.	1	$ 19,098.00	$ 19,098.00	$ -	$ -	$ 19,098.00
U05	230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 230 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	230 kV Cable Splice	EA.	36	$ 20,689.50	$ 744,822.00	$ 26,525.00	$ 954,900.00	$ 1,699,722.00
U08	Spare 230 kV Cable Splice	EA.	1	$ 20,689.50	$ 20,689.50	$ -	$ -	$ 20,689.50
U09	230 kV Lightning Arrester	EA.	24	$ 7,427.00	$ 178,248.00	$ 3,713.50	$ 89,124.00	$ 267,372.00
U10	Spare 230 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	35,456	$ 12.74	$ 451,709.44	$ 8.49	$ 301,021.44	$ 752,730.88
U12	Link Box Without SVL's	EA.	16	$ 5,305.00	$ 84,880.00	$ 1,803.70	$ 28,859.20	$ 113,739.20
U13	Link Box With SVL's	EA.	16	$ 7,957.50	$ 127,320.00	$ 1,803.70	$ 28,859.20	$ 156,179.20
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Fiber Optic/Communications System	L.F.	8,864	$ 4.34	$ 38,456.42	$ 5.42	$ 48,047.91	$ 86,504.33
U16	Digital Temperature Monitoring System	EA.	0	$ -	$ -	$ -	$ -	$ -
U17	Cable System Testing	L.S.	1	$ 124,972.22	$ 124,972.22	$ 489,516.18	$ 489,516.18	$ 614,488.40
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 6,531.30	$ 6,531.30	$ 167,189.11	$ 167,189.11	$ 173,720.41
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 247,050.12	$ 247,050.12	$ 247,050.12
				SUBTOTAL	**$ 25,427,955.48**		**$ 5,700,360.12**	**$ 31,128,315.60**
			CONTINGENCY	**20.00%**	**$ 5,085,591.10**		**$ 1,140,072.02**	**$ 6,225,663.12**
				TOTAL	**$ 30,513,546.58**		**$ 6,840,432.14**	**$ 37,353,978.72**

POWER CABLE DUCT SIZE: 8
NUMBER OF POWER CABLE DUCTS: 16

NUMBER OF OTHER DUCTS: 5
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	8,202	$ 180.02	$ 1,476,465.37	$ 319.92	$ 2,623,812.40	$ 4,100,277.77
C02	Rock Excavation (Trench & Vault)	C.Y.	3,669	$ -	$ -	$ 203.48	$ 746,639.51	$ 746,639.51
C03a	Concrete Encased Duct Bank	L.F.	8,202	$ 786.17	$ 6,448,166.34	$ 2,047.10	$ 16,790,314.20	$ 23,238,480.54
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	14,910	$ 135.39	$ 2,018,613.77	$ 22.92	$ 341,728.64	$ 2,360,342.41
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	1,890	$ 103.92	$ 196,416.32	$ 158.02	$ 298,664.50	$ 495,080.82
C07	Splice Vault Material	EA.	6	$ 75,671.08	$ 454,026.48	$ -	$ -	$ 454,026.48
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	6	$ 26,692.85	$ 160,157.10	$ 43,289.75	$ 259,738.50	$ 419,895.60
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 33,742.50	$ 33,742.50	$ 33,742.50	$ 33,742.50	$ 67,485.00
C10	Communication Handholes	EA.	5	$ 7,810.77	$ 39,053.85	$ 11,716.15	$ 58,580.75	$ 97,634.60
C11	Conduit Proofing (Civil)	L.S.	1	$ 29,993.34	$ 29,993.34	$ 209,953.33	$ 209,953.33	$ 239,946.67
C12	Substation Termination Structures	EA.	8	$ 31,170.30	$ 249,362.40	$ 35,999.98	$ 287,999.84	$ 537,362.24
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 187,418.17	$ 187,418.17	$ 159,204.68	$ 159,204.68	$ 346,622.85
C15	Trenchless Crossing not Constructible, Re-Routing Required	TBD	TBD	-	-	-	-	-
C16	Not Used	TBD	0	-	-	-	-	-
C17	Not Used	TBD	0	-	-	-	-	-
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 5,747.50	$ 5,747.50	$ 146,171.30	$ 146,171.30	$ 151,918.80
C19	Grading and Access Road	L.F.	6,312	$ 63.13	$ 398,476.56	$ 94.69	$ 597,683.28	$ 996,159.84
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 17,147.07	$ 17,147.07	$ 1,834,773.48	$ 1,834,773.48	$ 1,851,920.55
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 1,681,013.43	$ 1,681,013.43	$ 1,681,013.43
C22	Dewatering	L.S.	1	$ 366,488.44	$ 366,488.44	$ 614,730.37	$ 614,730.37	$ 981,218.81
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 460,210.20	$ 460,210.20	$ 460,210.20
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 392,262.36	$ 392,262.36	$ 392,262.36
				SUBTOTAL	**$ 12,081,275.21**		**$ 27,537,223.27**	**$ 39,618,498.48**
			CONTINGENCY	**20.00%**	**$ 2,416,255.04**		**$ 5,507,444.65**	**$ 7,923,699.70**
				TOTAL	**$ 14,497,530.25**		**$ 33,044,667.92**	**$ 47,542,198.18**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 32,020.35	$ 32,020.35	$ 608,386.65	$ 608,386.65	$ 640,407.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 145,038.75	$ 145,038.75	$ 2,755,736.25	$ 2,755,736.25	$ 2,900,775.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 4,244,808.85	$ 4,244,808.85	$ 4,244,808.85	$ 4,244,808.85	$ 8,489,617.70
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 4,421,867.95**		**$ 7,608,931.75**	**$ 12,030,799.70**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 30,513,546.58	$ 6,840,432.14	$ 37,353,978.72
CIVIL WORKS	LOT	$ 14,497,530.25	$ 33,044,667.92	$ 47,542,198.18
PROJECT OVERHEAD COSTS	LOT	$ 4,421,867.95	$ 7,608,931.75	$ 12,030,799.70
PROJECT TOTAL	**LOT**	**$ 49,432,944.78**	**$ 47,494,031.82**	**$ 96,926,976.60**
PROJECT TOTAL	**COST / MILE**	**$ 31,507,236.65**	**$ 30,271,425.40**	**$ 61,778,662.05**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy

VOLTAGE CLASS: 230 kV

PROJECT NAME: Golden to Mars UG Route R4
ROUTE LENGTH (ft): 8,284
ROUTE LENGTH (mile): 1.57

CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
NUMBER OF CIRCUITS: 1
NUMBER OF CABLES PER PHASE: 4

PREPARED BY Juan Morales 12/1/2024
CHECKED BY Gustavo Constreras 12/2/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF POWER CABLE DUCTS: 16

NUMBER OF OTHER DUCTS: 5
TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 230 kV Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 8284-ft for a (1)-Circuit, (4)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (16)-8in power conduits with (5) smaller conduits with overall ductbank dimensions of 86-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (158)-total working days for duct bank trenching activities. (15)-total working days for splice vault installations. (24)-total working days for cable pulling. (60)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $640407 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $2900775 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS: 230 kV			
PROJECT NAME:	Golden to Mars UG Route R4	CABLE SIZE/TYPE: 5000 kcmil Cu XLPE			
ROUTE LENGTH (ft):	8,284	NUMBER OF CIRCUITS: 1	PREPARED BY Juan Morales	12/1/2024	
ROUTE LENGTH (mile):	1.57	NUMBER OF CABLES PER PHASE: 4	CHECKED BY Gustavo Constreras	12/2/2024	

POWER CABLE DUCT SIZE: 8 — NUMBER OF OTHER DUCTS: 5

NUMBER OF POWER CABLE DUCTS: 16 — TYPICAL DUCT BANK DIMENSIONS: 86-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 106368-ft, with an additional spare cable length of 2800-ft. The accessories to be installed include: (24)-230 kV Open Air Terminators, with (1)-Spare 230 kV Open Air Terminators. (36)-230 kV Cable Splice, with (1)-Spare 230 kV Cable Splice. (24)-230 kV Lightning Arrester, with (1)-Spare 230 kV Lightning
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-days
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.8% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2800-ft and standard splice vault spacing of 2400-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (48)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 8202-ft with an average duct bank depth of cover of 5.01 feet, with a further breakdown
CIV-2	A total of 3669-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 3654-Cubic Yards of rock were assumed for open cut trenching and 15-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 8202-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (16)-8-inch power conduits as well as (5)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 86-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 14910-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 1890-linear feet. Surface restoration costs also included (0)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (6) splice vaults as well as excavation for (6) splice vaults. Assumed splice vault dimensions were: 10-ft width by 26-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (6)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in this
CIV-9	This cost estimate included material and installation for (5)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (16)-power conduits for (4)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (8)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 6394-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 6312-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall route
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 1% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (219)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to C15 &
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME: Dominion Energy
Golden to Mars UG Route R4,
PROJECT NAME: 100%DLF
ROUTE LENGTH (ft): 8,284
ROUTE LENGTH (mile): 1.57

VOLTAGE CLASS: 500 kV
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
NUMBER OF CIRCUITS: 1
NUMBER OF CABLES PER PHASE: 5

BURNS McDONNELL

PREPARED BY Juan Morales 12/1/2024
CHECKED BY Gustavo Constreras 12/2/2024

UNDERGROUND CABLE SYSTEM & ACCESSORIES

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
U01	500 kV 5000 kcmil Cu XLPE Cable	L.F.	136,260	$ 265.25	$ 36,142,965.00	$ 25.47	$ 3,470,542.20	$ 39,613,507.20
U02	Spare 500 kV 5000 kcmil Cu XLPE Cable	L.F.	2,000	$ 265.25	$ 530,500.00	$ -	$ -	$ 530,500.00
U03	500 kV Open Air Terminators	EA.	30	$ 38,196.00	$ 1,145,880.00	$ 53,050.00	$ 1,591,500.00	$ 2,737,380.00
U04	Spare 500 kV Open Air Terminators	EA.	1	$ 38,196.00	$ 38,196.00	$ -	$ -	$ 38,196.00
U05	500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U06	Spare 500 kV GIS Terminators	EA.	0	$ -	$ -	$ -	$ -	$ -
U07	500 kV Cable Splice	EA.	75	$ 41,379.00	$ 3,103,425.00	$ 53,050.00	$ 3,978,750.00	$ 7,082,175.00
U08	Spare 500 kV Cable Splice	EA.	1	$ 41,379.00	$ 41,379.00	$ -	$ -	$ 41,379.00
U09	500 kV Lightning Arrester	EA.	30	$ 7,427.00	$ 222,810.00	$ 3,713.50	$ 111,405.00	$ 334,215.00
U10	Spare 500 kV Lightning Arrester	EA.	1	$ 7,427.00	$ 7,427.00	$ -	$ -	$ 7,427.00
U11	Ground Continuity Conductor (Installed in Conduit)	L.F.	45,420	$ 12.74	$ 578,650.80	$ 8.49	$ 385,615.80	$ 964,266.60
U12	Link Box Without SVL's	EA.	30	$ 5,305.00	$ 159,150.00	$ 1,803.70	$ 54,111.00	$ 213,261.00
U13	Link Box With SVL's	EA.	30	$ 7,957.50	$ 238,725.00	$ 1,803.70	$ 54,111.00	$ 292,836.00
U14	Combination Link Box	EA.	0	$ -	$ -	$ -	$ -	$ -
U15	Not Used	TBD	0	$ -	$ -	$ -	$ -	$ -
U16	Digital Temperature Monitoring System	EA.	1	$ 230,909.99	$ 230,909.99	$ 52,829.79	$ 52,829.79	$ 283,739.78
U17	Cable System Testing	L.S.	1	$ 177,043.98	$ 177,043.98	$ 655,062.72	$ 655,062.72	$ 832,106.70
U18	Traffic Control, Flagger & Police (Cable System)	L.S.	1	$ 20,247.03	$ 20,247.03	$ 518,286.26	$ 518,286.26	$ 538,533.29
U19	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U20	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
U21	Admin / Mob / De-Mob by Contractor (Electrical)	L.S.	1	$ -	$ -	$ 428,076.18	$ 428,076.18	$ 428,076.18
				SUBTOTAL	**$ 42,637,308.80**		**$ 11,300,289.95**	**$ 53,937,598.75**
			CONTINGENCY	**20.00%**	**$ 8,527,461.76**		**$ 2,260,057.99**	**$ 10,787,519.75**
				TOTAL	**$ 51,164,770.56**		**$ 13,560,347.94**	**$ 64,725,118.50**

POWER CABLE DUCT SIZE: 8
NUMBER OF POWER CABLE DUCTS: 20

NUMBER OF OTHER DUCTS: 6
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

CIVIL WORKS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
C01	Trench Excavation	L.F.	8,077	$ 180.02	$ 1,453,932.28	$ 397.54	$ 3,210,720.50	$ 4,664,652.78
C02	Rock Excavation (Trench & Vault)	C.Y.	7,528	$ -	$ -	$ 203.48	$ 1,531,884.79	$ 1,531,884.79
C03a	Concrete Encased Duct Bank	L.F.	8,077	$ 1,335.16	$ 10,784,087.32	$ 2,626.12	$ 21,211,171.24	$ 31,995,258.56
C03b	Concrete Encased Duct Bank	L.F.	0	$ -	$ -	$ -	$ -	$ -
C04	Fluidized Thermal Backfill	C.Y.	32,660	$ 135.39	$ 4,421,725.40	$ 22.92	$ 748,548.45	$ 5,170,273.85
C05	Native Soil Backfill	C.Y.	0	$ -	$ -	$ -	$ -	$ -
C06	Pavement Restoration, Traffic Signal Repair and Temporary Steel Plating	L.F.	1,890	$ 145.70	$ 275,365.12	$ 328.82	$ 621,475.73	$ 896,840.85
C07	Splice Vault Material	EA.	15	$ 91,292.60	$ 1,369,389.00	$ -	$ -	$ 1,369,389.00
C07a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C08	Splice Vault Excavation	EA.	15	$ 28,117.22	$ 421,758.30	$ 49,728.08	$ 745,921.20	$ 1,167,679.50
C08a	Not Used	NA.	0	$ -	$ -	$ -	$ -	$ -
C09	Grounding System (Civil)	L.S.	1	$ 84,356.25	$ 84,356.25	$ 84,356.25	$ 84,356.25	$ 168,712.50
C10	Communication Handholes	EA.	7	$ 7,810.77	$ 54,675.39	$ 11,716.15	$ 82,013.05	$ 136,688.44
C11	Conduit Proofing (Civil)	L.S.	1	$ 56,237.49	$ 56,237.49	$ 393,662.50	$ 393,662.50	$ 449,899.99
C12	Substation Termination Structures	EA.	10	$ 61,651.75	$ 616,517.50	$ 71,354.68	$ 713,546.80	$ 1,330,064.30
C13	OH to UG Termination Structures	EA.	0	$ -	$ -	$ -	$ -	$ -
C14	Clearing/Grubbing and Loam/Seed	L.S.	1	$ 187,418.17	$ 187,418.17	$ 159,204.68	$ 159,204.68	$ 346,622.85
C15	Trenchless Crossing not Constructible, Re-Routing Required	TBD	TBD	-	-	-	-	-
C16	Not Used	TBD	0	-	-	-	-	-
C17	Not Used	TBD	0	-	-	-	-	-
C18	Traffic Control, Flagger & Police (Civil)	L.S.	1	$ 7,184.38	$ 7,184.38	$ 182,714.13	$ 182,714.13	$ 189,898.51
C19	Grading and Access Road	L.F.	6,234	$ 63.13	$ 393,552.42	$ 94.69	$ 590,297.46	$ 983,849.88
C20	Contaminated Material Testing & Disposal	L.S.	1	$ 16,885.73	$ 16,885.73	$ 2,625,031.99	$ 2,625,031.99	$ 2,641,917.72
C21	Utility Protection and Relocation (known and unknown)	L.S.	1	$ -	$ -	$ 2,473,615.41	$ 2,473,615.41	$ 2,473,615.41
C22	Dewatering	L.S.	1	$ 366,584.25	$ 366,584.25	$ 614,886.86	$ 614,886.86	$ 981,471.11
C23	Thermal Resistivity Testing	L.S.	1	$ -	$ -	$ 922,607.41	$ 922,607.41	$ 922,607.41
C24	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C25	Other (Provide a Description)	TBD	0	$ -	$ -	$ -	$ -	$ -
C26	Admin/Mob/De-Mob by Contractor (Civil)	L.S.	1	$ -	$ -	$ 574,213.27	$ 574,213.27	$ 574,213.27
				SUBTOTAL	**$ 20,509,669.00**		**$ 37,485,871.72**	**$ 57,995,540.72**
			CONTINGENCY	**20.00%**	**$ 4,101,933.80**		**$ 7,497,174.34**	**$ 11,599,108.14**
				TOTAL	**$ 24,611,602.80**		**$ 44,983,046.06**	**$ 69,594,648.86**

PROJECT OVERHEAD COSTS

ITEM NO.	ITEM	UNIT	QUANTITY	MATERIAL UNIT PRICE ($USD)	MATERIAL COST ($USD)	LABOR UNIT PRICE ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
P01	Design Engineering	L.S.	1	$ 33,370.35	$ 33,370.35	$ 634,036.65	$ 634,036.65	$ 667,407.00
P02	Engineering Support During Construction	NA.	0	$ -	$ -	$ -	$ -	$ -
P03	Utility SUE Survey & Topographic Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P04	Utility Test Hole Survey	NA.	0	$ -	$ -	$ -	$ -	$ -
P05	Geotechnical Investigation and Report	NA.	0	$ -	$ -	$ -	$ -	$ -
P06	Traffic Control Design	NA.	0	$ -	$ -	$ -	$ -	$ -
P07	Construction Management	L.S.	1	$ 189,552.90	$ 189,552.90	$ 3,601,505.10	$ 3,601,505.10	$ 3,791,058.00
P08	Site Laydown Yards	NA.	0	$ -	$ -	$ -	$ -	$ -
P09	Environmental Survey, Services and Permitting Support	NA.	0	$ -	$ -	$ -	$ -	$ -
P10	Environmental Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P11	Construction Permits	NA.	0	$ -	$ -	$ -	$ -	$ -
P12	Real Estate / Land Costs	NA.	0	$ -	$ -	$ -	$ -	$ -
P13	Contractor Markup and Profit	L.S.	1	$ 6,715,988.37	$ 6,715,988.37	$ 6,715,988.37	$ 6,715,988.37	$ 13,431,976.74
P14	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P15	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P16	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P17	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
P18	TBD	NA.	0	$ -	$ -	$ -	$ -	$ -
				TOTAL	**$ 6,938,911.62**		**$ 10,951,530.12**	**$ 17,890,441.74**

SUMMARY OF COSTS	UNIT	MATERIAL COST ($USD)	LABOR COST ($USD)	TOTAL COST ($USD)
UNDERGROUND CABLE SYSTEM & ACCESSORIES	LOT	$ 51,164,770.56	$ 13,560,347.94	$ 64,725,118.50
CIVIL WORKS	LOT	$ 24,611,602.80	$ 44,983,046.06	$ 69,594,648.86
PROJECT OVERHEAD COSTS	LOT	$ 6,938,911.62	$ 10,951,530.12	$ 17,890,441.74
PROJECT TOTAL	**LOT**	**$ 82,715,284.98**	**$ 69,494,924.12**	**$ 152,210,209.10**
PROJECT TOTAL	**COST / MILE**	**$ 52,720,509.98**	**$ 44,294,205.62**	**$ 97,014,715.60**

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

PROJECTED ESTIMATE OF PROJECT COST

CLIENT NAME: Dominion Energy
PROJECT NAME: Golden to Mars UG Route R4, 100%DLF
ROUTE LENGTH (ft): 8,284
ROUTE LENGTH (mile): 1.57

VOLTAGE CLASS: 500 kV
CABLE SIZE/TYPE: 5000 kcmil Cu XLPE
NUMBER OF CIRCUITS: 1
NUMBER OF CABLES PER PHASE: 5

PREPARED BY Juan Morales 12/1/2024
CHECKED BY Gustavo Constreras 12/2/2024

POWER CABLE DUCT SIZE: 8
NUMBER OF POWER CABLE DUCTS: 20

NUMBER OF OTHER DUCTS: 6
TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

GENERAL PROJECT SUMMARY

GEN-1	The 500 kV Project being estimated for Dominion Energy by Burns & McDonnell includes an overall route installation length of 8284-ft for a (1)-Circuit, (5)-cables per phase cable system. The estimated was prepared based upon a ductbank composed of (20)-8in power conduits with (6) smaller conduits with overall ductbank dimensions of 206-in Wide X 87-in High. Unit Costs based upon 3% Escalation, Per Year from 2024 to 2026 for a Total of 6.1% Escalation. Unit Costs include an assumed 6% Tax. Unit Costs based upon an RSMeans combined city cost index of 0.926.
GEN-2	This cost estimate included 20% contingency for the cable system. This cost estimate included 20% contingency for the civil system. These contingency values represent project 'known unknowns' and should be adjusted based upon the level of field investigation and design completed for the Project.
GEN-3	This cost estimate was prepared based upon the following assumed durations: (155)-total working days for duct bank trenching activities. (38)-total working days for splice vault installations. (45)-total working days for cable pulling. (105)-total working days for cable splicing.
GEN-4	This cost estimate is an AACE class 5 estimate, with a range of -50% to 100%

PROJECT OVERHEAD COSTS SUMMARY

PR OH-1	The Design Engineering was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $667407 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-2	NA.
PR OH-3	NA.
PR OH-4	NA.
PR OH-5	NA.
PR OH-6	NA.
PR OH-7	The Construction Management was estimated based upon the following assumptions: The costs were MANUAL ENTERED based upon a total lump sum of $3791058 of pre-contingency overall project costs. This was assumed with an overall 5% material precentage to 95% labor percentage.
PR OH-8	NA.
PR OH-9	NA.
PR OH-10	NA.
PR OH-11	NA.
PR OH-12	NA.
PR OH-13	Contractor Markup and Profit was estimated based upon the following assumptions: The costs were PERCENTAGE based upon 10% of pre-contingency overall project costs. This was assumed with an overall 50% material percentage to 50% labor percentage.
PR OH-14	NA.
PR OH-15	NA.
PR OH-16	NA.
PR OH-17	NA.
PR OH-18	NA.
PR OH-19	AFUDC / Client costs are not included.

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

CLIENT NAME:	Dominion Energy	VOLTAGE CLASS: 500 kV			
PROJECT NAME:	Golden to Mars UG Route R4, 100%DLF	CABLE SIZE/TYPE: 5000 kcmil Cu XLPE			
ROUTE LENGTH (ft):	8,284	NUMBER OF CIRCUITS: 1	PREPARED BY Juan Morales	12/1/2024	
ROUTE LENGTH (mile):	1.57	NUMBER OF CABLES PER PHASE: 5	CHECKED BY Gustavo Constreras	12/2/2024	

POWER CABLE DUCT SIZE: 8 NUMBER OF OTHER DUCTS: 6

NUMBER OF POWER CABLE DUCTS: 20 TYPICAL DUCT BANK DIMENSIONS: 206-in Wide X 87-in High

ELECTRICAL CABLE SYSTEM SUMMARY

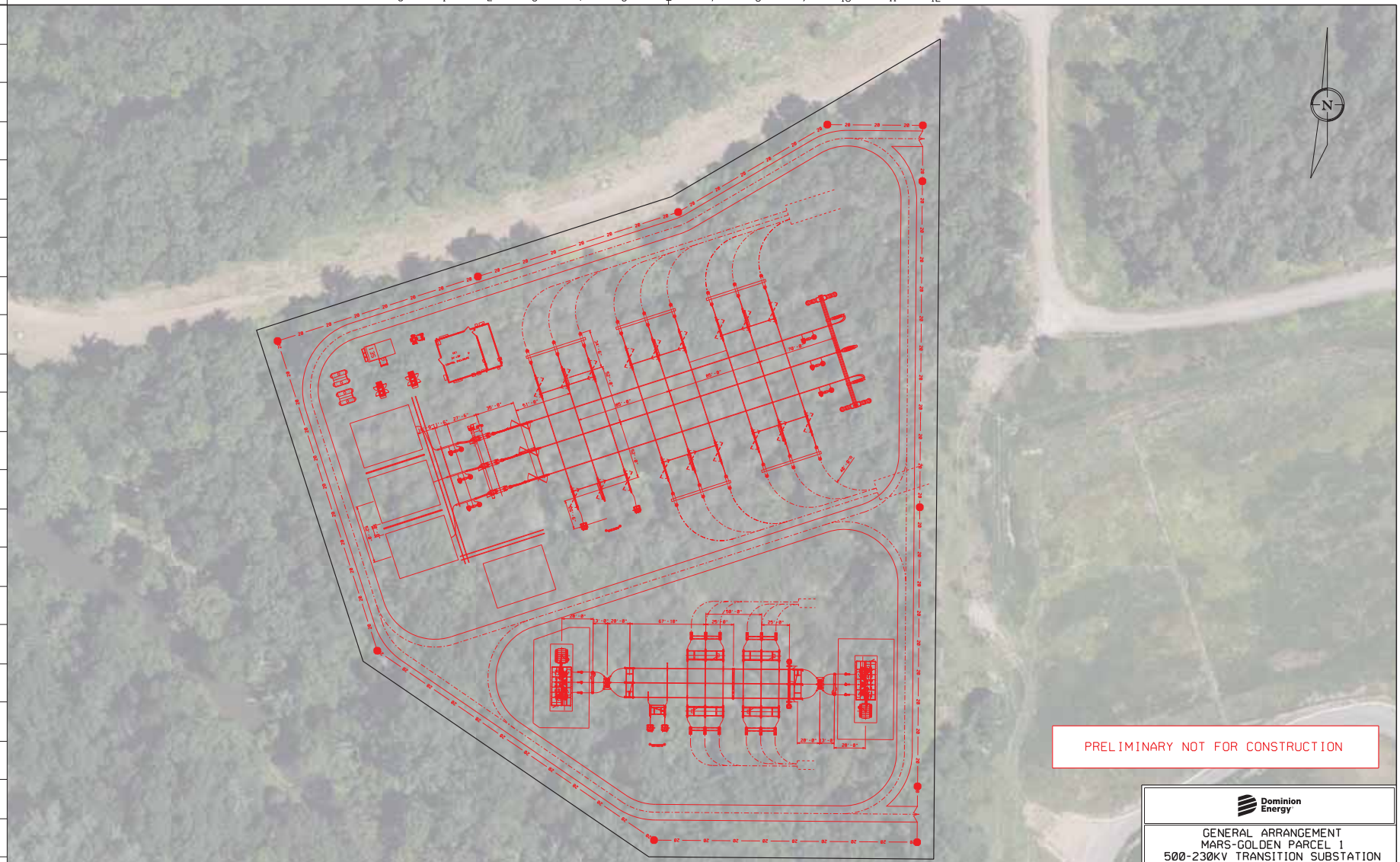
ELEC-1	The cost estimate for the proposed cable system is composed of a total installed cable length of 136260-ft, with an additional spare cable length of 2000-ft. The accessories to be installed include: (30)-500 kV Open Air Terminators, with (1)-Spare 500 kV Open Air Terminators. (75)-500 kV Cable Splice, with (1)-Spare 500 kV Cable Splice. (30)-500 kV Lightning Arrester, with (1)-Spare 500 kV
ELEC-2	The cost estimate for the proposed cable system assumed the following production rates for the cable system installation: Cable Pulling; (3)-Days per vault per set of three cables. Cable Splicing; (6)-
ELEC-3	The cost estimate for the proposed cable system included: (1)-Lump Sum Traffic Control, Flagger & Police (Cable System) composed of (2)-crew. Each crew was composed of: (2)-Police officers
ELEC-4	The cost estimate for the proposed cable system included: (1)-Lump Sum Admin / Mob / De-Mob by Contractor (Electrical) calculated based upon a 0.8% of Total Electrical Cost.
ELEC-5	The cost estimate for the proposed cable system assumed a maximum standard cable reel length of 2400-ft and standard splice vault spacing of 1700-ft.
ELEC-6	This cost estimate included the following assumptions for cable system testing: (90)-Cables for Jacket Integrity Test. (1)-AC HiPot Test. (1)-24 Hour Soak. No Type Test. No PQ Test.
ELECTRICAL PRICING ASSUMPTIONS:	Electrical cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

CIVIL SUMMARY

CIV-1	The costs estimated for the open cut trenching activities were based upon an overall trenching route length of 8077-ft with an average duct bank depth of cover of 5.01 feet, with a further breakdown
CIV-2	A total of 7528-Cubic Yards of rock excavation have been included in this cost estimate. Of this total; 7497-Cubic Yards of rock were assumed for open cut trenching and 32-Cubic Yards of rock were
CIV-3	This cost estimate included an assumed total installation length of 8077-Linear Feet of concrete encased duct bank. The concrete encased duct bank consisted of (20)-8-inch power conduits as well as (6)-smaller conduits for communications and grounding. The overall concrete encased duct bank outside dimensions were 206-in Wide X 87-in High.
CIV-4	No direct buried duct banks were included in this cost estimate.
CIV-5	This cost estimate included a total of 32660-Cubic Yards of Fluidized Thermal Backfill installed above the duct bank.
CIV-6	This cost estimate included a total surface restoration length of 1890-linear feet. Surface restoration costs also included (0)-Traffic Signal Loop Detector Repair, as well as 100-Linear Feet of continuous Steel Plating.
CIV-7	This cost estimate included material for (15) splice vaults as well as excavation for (15) splice vaults. Assumed splice vault dimensions were: 15-ft width by 40-ft length by 8-ft height (inside dimensions).
CIV-8	This cost estimate included (1)-Lump Sum Grounding System (Civil). This includes (15)-vault grounding systems (one per vault). There were no ground conductors embedded in concrete included in
CIV-9	This cost estimate included material and installation for (7)-Communication Handholes.
CIV-10	This cost estimate included Conduit Proofing (Civil) for (20)-power conduits for (6)-vault to vault or vault to termination segments.
CIV-11	This cost estimate included (10)-Substation Termination Structures each with (3)-terminations per structure. This cost estimate did not include any OH to UG Termination Structures.
CIV-12	This cost estimate included Clearing/Grubbing and Loam/Seed as follows: 6394-linear feet of the route requiring clearing and grubbing with a right-of-way width of 38-feet wide, and an assumed
CIV-13	Not Used
CIV-14	Not Used
CIV-15	Not Used
CIV-16	The cost estimate for the proposed civil installation included: (1)-Lump Sum Traffic Control, Flagger & Police (Civil) composed of (2)-crew. Each crew was composed of: (2)-Police officers during
CIV-17	This cost estimate included 6234-L.F. of Grading and Access Road with an assumed width of 24-ft, and Low amount of regrading required to construct the access road.
CIV-18	This cost estimate included (1)-Lump Sum Contaminated Material Testing & Disposal based upon 5% of total civil cost
CIV-19	This cost estimate included (1)-Lump Sum Utility Protection and Relocation (known and unknown) based upon 5% of total civil cost
CIV-20	This cost estimate included (1)-Lump Sum Dewatering for the project based upon groundwater present at an assumed average depth of 5-ft below grade. It was assumed that 100% of the overall route
CIV-21	This cost estimate for the proposed installation included: (1)-Lump Sum Admin/Mob/De-Mob by Contractor (Civil) calculated based upon a 1% of Total Civil Cost.
CIV-22	This cost estimate included thermal resistivity testing as follows: (515)-samples related to C04 - Fluidized Thermal Backfill. (0)-samples related to C05 - Native Soil Backfill. (0)-samples related to C15 &
CIV-23	Note: Construction Staking has been lumped into the unit rates of trenching, splice vault installation, horizontal directional drill, and jack and bore, as applicable.
CIVIL PRICING ASSUMPTIONS:	Civil cost estimate pricing was based upon BMcD internal pricing. Vendor pricing was used if listed here:

Note: The individual unit rates and quantities represented in this Cost Estimate provide a preliminary estimate of the associated costs prior to design. The unit rates may vary in construction bids and during construction due to placement of the contractors profit and contingency. The unit rates have been increased in an effort to anticipate unforeseen conditions and unknown market fluctuations. Although the unit rates may vary, the overall cost per mile is within the industry standard level of accuracy.

APPENDIX D PRELIMINARY STATION LAYOUTS



PRELIMINARY NOT FOR CONSTRUCTION

Dominion Energy

GENERAL ARRANGEMENT
MARS-GOLDEN PARCEL 1
500-230KV TRANSITION SUBSTATION

	Name	Date	Project No.	Sheet No.
Designed by:	KAJ(BMC)	07-25-24	99-2970	1 OF 1
Approvals			Scale	
Approvals			1"=30'	
		B/M No.	Revisions	

Cad File Name
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Drawing No.
PRELIM GA

$FILENAME$
PLOTTED: $$$$$$$$$$$$SYTIME
$USERNAME$

No.	Date	By	Checked/Appr.	Description	Project Number	B/M

Revisions

$USERNAME$

Typical Drawing Information	Library Location	Cell Name	B/M Assembly	Pipe Stand Foundation Cells (Pier)	Pipe Stand Foundation Cells (Spread)	Foundation Cells for Other Typical Structures (Pier)	(Spread)	Steel Detail & Assembly

PRELIMINARY NOT FOR CONSTRUCTION

Dominion Energy

GENERAL ARRANGEMENT
MARS-GOLDEN PARCEL 2
500-230KV TRANSITION SUBSTATION

	Name	Date	Project No.	Sheet No.
Designed by:	KAJ(BMC)	07-25-24	99-2970	1 OF 1
Approvals			Scale	
Approvals			1"=30'	
		B/M No.	Revisions	

Cad File Name
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Drawing No.
PRELIM GA

$FILENAME$
PLOTTED: $$$$$$$$$$$$SYTIME
$USERNAME$

No.	Date	By	Checked/Appr.	Description	Project Number	B/M

Revisions

$USERNAME$

Typical Drawing Information	Library Location	Cell Name	B/M Assembly	Pipe Stand Foundation Cells (Pier)	Pipe Stand Foundation Cells (Spread)	Foundation Cells for Other Typical Structures (Pier)	(Spread)	Steel Detail & Assembly

Microsoft Bing

APPENDIX E NEW ROUTES TRENCHLESS INSTALLATIONS FEASIBILITY ANALYSIS

E.1 Trenchless Installations Feasibility Analysis

This Appendix presents a technical feasibility analysis of trenchless installations required along the alignment of four new routes (UG Route R1 through UG Route R4) developed by ERM for DEV and provided to BMcD. This analysis relies on minimum ROW widths and maximum cover depths derived from the ampacity analysis detailed in Section 3.4.4 and Appendix F, ensuring compliance with 230-kV and 500-kV cable ratings. Due to the absence of site-specific geotechnical data, subsurface conditions are assumed to consist of rock based on geotechnical findings from a nearby project site. Diabase rock has been identified as the bedrock formation at the nearby project site. Diabase rock is an igneous rock that is typically hard and abrasive. As such, trenchless installations within this formation typically have long drilling times and care must be taken to select proper drill heads such that they do not wear down beyond use during drilling operations. Maximum borehole size and depth of cover are also dictated by existing Geotech data and circuit ampacity requirements. The final determination of trenchless crossing feasibility is subject to field investigation, site-specific geotechnical data, and survey information. This may necessitate changes to the proposed trenchless designs and anticipated technologies outlined in this section.

E.2 Typical trenchless Crossing Parameters

The proposed trenchless technology requirements for each crossing are outlined in the following sections. Typical design parameters for each trenchless technology are outlined in Table E.2-1 through Table E.2-3. Workspace dimensions outlined in the table are subject to change depending on available space and above grade features.

Table E.2-1: Typical J&B Parameters

Description	Value
Number of Bores	9
Nominal Casing Diameter	36”
Maximum Depth of Cover	30’-0”
Bore-to-Bore Centerline Spacing (230-kV)	15’-0”
Bore-to-Bore Centerline Spacing (500-kV)	45’-0”
Bore-to-Bore Centerline Spacing (230-kV & 500-kV)	15’-0”
Launching Pit Workspace Width (Total)	295’-0”
Launching Pit Workspace Length (Total)	145’-0”
Launching Pit Width (Each)	16’-0”
Launching Pit Length (Each)	40’-0”
Receiving Pit Workspace Width (Total)	295’-0”
Receiving Pit Workspace Length (Total)	125’-0”
Receiving Pit Width (Each)	15’-0”
Receiving Pit Length (Each)	20’-0”

Table E.2-2: Typical HDD Parameters

Description	Value
Number of Bores	9
Nominal Casing Diameter	36”
Maximum Depth of Cover	45’-0”
Bore-to-Bore Centerline Spacing (230-kV)	20’-0”
Bore-to-Bore Centerline Spacing (500-kV)	65’-0”
Bore-to-Bore Centerline Spacing (230-kV & 500-kV)	70’-0”
HDD Entry Workspace Width (Total)	540’-0”
HDD Entry Workspace Length (Total)	200’-0”
HDD Exit Workspace Width (Total)	490’-0”
HDD Exit Workspace Length (Total)	100’-0” Min*

*Total HDD exit workspace length depends on pipe string length. The 100’-0” minimum requirement is only allocated for workspace during drilling operations

Table E.2-3: Typical Microtunnel Parameters

Description	Value
Number of Bores	9
Nominal Casing Diameter	36”
Maximum Depth of Cover	40’-0”
Bore-to-Bore Centerline Spacing (230-kV)	15’-0”
Bore-to-Bore Centerline Spacing (500-kV)	60’-0”
Bore-to-Bore Centerline Spacing (230-kV & 500-kV)	60’-0”
Entry Pit Length (Each)	40’-0”
Entry Pit Width (Each)	16’-0”
Exit Pit Length (Each)	20’-0”

Description	Value
Exit Pit Width (Each)	15’-0”
Entry Pit Workspace Width (Total)	415’-0”
Entry Pit Workspace Length (Total)	145’-0”
Exit Pit Workspace Width (Total)	145’-0”
Exit Pit Workspace Length (Total)	125’-0”

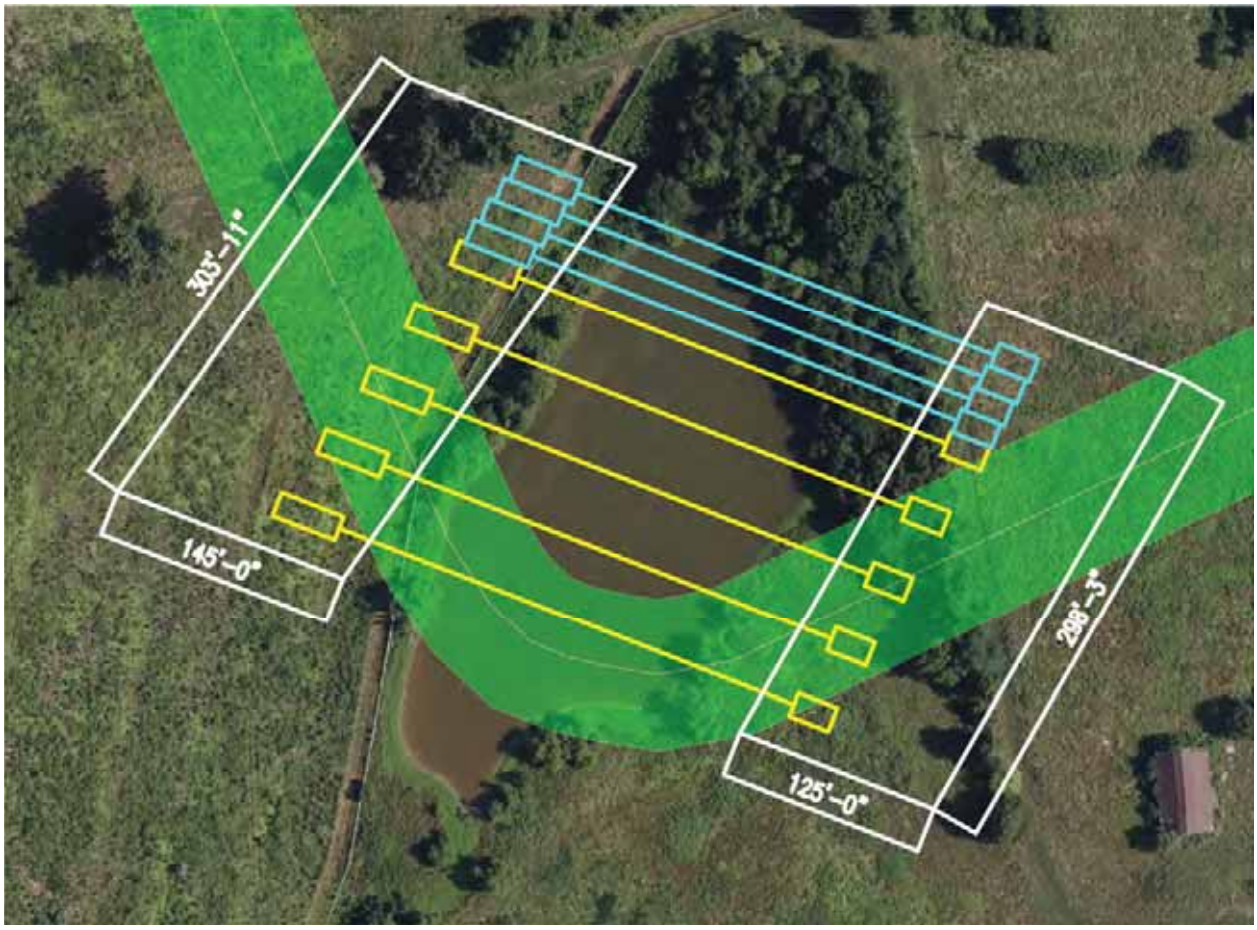
E.3 UG Route R1 Trenchless Feasibility Analysis

Through the desktop high-level analysis performed by BMcD over UG Route R1, a total of two (2) preliminary trenchless crossings were identified in Section 4.1.8 of the main report body. The following sections contain the feasibility analysis for each crossing along the route.

E.3.1.1 Feasibility Assessment of Preliminary Trenchless Crossing R1_TC1

The first trenchless crossing along the preferred route, R1_TC1, is located near the Mars Substation to the north of W Perimeter Road. At this location, the proposed route crosses a small pond with a maximum width (along the alignment) of approximately 230 feet. Based on this length, a J&B is the appropriate trenchless technology for this location. See Figure E.3-1 for a plan view of the proposed J&B with launching/receiving pits and workspaces.

Figure E.3-1: Trenchless Crossing R1_TC1



The white lines represent workspaces, yellow lines represent 500-kV bores, cyan lines represent 230-kV bores, and the green area represents the proposed route and right of way. Launching and

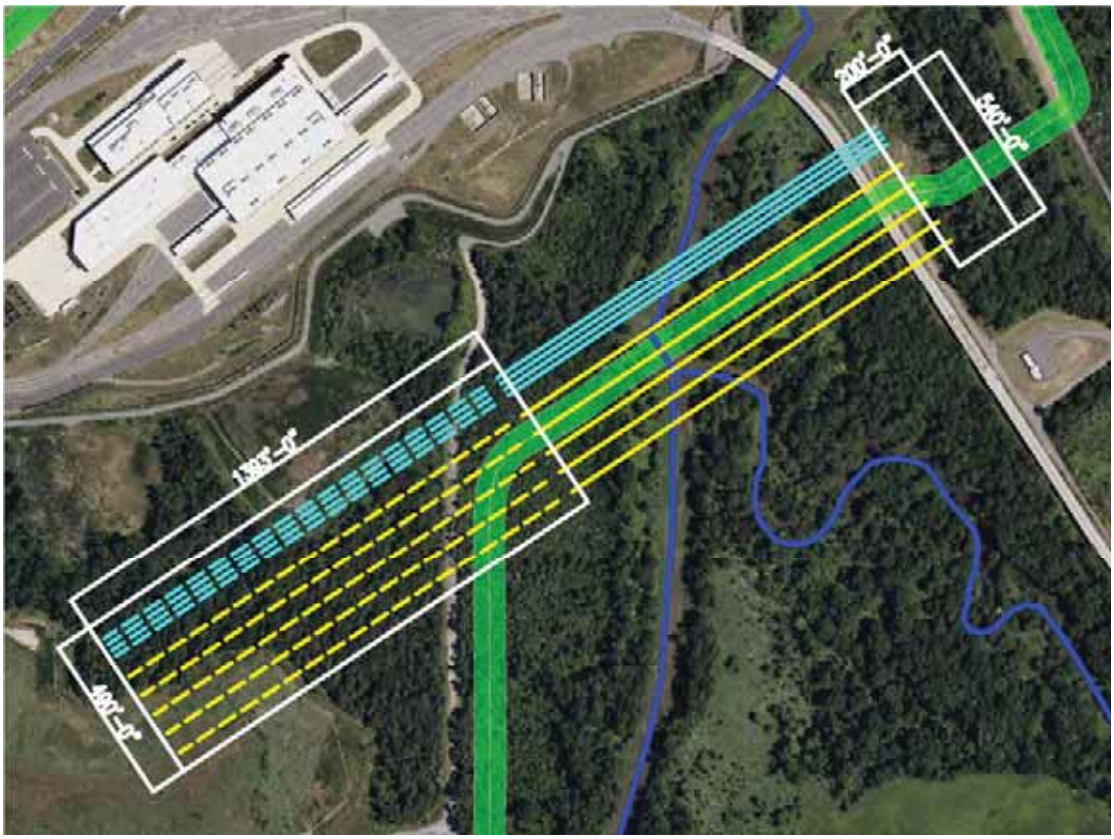
receiving pits, located west (left) and east (right) of the pond respectively, have been placed approximately 50 feet back from the water's edge in an effort to reduce the amount of groundwater present at the pit locations. As such, the longest J&B in the above installation is approximately 290 feet, still satisfying the J&B design constraints outlined in this document. The workspace extends 20 feet pond-side of each launching and receiving pit. The J&B installation is approximately centered over the pond to facilitate open-cut connections for the 500-kV circuits. Shifting the installation further south may require a smaller bend radius for the cables to reconnect to the proposed ROW while avoiding the existing building to the southeast of the pond. This could necessitate the use of specialized trenchless equipment or techniques.

The primary concern with this installation is going to be dewatering in the J&B pits due to the likelihood of groundwater near the pond. Should too much groundwater be present at the project site such that it fills pits at a rate where dewatering is not effective, this installation will need to be converted to a microtunnel or re-rerouted around the pond. Additional right of way acquisition is required for the bores and subsequent open-cut connections to the launching/receiving pits and temporary easement will be required for the workspaces and any access roads constructed for construction crews and equipment to reach the site. The proposed route could bypass the pond entirely, eliminating the need for the R1_TC1 trenchless crossing.

E.3.1.2 Feasibility Assessment of Preliminary Trenchless Crossing R1_TC7

The second location that requires a trenchless installation resides between the Dulles International Airport and the WMATA Dulles Rail Yard. At this location, the proposed route crosses beneath Horsepen Pond, a future pond belonging to the future sewer line project and a railway overpass into the WMATA Dulles Rail Yard. At the crossing location, the Horsepen Pond and the railway overpass exist approximately 750 feet apart from one another, with the future pond between them. To simplify construction, it is preferred to cross all three entities with one drill. As such, an HDD is the preferred trenchless technology for this crossing. An overview of the crossing, including workspaces, can be found below in Figure E.3-2.

Figure E.3-2: Trenchless Crossing R1_TC7



In the above configuration, the HDD entry locations are on the east (right) and the exit locations are on the west (left). The white lines represent workspaces, yellow lines represent 500-kV HDDs, cyan lines represent 230-kV HDDs, dashed lines represent pipe laydown area, and the green area represents the proposed route and right of way. The total length of this installation is approximately 1,300 feet. With this configuration, a midpoint fusion of the conduits will not be necessary. Additional right of way and easements will be required for the cables and trenchless workspaces.

The two primary concerns with this installation reside with assumed geotechnical conditions and ampacity considerations. Due to the presence of diabase rock in the area, a maxi (large) drill rig will be required for the HDD installation. The abrasive nature of diabase necessitates careful selection of drill heads to prevent excessive wear during drilling operations. The maxi rig requires more workspace and the presence of rock greatly extends the time required to complete the drill. Additionally, since HDDs require a greater depth of cover to J&Bs, ampacity must be closely monitored when designing this crossing due to the high load of the circuits. To assist with ampacity, these HDDs shall be designed to include casings and thermal grout. The assumed depth

of cover for this HDD crossing is currently 45 feet. This depth of cover combined with thermal grout and the bore center-to-center spacing outlined in Table E.2-2 allows for the circuits to reach the target load; however, a site-specific geotechnical investigation and subsequent annular pressure analysis is required before detailed design can proceed. Should geotechnical conditions prove unfavorable for an HDD installation, a microtunnel may be feasible. The HDD entry angle and location is subject to change pending railroad overpass foundation locations or depth of cover requirements.

E.4 UG Route R2 Trenchless Crossings Feasibility Analysis

Through the desktop high-level analysis performed by BMcD over UG Route R2, a total of three (3) preliminary trenchless crossings were identified in Section 4.1.9 of the main report body. The following sections contain the feasibility analysis for each crossing along the route.

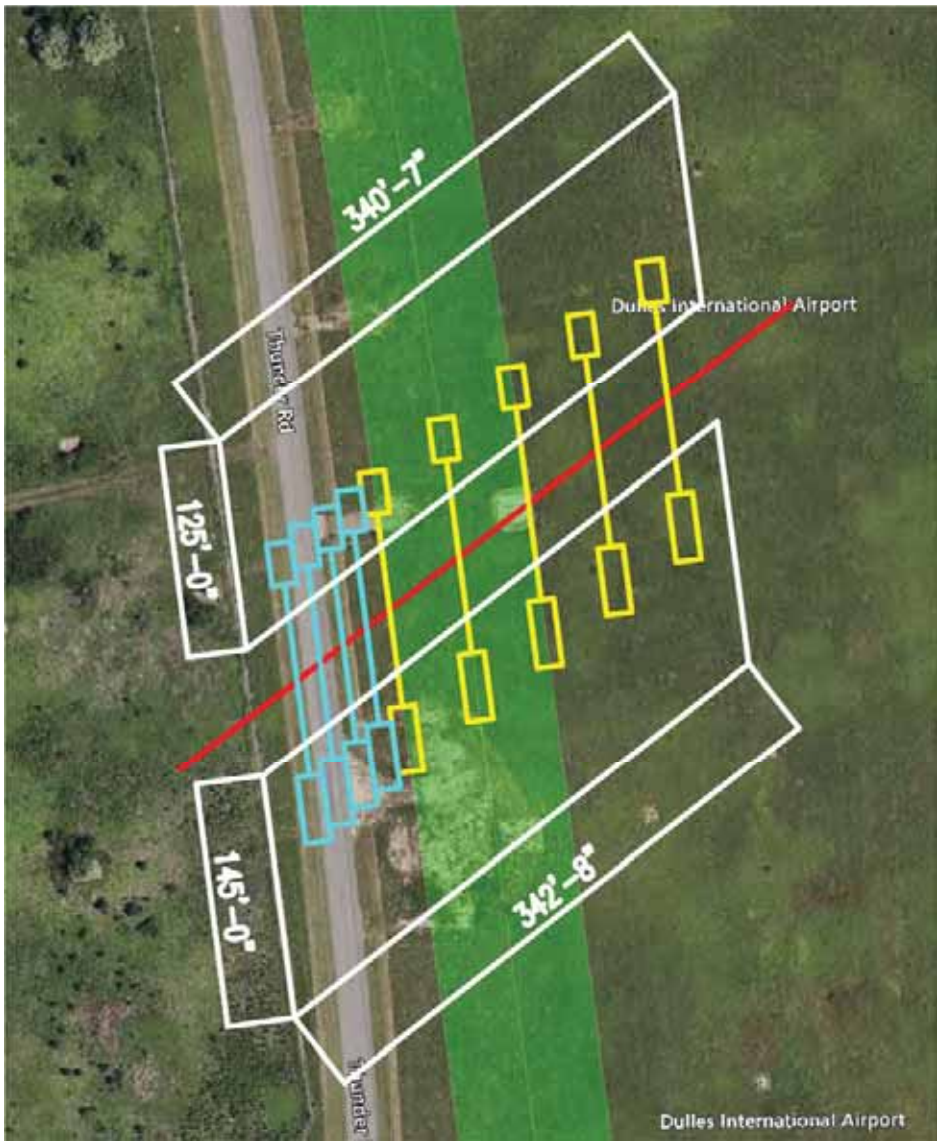
E.4.1.1 Feasibility Assessment of Preliminary Trenchless Crossing R2_TC1

Trenchless crossing R2_TC1 is the same as trenchless crossing R1_TC1. See Section E.3.1.1 for details.

E.4.1.2 Feasibility Assessment of Preliminary Trenchless Crossing R2_TC6

The second trenchless crossing along proposed UG Route R2 crosses beneath a proposed 24-inch storm between Route 606 and Weather Service Road. It is assumed that the storm pipe is to be installed prior to the proposed route, so a trenchless installation will be used in lieu of trenching beneath it. Since this crossing is only for a single utility, the overall length will be short. As such, a J&B is the appropriate trenchless technology for this crossing. See Figure E.4-1 for plan view of the proposed crossing.

Figure E.4-1: Trenchless Crossing R2_TC6

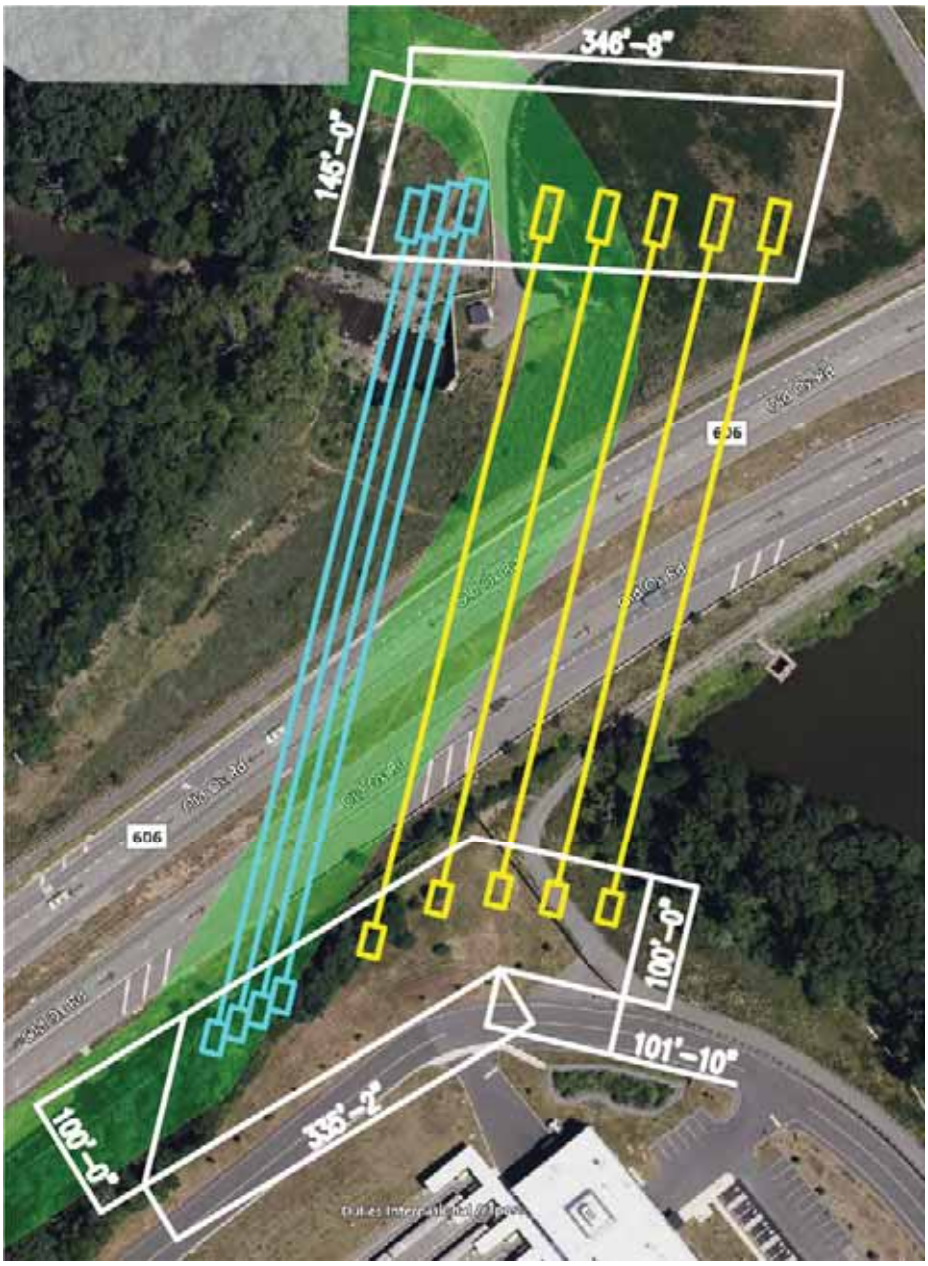


The white lines represent workspaces, yellow lines represent 500-kV bores, cyan lines represent 230-kV bores, the green area represents the proposed route and right of way, and the red line represents the approximate location of the proposed sewer line at the crossing. Launching and receiving pits, located south (bottom) and north (top) of the pond respectively, have been placed approximately 50 feet back from the proposed pipe. As such, the longest J&B in the above installation is approximately 115 feet, still satisfying the J&B design constraints outlined in this document. The workspace extends 20 feet towards the proposed sewer in front of the launching and receiving pits. Additional right of way and easement will be required for the cables and the workspace respectively.

E.4.1.3 Feasibility Assessment of Preliminary Trenchless Crossing R2_TC7

The final trenchless crossing along proposed UG Route R2 is located beneath Route 606 and Horsepen Pond/Horsepen Run. The longest bore at this location must be at least 650 feet to accommodate the width of the road, the required bore angle, and the presence of a drainage culvert feeding Horsepen Run from Horsepen Pond. The property to the south of Route 606 belongs to the WMATA Dulles Rail Yard and, assuming the proper easements can be acquired, there is minimal space between Route 606 and Rail Operations Drive, WMATA's private road. Since Rail Operations Drive is the only road which accesses the Dulles Rail Yard Operations Building, it is assumed that no road closures are permitted for this installation. There is approximately 100 feet available for workspace here, which makes a J&B the appropriate trenchless installation; however, the industry standard maximum length for a J&B is only 600 feet. As such, a guided pilot bore method is required at this installation to ensure accuracy along the bore path. See Figure E.4-2 for the guided J&B plan.

Figure E.4-2: Trenchless Crossing R2_TC7



The white lines represent workspaces, yellow lines represent 500-kV bores, cyan lines represent 230-kV bores, and the green area represents the proposed route and right of way. Launching and receiving pits, located north (top) and south (bottom) of the road respectively, have been placed approximately 50 feet back from the road's edge and 50 feet back from the water's edge where applicable in an effort to reduce the amount of groundwater present at the pit locations. The workspace extends 20 feet pond-side of each launching and receiving pit. The J&B installation is

angled to find the shortest possible path across the obstructions while generally following the proposed route.

Guided pilot bore installations can be difficult to construct. As such, prior to detailed design it is important to identify a contractor that can confidently execute this installation. The guided pilot bore will require precision equipment and skilled operators to maintain bore path accuracy over the extended length. Additionally, settlement analysis will be required for all bores prior to detailed design due to the crossing of a major roadway, large underground reinforced concrete pipe, and a retaining wall at the mouth of Horsepen Run. Due to the apparent large grade change at the launching pit site and towards the receiving pits, a topographic survey is required to verify grade changes, required pit depths, and maximum depth of cover for ampacity analysis. Care should be taken during open-cut routing to ensure the conduits can bend into the transition station at an acceptable radius and the cables do not undergo undue pulling tensions. Additional ROW and easements will be required for the cables and trenchless workspaces.

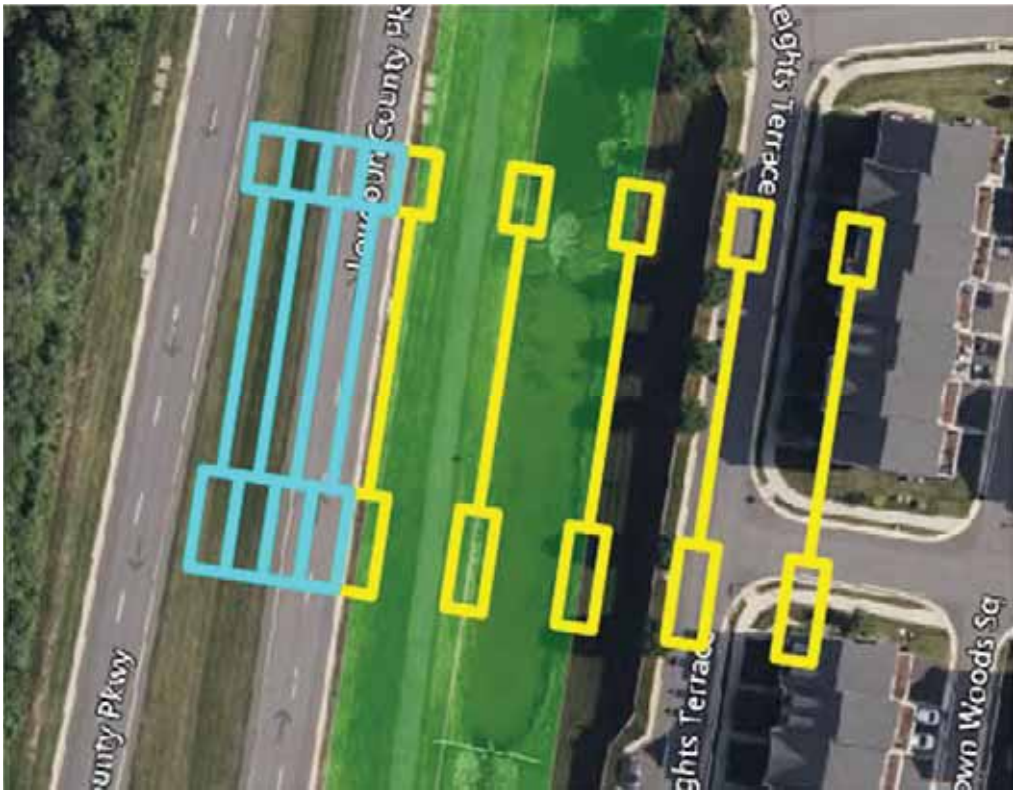
E.5 UG Route R3 Trenchless Crossings Feasibility Analysis

Through the desktop high-level analysis performed by BMcD over UG Route R3, a total of six (6) preliminary trenchless crossings were identified in Section 4.1.10 of the main report body. The following sections contain the feasibility analysis for each crossing along the route.

E.5.1.1 Feasibility Assessment of Preliminary Trenchless Crossing R3_TC2

The first location along proposed UG Route R3 which requires a trenchless installation underneath two small ponds between Route 607 and Madison Heights Terrace just north of Evergreen Ridge Drive. The ponds in this area span approximately 300 feet along the road. A J&B is the preferred trenchless method for this crossing, provided sufficient space is available. Figure E.5-1 illustrates the workspace required for a J&B centered beneath the ponds. Based on BMcD's understanding, VDOT does not permit open-cut installations beneath Route 607, and the available space between the road and adjacent residences to the east is approximately 140 feet. Consequently, the space constraints at this site make a trenchless installation unfeasible.

Figure E.5-1: Trenchless Crossing R3_TC2

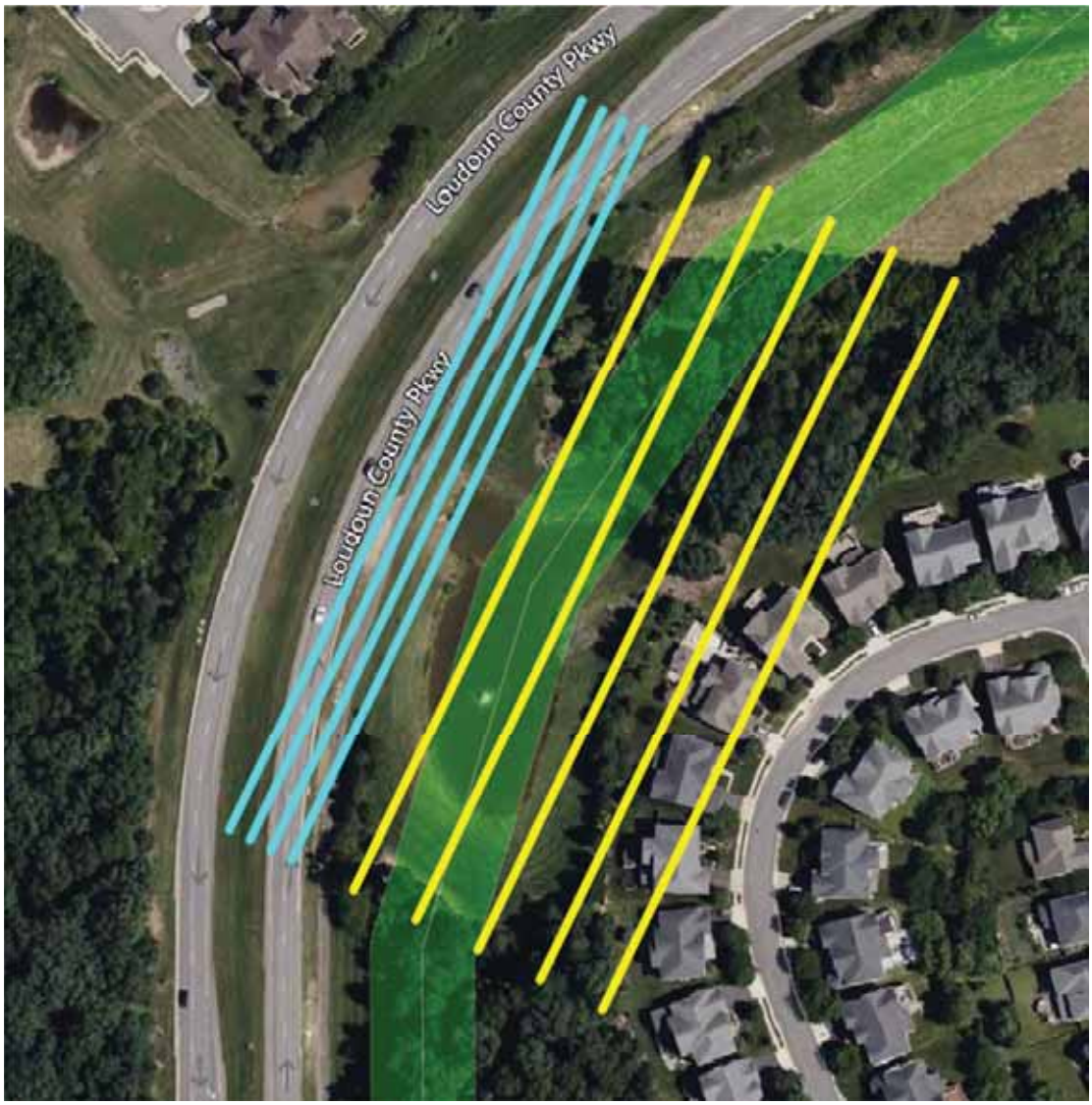


The yellow lines represent 500-kV bores and pits, cyan lines represent 230-kV bores and pits, and the green area represents the proposed route and right of way.

E.5.1.2 Feasibility Assessment of Preliminary Trenchless Crossing R3_TC3

The second trenchless location along proposed UG Route R3 crosses beneath a pond and a large storm drain. It is located between Route 607 and Addlestone Place. The proposed trenchless technology at this crossing shall be a microtunnel due to the likelihood of groundwater near the pond and the approximate installation length of 650 feet. Similar to the previous trenchless crossing on this route, R3_TC3, there is limited space available for construction (approximately 280 feet at the narrowest location) between Route 607 and private residences. As a result, a trenchless crossing at this location is not feasible. See Figure E.5-2 for a plan view of the required space for a microtunnel at this location.

Figure E.5-2: Trenchless Crossing R3_TC3



The yellow lines represent 500-kV bores, cyan lines represent 230-kV bores, and the green area represents the proposed route and right of way.

E.5.1.3 Feasibility Assessment of Preliminary Trenchless Crossing R3_TC5

The third location along proposed UG Route R3 which requires a trenchless installation is underneath a large drainage culvert located next to Route 607 and south of Zulla Chase Place. Similar to the first two crossings along this route, there is limited space available for construction (approximately 200 feet at the narrowest point) between private residences and Route 607. Based on the required space for the trenchless documents on the previous two routes, there space available at this site is insufficient for a trenchless installation. A J&B would be the preferred

trenchless technology for this crossing, should sufficient space be available, due to the short length of a drainage culvert crossing. Figure E.5-3 shows the space required for a J&B centered underneath the ponds at this location.

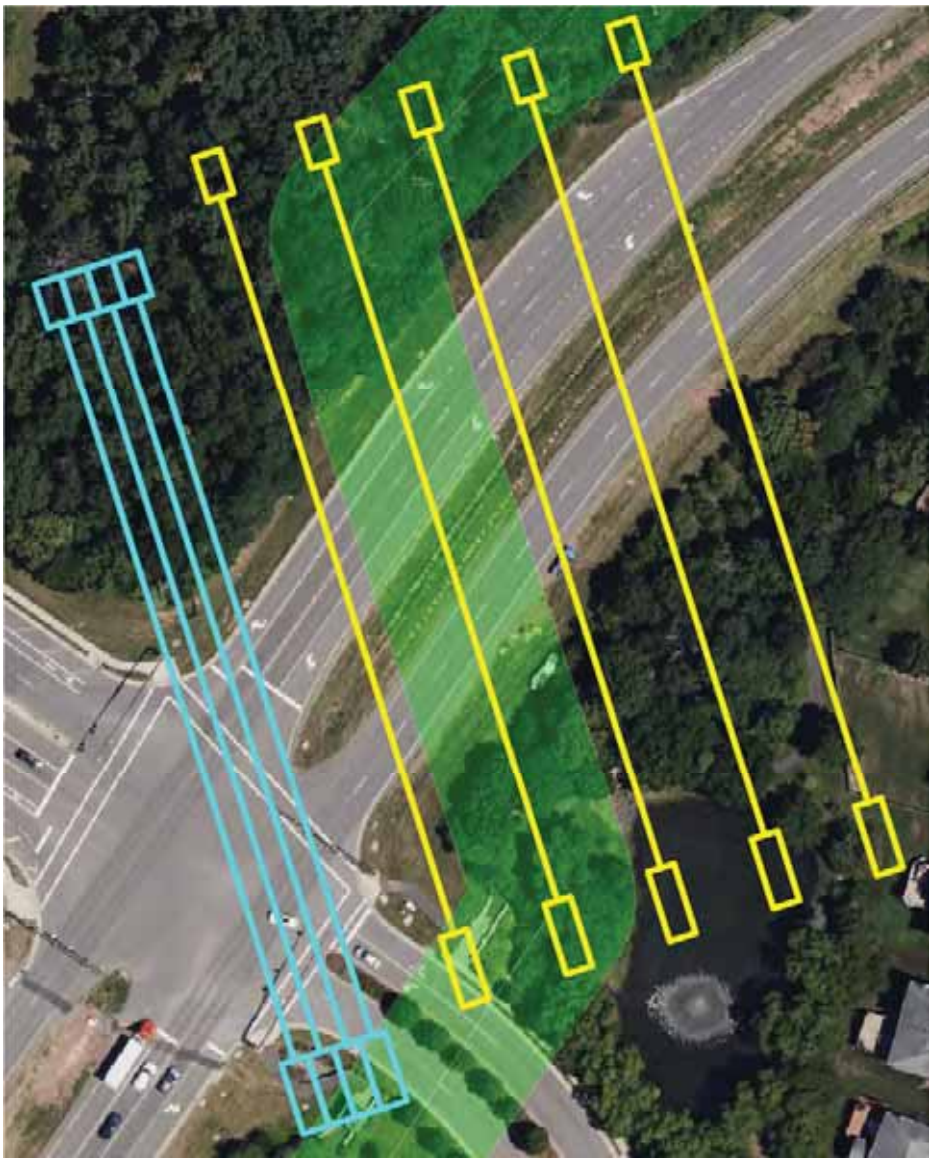
Figure E.5-3: Trenchless Crossing R3_TC5

The yellow lines represent 500-kV bores and pits, cyan lines represent 230-kV bores and pits, and the green area represents the proposed route and right of way.

E.5.1.4 Feasibility Assessment of Preliminary Trenchless Crossing R3_TC6

The fourth location along proposed UG Route R3 which requires a trenchless installation crosses Route 607 at its intersection with Gleedsville Manor Drive. The required length to cross Route 607 at this location is approximately 430 feet; as such, a J&B is the preferred trenchless technology for this installation. Based on the required space for a J&B, the private property at the launching site, and the presence of a pond at the launching pit site, this location is not feasible for a trenchless crossing. Figure E-8 shows the required space for a J&B at this location.

Figure E.5-4: Trenchless Crossing R3_TC6



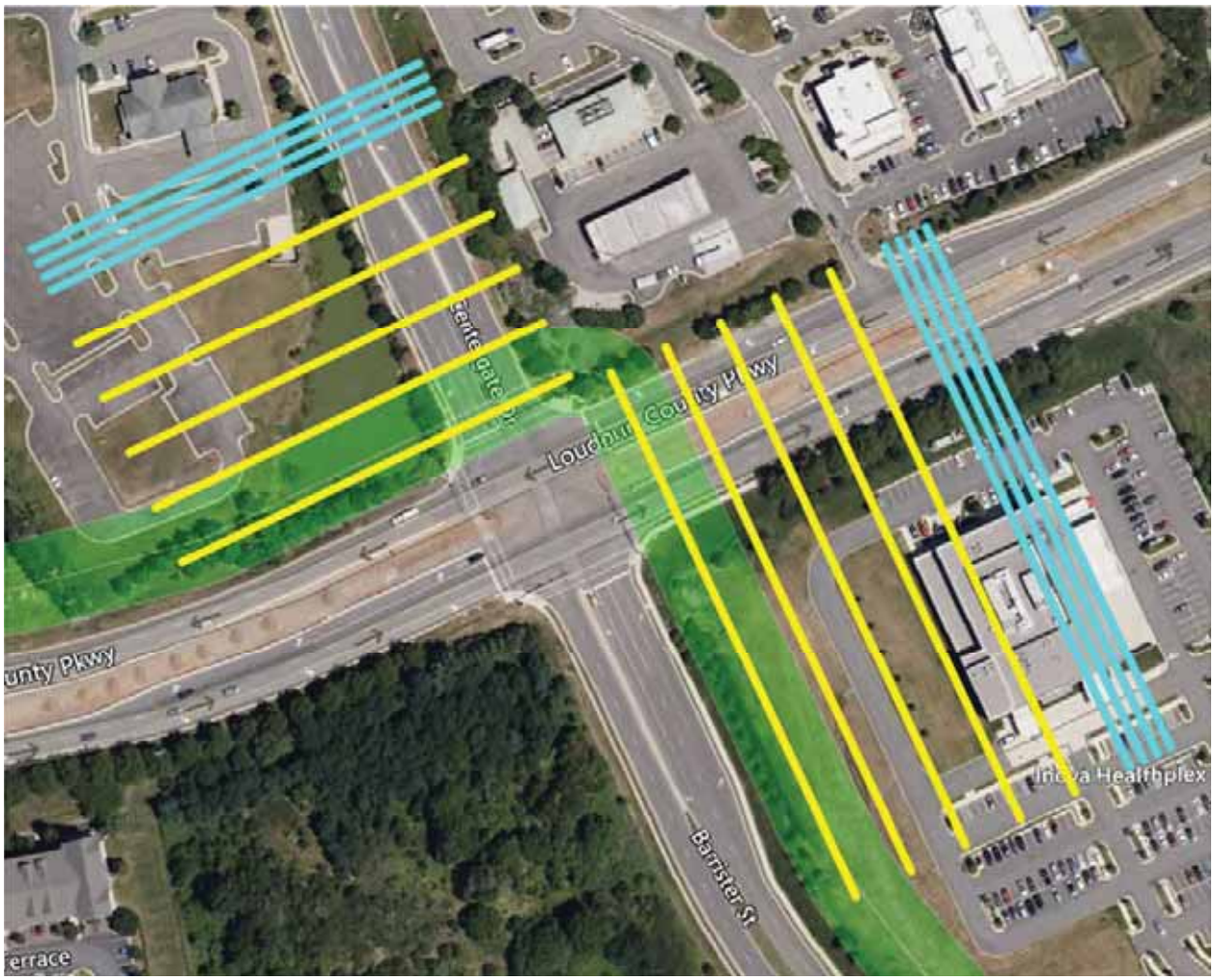
The yellow lines represent 500-kV bores and pits, cyan lines represent 230-kV bores and pits, and the green area represents the proposed route and right of way.

E.5.1.5 Feasibility Assessment of Preliminary Trenchless Crossings R3_TC10 and R3_TC11

The fifth and final location along proposed UG Route R3 which requires a trenchless installation is at the intersection of Route 607 and Centergate Drive. The route at this intersection crosses a pond, Route 607, and a drainage culvert beneath Route 607 in addition to turning 90 degrees. As such, two trenchless installations will be required at this location. To facilitate the 90-degree turn,

two (2) microtunnels will be installed, where they will share a pit at the northern corner of the intersection. Figure E-8 shows the preliminary alignments of the microtunnels at the location.

Figure E.5-5: Trenchless Crossings R3-TC10 (Microtunneling) & R3-TC11 (Long Microtunneling). Preliminary Location of Shared Pit at Route 607 & Centergate Drive Intersection



The yellow lines represent 500-kV bores, cyan lines represent 230-kV bores, and the green area represents the proposed route alignment and ROW. A review of the proposed microtunnel paths indicates this crossing is not feasible. The shared pit site lacks sufficient space for connecting the two microtunnels via open-cut without necessitating the demolition of an Exxon gas station and nearby businesses. Additionally, the required bore-to-bore spacing south of Route 607 places the microtunnels beneath the Ashburn HealthPlex near Barrister Street, a facility providing critical emergency services, making permanent easement approvals highly unlikely.

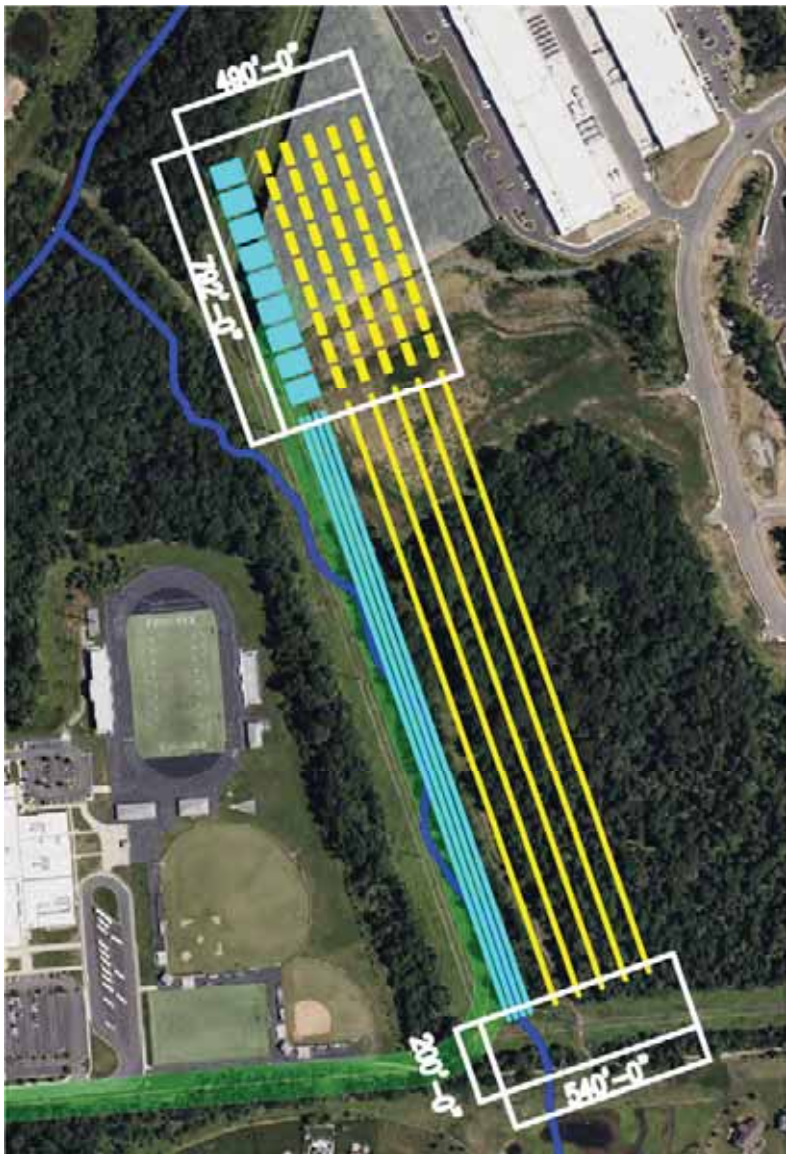
E.6 UG Route R4 - Trenchless Crossings Feasibility Analysis

Through the desktop high-level analysis performed by BMcD over UG Route R4, a total of one (1) preliminary trenchless crossing was identified in Section 4.1.11 of the main report body. The following section contains the feasibility analysis for the crossing along this route.

E.6.1.1 Feasibility Assessment of Preliminary Trenchless Crossing R4_TC1

The only location along proposed UG Route R4 that requires a trenchless crossing is located in between Light Speed Plaza and Rock Ridge High School. At this location, a stream persists which also runs parallel to Light Speed Plaza spanning approximately 1,400 feet along the proposed alignment. As such, an HDD will be required along this portion of the route to cross the stream. Figure E.6-1 shows a preliminary overview of the crossing, including workspaces and pipe string area. The yellow lines represent 500-kV bores, cyan lines represent 230-kV bores, the dashed lines depict the respective pipe string areas, the white lines represent the workspace, and the greed area represents the proposed alignment and ROW. Note that the pipe string requires a midpoint conduit fuse due to the limited space between the exit location and Broad Run.

Figure E.6-1: Trenchless Crossing R4-TC1



According to geotechnical reports near Rock Ridge High School, the diabase rock formation begins at a depth of cover of approximately 15 feet. The presence of diabase rock at a depth of approximately 15 feet poses significant challenges for the construction of an HDD or any other trenchless installation. The rock's hardness and abrasiveness may necessitate specialized drilling equipment and techniques, potentially increasing the installation time and cost. Furthermore, the stream's alignment parallel to the HDD path increases the risk of water intrusion into the bore and entry/exit pits due to the high groundwater levels in the area. Consequently, a trenchless crossing at this location is not feasible.

APPENDIX F TRENCHLESS CROSSINGS AMPACITY MEMO

Memorandum

Date: 11/05/2024

To: Corey Anderson

From: Gustavo Contreras

Subject: Dominion Golden to Mars - 230kV and 500-kV Underground Cable Preliminary Ampacity Study – Trenchless Crossings

In support of the 230-kV and 500-kV Dominion (DEV) Golden to Mars UG Transmission Line project, Burns & McDonnell Engineering Company, Inc. (BMcD) has performed preliminary ampacity calculations to identify the underground conductor size, and the number of cables-per-phase (CPP) needed to meet the target circuit loading requirements. In a previous study, it was determined that for open-cut installation of both 230-kV and 500-kV circuits in the same right of way (ROW), a five (5) CPP configuration was required to meet the ampacity ratings for the 500-kV circuit, within a single duct bank, and a four (4) CPP configuration was required for the 230-kV circuit, within a single duct bank. Dominion has requested BMcD additional ampacity calculations to evaluate the minimum ROW required considering both circuits in the same ROW for trenchless installations of four (4) new routes provided by Dominion.

The trenchless installations considered correspond to three (3) alternatives: Jack & Bore (J&B), Microtunneling, and Horizontal directional Drilling (HDD). J&B and Micortunneling are analyzed with two (2) maximum probable bore depths that are assumed to cover all the J&B and Microtunneling crossings in these new routes; 40 feet and 30 feet. HDD is considered as an alternative to Microtunneling at Horsepen Pond and WMATA Dulles Railway crossing on Loudoun Water Sewer route and is analyzed with 45 feet maximum probable depth of cover. These trenchless installations are investigated with the same number of CPP for open-cut installation from the previous study to determine the minimum trenchless ROW required to meet cable ratings. This is accomplished by running the cables to their maximum operating temperature of 90°C at different bore depths and adjusting the bores center-to-center separation. The following writeup summarizes the results for these installations.

Ampacity calculations were computed using the CYMCAP ampacity program by CYME. The CYMCAP software utilizes the Neher-McGrath method of calculating the achievable ampacities of underground cables and conforms to IEC standards 60287 and 60853. This software is accepted as the industry standard for performing ampacity calculations for underground electrical systems. The individual CYMCAP execution reports and an ampacity table for all calculations included as part of this Memo can be seen in Appendix A.

DESIGN PARAMETERS AND INSTALLATION CONDITIONS

The parameters for these ampacity calculations are based on engineering judgment and the design criteria established for this project in Sections 3.1 and 3.2 of Dominion Golden to Mars – 230-kV and 500-kV Underground Feasibility Report, Revision 4 dated 09/10/2024. The design parameters used for the 230-kV and 500-kV circuits can be seen below in Table 1 and Table 2, respectively. Since these circuits' purpose is to feed data centers, a single daily load factor (DLF) equal to 1.0 was used hereinafter. The underground cable systems operating environment can be seen below in Table 3.

Table 1 230-kV Design Parameters

Design Parameter	Parameter Value	Source
Nominal Operating Voltage	230-kV	Dominion
Nominal Frequency	60 Hz	Industry Standard
Circuit Rating	3,950 A	Dominion
Maximum Normal Conductor Temperature	90°C	Industry Standard
Maximum Emergency Conductor Temperature	105°C	Industry Standard
Daily Load Factor (DLF)	100 %	Dominion
Sheath Bonding	Single Point	Assumed

Table 2 500-kV Design Parameters

Design Parameter	Parameter Value	Source
Nominal Operating Voltage	500-kV	Dominion
Nominal Frequency	60 Hz	Industry Standard
Circuit Rating	5,000 A	Dominion
Maximum Normal Conductor Temperature	90°C	Industry Standard
Maximum Emergency Conductor Temperature	105°C	Industry Standard
Daily Load Factor (DLF)	100 %	Dominion
Sheath Bonding	Single Point	Assumed

Table 3 Environmental Criteria

Description	Value	Source
Summer Ambient Earth Temperature (20'<= d)	12°C	Assumed
Native Soil Thermal Resistivity*	115°C-cm/W - 100% DLF	Assumed
Grout Thermal Resistivity	80°C-cm/W	Assumed
Minimum Burial Depth to Top of Bore	10 feet	Assumed
Installation Conditions	Bore Casign	BMcD Preliminary Study

*Actual native soil thermal resistivity is unknown. This value is being assumed equal to the one used for DLF=1.0 in Dominion Golden to Mars – 230-kV and 500-kV Underground Feasibility Report, Revision 4 dated 09/10/2024. When data from filed investigations are available this value may need to be revised and analysis results in this memo may change.

THERMAL PINCH POINT IDENTIFICATION AND NEW INSTALLATION SCENARIOS

A previous study found that the 230-kV circuit would need four (4) cables per phase and 500-kV would need five (5) cables per phase to meet rating requirements for both circuits in the same ROW with open-cut installation. The new routes provided by DEV are assumed to be covered by those previous analysis for the open-cut segments. Following the request from DEV for additional calculations for trenchless crossings of those new routes, to determine the minimum 230-kV bores center-to-center spacing and minimum 500-kV bores center-to-center spacing in the same ROW able to satisfy the required load defined in Table 1 and Table 2, a series of parametric studies were performed for three (3) different installation cases iterating the spacing between bores until the minimum ratings were met or slightly exceeded with cables at 90°C operating temperature. The following sections detail the installation scenarios for each case.

CASE 1 INSTALLATION SCENARIOS – MICROTUNNELING AND J&B AT 40 FEET MAXIMUM DEPTH

As part of the new study request, in this Case 1, both 230-kV and 500-kV circuits are set in the same trenchless ROW, then the bore is modeled at 40 feet maximum depth to calculate the minimum ROW required to meet cable ampacities.

Below are the installation scenarios that were modeled as part of this Case 1 study:

1. Each 230-kV and 500-kV CPP is set in a single bore, that is:
    a. Four (4) 230-kV bores and five (5) 500-kV bores in the same ROW, nine (9) bores in total.
        i. Each bore will have a 36" HOBAS casing, with three (3) cables conduits and one (1) spare conduit. See Figure 1 for bore cross section.
2. Two (2) 230-kV CPP are set in the same bore, and each 500-kV CPP is set in a single bore, that is:
    a. Two (2) 230-kV bores and five (5) 500-kV bores in the same ROW, seven (7) bores in total.
        i. Each 230-kV bore will have a 48" HOBAS casing, with six (6) cables conduits and two (2) spare conduits. See Figure 2 for bore cross section.
        ii. Each 500-kV bore will have a 36" HOBAS casing, with three (3) cables conduits and one (1) spare conduit. See Figure 1 for bore cross section.

Figure 1 Preliminary 230-kV and 500-kV Single Phase XLPE Microtunneling and J&B Cross Section (Section A) Not to Scale (NTS)

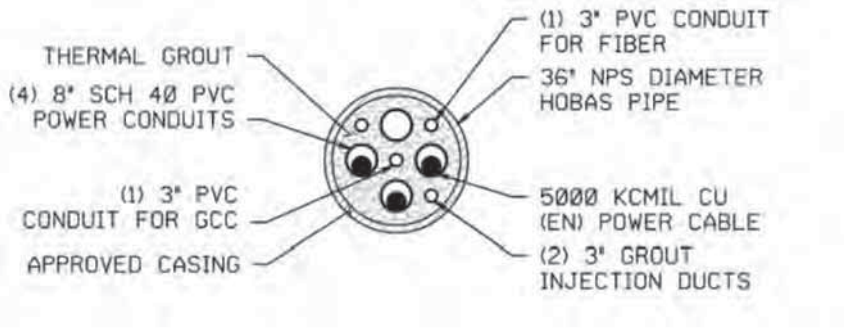
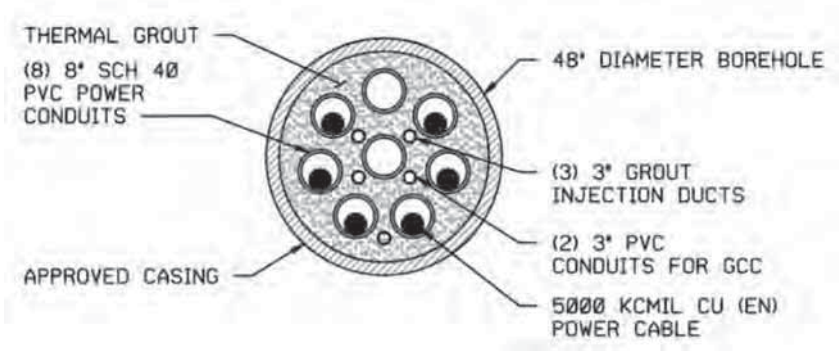


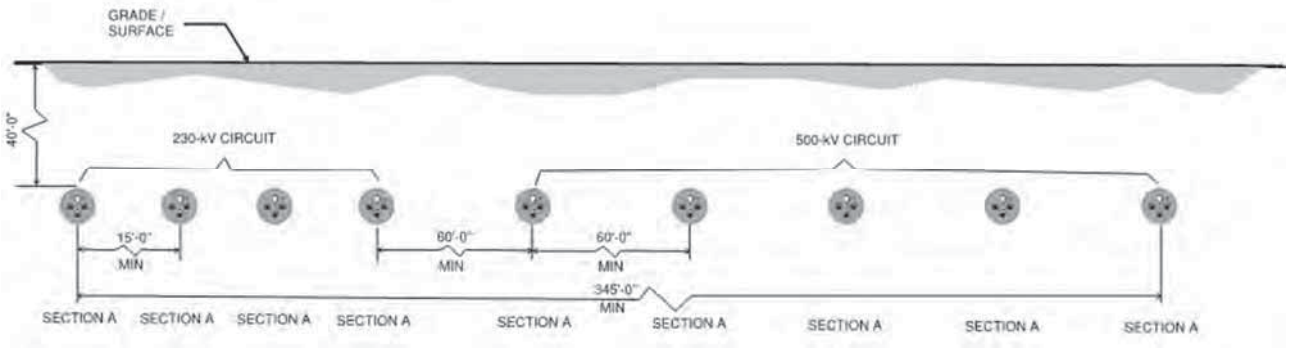
Figure 2 Preliminary 230-kV Double Phase XLPE Microtunneling and J&B Cross Section (Section B) NTS



Case 1: Four (4) 230-kV 36" Bores and Five (5) 500-kV 36" Bores - Nine (9) Bores at 40 Feet Depth in the Same ROW

The parametric study detailed in H execution series, showed that 230-kV and 500-kV circuits meet the minimum ampacity requirements with a bore center-to-center separation of 15 feet between 230-kV 36" bores, 60 feet between 230-kV 36" and 500-kV 36" bores, and 60 feet between 500-kV 36" bores, for a total minimum ROW required of 375 feet, including 15 feet at each end assumed for work space and steering tolerances, for all nine (9) bores to be installed in the same ROW. The convergence case, detailed in execution H105, indicates that ampacities achieved are 3,972A for 230-kV circuit and 5,140A for 500-kV with 375 feet ROW. Figure 3 below shows the Microtunneling and J&B configuration for this case.

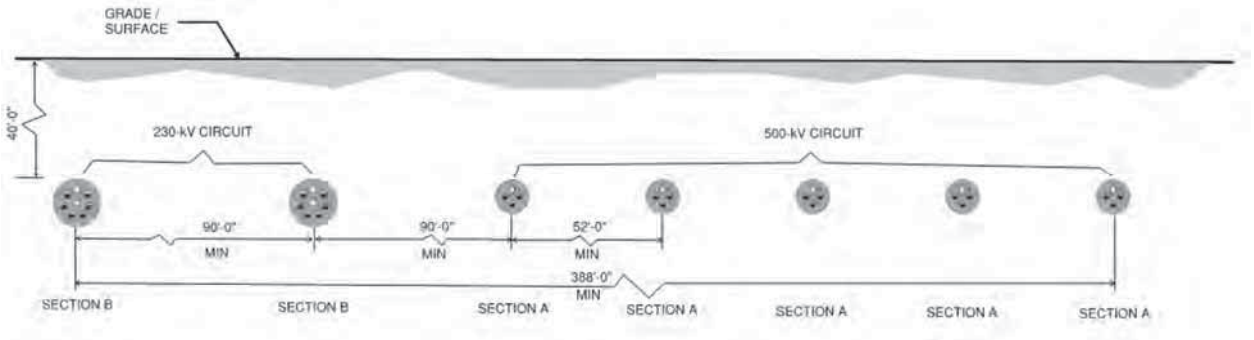
Figure 3 Preliminary Microtunneling and J&B Configuration for Nine 36" Bores - 230-kV and 500-kV Circuits in the Same ROW at 40 Feet Depth NTS



Case 1: Two (2) 230-kV 48" Bores and Five (5) 500-kV 36" Bores - Nine (9) Bores at 40 Feet Depth in the Same ROW

The parametric study detailed in G execution series, showed that 230-kV and 500-kV circuits meet the minimum ampacity requirements with a bore center-to-center separation of 90 feet between 230-kV 48" bores, 90 feet between 230-kV 48" and 500-kV 36" bores, and 52 feet between 500-kV 36" bores, for a total minimum ROW required of 418 feet, including 15 feet at each end assumed for work space and steering tolerances, for all nine (9) bores to be installed in the same ROW. The convergence case, detailed in execution G104, indicates that ampacities achieved are 3,974A for 230-kV circuit and 5,084A for 500-kV with 418 feet ROW. Figure 4 below shows the Microtunneling and J&B configuration for this case.

Figure 4 Microtunneling and J&B Configuration for Two 48" Bores and Five 36" Bores - 230-kV and 500-kV Circuits in the Same ROW at 40 Feet Depth NTS



CASE 2 INSTALLATION SCENARIOS – MICROTUNNELING AND J&B AT 30 FEET MAXIMUM DEPTH

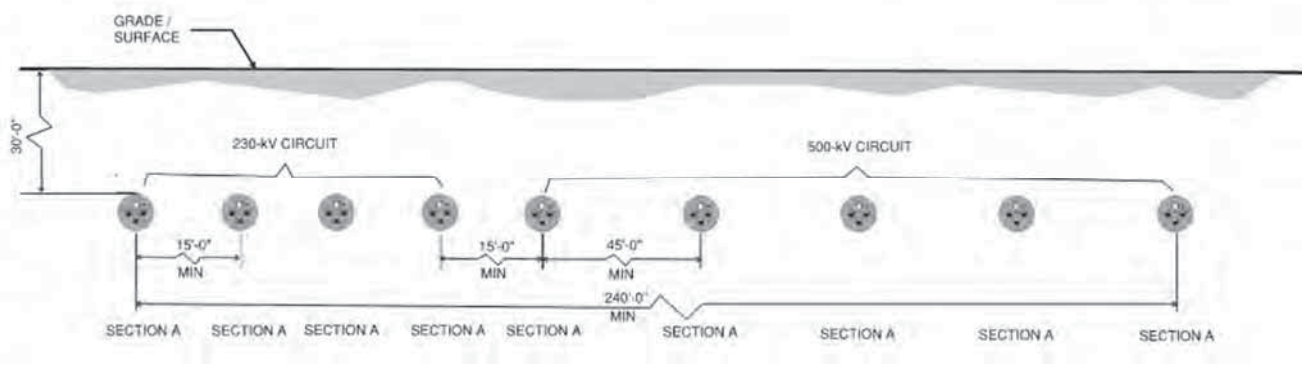
Similar to Case 1, both 230-kV and 500-kV circuits are set in the same trenchless ROW, then the bore is modeled at 30 feet maximum depth to calculate the minimum ROW required to meet cable ampacities.

The installation scenarios that were modeled as part of this Case 2 study are similar to the ones detailed in Case 1, but the assumed maximum depth is changed to 30 feet of cover.

Case 2: Four (4) 230-kV 36" Bores and Five (5) 500-kV 36" Bores - Nine (9) Bores at 30 Feet Depth in the Same ROW

The parametric study detailed in J execution series, showed that 230-kV and 500-kV circuits meet the minimum ampacity requirements with a bore center-to-center separation of 15 feet between 230-kV 36" bores, 15 feet between 230-kV 36" and 500-kV 36" bores, and 45 feet between 500-kV 36" bores, for a total minimum ROW required of 270 feet, including 15 feet at each end assumed for work space and steering tolerances, for all nine (9) bores to be installed in the same ROW. The convergence case, detailed in execution J103, indicates that ampacities achieved are 4,047A for 230-kV circuit and 5,043A for 500-kV with 270 feet ROW. Figure 5 below shows the Microtunneling and J&B configuration for this case.

Figure 5 Microtunneling and J&B Configuration for Nine 36" Bores - 230-kV and 500-kV Circuits in the Same ROW at 30 Feet Depth NTS

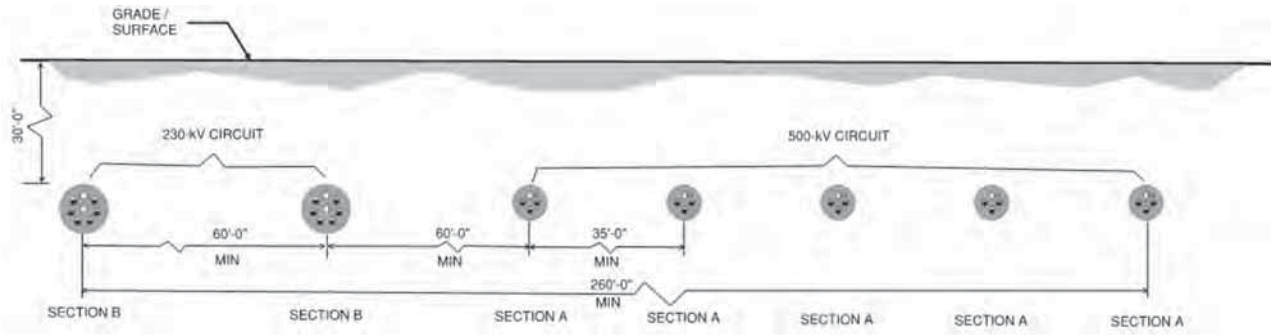


Case 2: Two (2) 230-kV 48" Bores and Five (5) 500-kV 36" Bores - Nine (9) Bores at 30 Feet Depth in the Same ROW

The parametric study detailed in I execution series, showed that 230-kV and 500-kV circuits meet the minimum ampacity requirements with a bore center-to-center separation of 60 feet between 230-kV 48" bores, 60 feet between 230-kV 48" and 500-kV 36" bores, and 35 feet between 500-kV 36" bores, for a total minimum ROW required of 290 feet, including 15 feet at each end assumed for work space and steering tolerances, for all nine (9) bores to be installed in

the same ROW. The convergence case, detailed in execution I103, indicates that ampacities achieved are 4,016A for 230-kV circuit and 5,043A for 500-kV with 290 feet ROW. Figure 6 below shows the Microtunneling and J&B configuration for this case.

Figure 6 Microtunneling and J&B Configuration for Two 48" Bores and Five 36" Bores - 230-kV and 500-kV Circuits in the Same ROW at 30 Feet Depth NTS



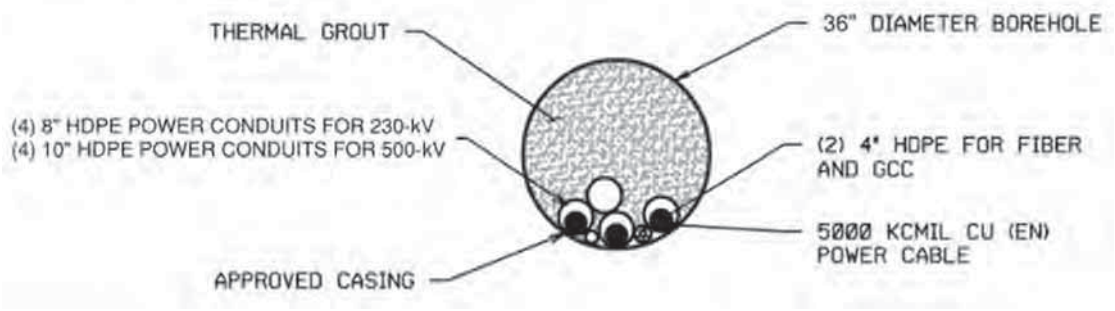
CASE 3 INSTALLATION SCENARIO – HDD AT 45 FEET MAXIMUM DEPTH

In this Case 3, both 230-kV and 500-kV circuits are set in the same trenchless ROW, then the bore is modeled at 45 feet maximum depth to calculate the minimum HDD ROW required to meet cable ampacities.

Since Case 1 and Case 2 showed that trenchless installation scenarios with double phase bores yielded larger ROW, for Case 3 the only installation scenario considered corresponds to single phase bores as indicated below:

1. Each 230-kV and 500-kV CPP is set in a single bore, that is:
    a. Four (4) 230-kV bores and five (5) 500-kV bores in the same ROW, nine (9) bores in total.
        i. Each bore will have a 36" HDPE DR 13.5 casing, with three (3) cables conduits and one (1) spare conduit. See Figure 7 for bore cross section.

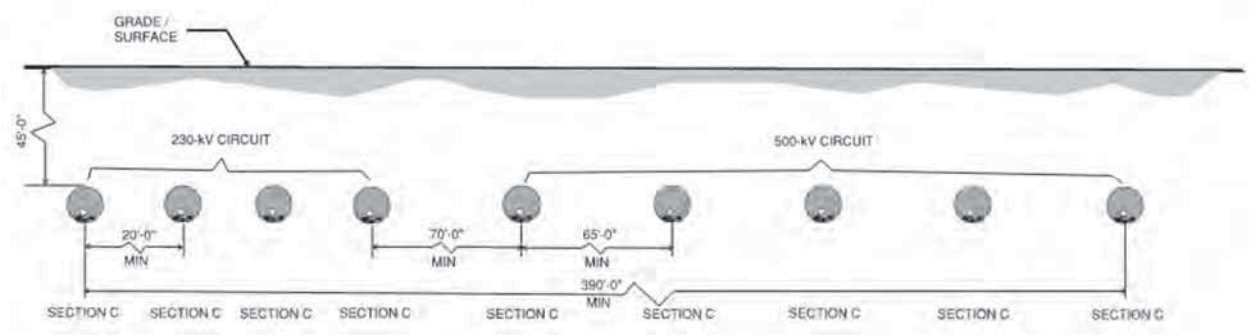
Figure 7 Preliminary 230-kV and 500-kV Single Phase XLPE HDD Cross Section (Section C) NTS



Case 3: Four (4) 230-kV 36" Bores and Five (5) 500-kV 36" Bores - Nine (9) Bores at 45 Feet Depth in the Same ROW

The parametric study detailed in K execution series, showed that 230-kV and 500-kV circuits meet the minimum ampacity requirements with a bore center-to-center separation of 20 feet between 230-kV 36" bores, 70 feet between 230-kV 36" and 500-kV 36" bores, and 65 feet between 500-kV 36" bores, for a total minimum ROW required of 420 feet, including 15 feet at each end assumed for work space and steering tolerances, for all nine (9) bores to be installed in the same ROW. The convergence case, detailed in execution K104, indicates that ampacities achieved are 4,061A for 230-kV circuit and 5,006A for 500-kV with 420 feet ROW. Figure 8 below shows the HDD configuration for this case.

Figure 8 HDD Configuration for Nine 36" Bores - 230-kV and 500-kV Circuits in the Same ROW at 45 Feet Depth NTS



SUMMARY OF RESULTS

The following summarizes the results of the additional ampacity case studies for the 230-kV and 500-kV cable systems when operating under the design parameters and installation conditions outlined in this memo.

For Case 1 and Case 2, microtunneling and J&B Installations at 40 feet and 30 feet maximum depths, respectively, the trenchless installations analyzed yielded consistently to a larger ROW for the case of two (2) 48" bores and five (5) 36" bores in the same corridor, when compared with nine (9) 36" bores configuration. Therefore, at 40 feet maximum installation depth, the minimum ROW achieved in the parametric study was 375 feet, corresponding to (9) 36" single phase bores for the parallel 230-kV and 500-kV cable systems arriving to 3,972A and 5,140A, respectively, meeting the required target ratings of 3,950A for 230-kV and 5,000A for 500-kV. Likewise, at 30 feet maximum installation depth, the (9) 36" single phase bores configuration produced the minimum ROW equal to 270 feet, arriving to 4,047A and 5,043A for 230-kV and 500-kV cable systems in parallel, respectively. These values meet the target ratings.

Case 3 – HDD Installation at 45 Feet Maximum Depth

The parametric analysis performed arrived to a minimum ROW equal to 420 for (9) 36" single phase bores in this HDD installation, where the parallel 230-kV and 500-kV cable systems are in the same corridor, yielding to 4,061A and 5,006A, respectively, satisfying the target ratings.

For ampacity calculation summary table and detailed results of all executions refer to Appendix A. See Appendix B for UG cable cut sheets used for this ampacity analysis.

Sincerely,

Gustavo Contreras
Underground Transmission Lead Engineer, BMcD

Appendix A: Ampacity Execution Reports
Appendix B: UG Cable Cutsheets

APPENDIX A AMPACITY SUMMARY TABLE AND EXECUTION REPORTS

CLIENT NAME: DOMINION ENERGY, VIRGINIA (DEV)
PROJECT NAME: GOLDEN TO MARS TRANSMISSION LINE - 4 NEW ROUTES
Prepared By: J. Morales **Date:** 2024-10-31
Reviewed BY: G. Contreras **Date:** 2024-11-01

VOLTAGE CLASS: 230-kV & 500-kV
ROUTE LENGTH [ft]: Varies

PACKAGE: IFR Using Taihan and Prysmian Reference Cable Cutsheets
Underground Transmission Cable System

ITERATION # 1

Modeling Scenario		Execution	Voltage (kV)	Trenchless Technology (6)	Casing Configuration	Casing Size and Material (1)	Casing Horizontal Separation (Center to Center) (ft)	Approximate ROW w/15ft at Each End (ft)	Conduit Bundle Duct Size and Material	Grout Thermal Resistivity (°C-m/W) (2)	Native soil Thermal Resistivity (°C-m/W) (3)	Depth of Cover to Top of Casing (ft) (5)	Ambient Temperature (°C)	Conductor Size/Type (4)	Number of Circuits	Cables per Phase (CPP)	DLF	Rating (MVA)	Rating (Amps)	DEV's Target Ampacity/ Circuit (Amps)	Ampacity Capacity Circuit (Amps)	Proposed Transmission Cable max Temp (°C)
SET 1: 230-kV & 500-kV in Same ROW	*230-kV - 4 CPP - 5,000kcmil Ins Cu XLPE *500-kV - 5 CPP - 5,000kcmil Ins Cu XLPE Steady State Loading Trenchless	G100	230	J&B and Microtunneling	7 - 2 with (2) 230-kV CPP and 5 with (1) 500-kV CPP each.	2 - 48" HOBAS 5 - 36" HOBAS	60.00	390.00	8-8" SCH40 PVC Per 48" HOBAS & 4-8" SCH40 PVC Per 36" HOBAS	0.80	1.15	40.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	3772	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	5169	90
		G101	230	J&B and Microtunneling	7 - 2 with (2) 230-kV CPP and 5 with (1) 500-kV CPP each.	2 - 48" HOBAS 5 - 36" HOBAS	70 for 48" HOBAS & 50 for 36" HOBAS	370.00	8-8" SCH40 PVC Per 48" HOBAS & 4-8" SCH40 PVC Per 36" HOBAS	0.80	1.15	40.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	3844	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	4985	90
		G102	230	J&B and Microtunneling	7 - 2 with (2) 230-kV CPP and 5 with (1) 500-kV CPP each.	2 - 48" HOBAS 5 - 36" HOBAS	80 for 48" HOBAS & 55 for 36" HOBAS	410.00	8-8" SCH40 PVC Per 48" HOBAS & 4-8" SCH40 PVC Per 36" HOBAS	0.80	1.15	40.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	3919	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	5127	90
		G103	230	J&B and Microtunneling	7 - 2 with (2) 230-kV CPP and 5 with (1) 500-kV CPP each.	2 - 48" HOBAS 5 - 36" HOBAS	85 for 48" HOBAS & 52 for 36" HOBAS	408.00	8-8" SCH40 PVC Per 48" HOBAS & 4-8" SCH40 PVC Per 36" HOBAS	0.80	1.15	40.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	3946	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	5072	90
		G104	230	J&B and Microtunneling	7 - 2 with (2) 230-kV CPP and 5 with (1) 500-kV CPP each.	2 - 48" HOBAS 5 - 36" HOBAS	90 for 48" HOBAS & 52 for 36" HOBAS	418.00	8-8" SCH40 PVC Per 48" HOBAS & 4-8" SCH40 PVC Per 36" HOBAS	0.80	1.15	40.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	3974	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	5084	90
		H101	230	J&B and Microtunneling	9 - 4 with (1) 230-kV CPP and 5 with (1) 500-kV CPP each.	9 - 36" HOBAS	30 for 230-kV HOBAS & 50 for 500-kV HOBAS	350.00	4-8" SCH40 PVC Per 36" HOBAS	0.80	1.15	40.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	4369	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	4789	90
		H102	230	J&B and Microtunneling	9 - 4 with (1) 230-kV CPP and 5 with (1) 500-kV CPP each.	9 - 36" HOBAS	30 for 230-kV HOBAS, 50 between 230-kV and 500-kV HOBAS & 50 for 500-kV HOBAS	370.00	4-8" SCH40 PVC Per 36" HOBAS	0.80	1.15	40.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	4454	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	4893	90
		H103	230	J&B and Microtunneling	9 - 4 with (1) 230-kV CPP and 5 with (1) 500-kV CPP each.	9 - 36" HOBAS	30 for 230-kV HOBAS, 60 between 230-kV and 500-kV HOBAS & 60 for 500-kV HOBAS	420.00	4-8" SCH40 PVC Per 36" HOBAS	0.80	1.15	40.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	4499	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	5152	90
		H104	230	J&B and Microtunneling	9 - 4 with (1) 230-kV CPP and 5 with (1) 500-kV CPP each.	9 - 36" HOBAS	25 for 230-kV HOBAS, 60 between 230-kV and 500-kV HOBAS & 60 for 500-kV HOBAS	405.00	4-8" SCH40 PVC Per 36" HOBAS	0.80	1.15	40.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	4355	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	5147	90
		H105	230	J&B and Microtunneling	9 - 4 with (1) 230-kV CPP and 5 with (1) 500-kV CPP each.	9 - 36" HOBAS	15 for 230-kV HOBAs, 60 between 230-kV and 500-kV HOBASs & 60 for 500-kV HOBAAs	375.00	4-8" SCH40 PVC Per 36" HOBAS	0.80	1.15	40.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	3972	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	5140	90
		I100	230	J&B and Microtunneling	7 - 2 with (2) 230-kV CPP and 5 with (1) 500-kV CPP each.	2 - 48" HOBAS 5 - 36" HOBAS	90 for 48" HOBAS & 52 for 36" HOBAS	418.00	8-8" SCH40 PVC Per 48" HOBAS & 4-8" SCH40 PVC Per 36" HOBAS	0.80	1.15	30.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	4222	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	5590	90
		I101	230	J&B and Microtunneling	7 - 2 with (2) 230-kV CPP and 5 with (1) 500-kV CPP each.	2 - 48" HOBAS 5 - 36" HOBAS	85 for 48" HOBAS & 45 for 36" HOBAS	380.00	8-8" SCH40 PVC Per 48" HOBAS & 4-8" SCH40 PVC Per 36" HOBAS	0.80	1.15	30.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	4195	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	5420	90
		I102	230	J&B and Microtunneling	7 - 2 with (2) 230-kV CPP and 5 with (1) 500-kV CPP each.	2 - 48" HOBAS 5 - 36" HOBAS	65 for 48" HOBAS & 30 for 36" HOBAS	280.00	8-8" SCH40 PVC Per 48" HOBAS & 4-8" SCH40 PVC Per 36" HOBAS	0.80	1.15	30.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	4052	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	4857	90
		I103	230	J&B and Microtunneling	7 - 2 with (2) 230-kV CPP and 5 with (1) 500-kV CPP each.	2 - 48" HOBAS 5 - 36" HOBAS	60 for 48" HOBAS & 35 for 36" HOBAS	290.00	8-8" SCH40 PVC Per 48" HOBAS & 4-8" SCH40 PVC Per 36" HOBAS	0.80	1.15	30.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	4016	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	5043	90
		J100	230	J&B and Microtunneling	9 - 4 with (1) 230-kV CPP and 5 with (1) 500-kV CPP each.	9 - 36" HOBAS	15 for 230-kV HOBAS, 60 between 230-kV and 500-kV HOBAS & 60 for 500-kV HOBAS	375.00	4-8" SCH40 PVC Per 36" HOBAS	0.80	1.15	30.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	4307	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	5650	90
		J101	230	J&B and Microtunneling	9 - 4 with (1) 230-kV CPP and 5 with (1) 500-kV CPP each.	9 - 36" HOBAS	15 for 230-kV HOBAS, 35 between 230-kV and 500-kV HOBAS & 35 for 500-kV HOBAS	250.00	4-8" SCH40 PVC Per 36" HOBAS	0.80	1.15	30.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	4162	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	4888	90
		J102	230	J&B and Microtunneling	9 - 4 with (1) 230-kV CPP and 5 with (1) 500-kV CPP each.	9 - 36" HOBAS	15 for 230-kV HOBAS, 30 between 230-kV and 500-kV HOBAS & 45 for 500-kV HOBAS	285.00	4-8" SCH40 PVC Per 36" HOBAS	0.80	1.15	30.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	4156	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	5184	90
		J103	230	J&B and Microtunneling	9 - 4 with (1) 230-kV CPP and 5 with (1) 500-kV CPP each.	9 - 36" HOBAS	15 for 230-kV HOBAS, 15 between 230-kV and 500-kV HOBAS & 45 for 500-kV HOBAS	270.00	4-8" SCH40 PVC Per 36" HOBAS	0.80	1.15	30.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	4047	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	5043	90
		K100	230	HDD	9 - 4 with (1) 230-kV CPP and 5 with (1) 500-kV CPP each.	9 - 36" HDPE DR 13.5	15 for 230-kV HDPEs, 60 between 230-kV and 500-kV HDPEs & 60 for 500-kV HDPEs	375.00	4-8" HDPE DR 11 for 230-kV 36" HDPE 4-10" HDPE DR 11 for 500-kV 36" HDPE	0.80	1.15	45.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	3825	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	4878	90
		K101	230	HDD	9 - 4 with (1) 230-kV CPP and 5 with (1) 500-kV CPP each.	9 - 36" HDPE DR 13.5	25 for 230-kV HDPEs, 70 between 230-kV and 500-kV HDPEs & 70 for 500-kV HDPEs	455.00	4-8" HDPE DR 11 for 230-kV 36" HDPE 4-10" HDPE DR 11 for 500-kV 36" HDPE	0.80	1.15	45.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	4229	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	5092	90
		K102	230	HDD	9 - 4 with (1) 230-kV CPP and 5 with (1) 500-kV CPP each.	9 - 36" HDPE DR 13.5	20 for 230-kV HDPEs, 60 between 230-kV and 500-kV HDPEs & 65 for 500-kV HDPEs	410.00	4-8" HDPE DR 11 for 230-kV 36" HDPE 4-10" HDPE DR 11 for 500-kV 36" HDPE	0.80	1.15	45.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	4032	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	4974	90
		K103	230	HDD	9 - 4 with (1) 230-kV CPP and 5 with (1) 500-kV CPP each.	9 - 36" HDPE DR 13.5	20 for 230-kV HDPEs, 65 between 230-kV and 500-kV HDPEs & 65 for 500-kV HDPEs	415.00	4-8" HDPE DR 11 for 230-kV 36" HDPE 4-10" HDPE DR 11 for 500-kV 36" HDPE	0.80	1.15	45.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	4047	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	4990	90
		K104	230	HDD	9 - 4 with (1) 230-kV CPP and 5 with (1) 500-kV CPP each.	9 - 36" HDPE DR 13.5	20 for 230-kV HDPEs, 70 between 230-kV and 500-kV HDPEs & 65 for 500-kV HDPEs	420.00	4-8" HDPE DR 11 for 230-kV 36" HDPE 4-10" HDPE DR 11 for 500-kV 36" HDPE	0.80	1.15	45.00	12	5,000kcmil Ins Cu XLPE	1	4	1.00	1572	3947	3950	4061	90
			500											5,000kcmil Ins Cu XLPE	1	5		4330	5000	5000	5006	90

*NA: Not Applicable

LEGEND:
Ampacity achieved does not meet DEVs target ampacity
Convergence case

NOTES:
1. Casing size and material based off high-level and generic information. When each crossing site-specific geotechnical investigation is available they may need to be revised and anlysis results in this memo may change.
2. Grout Thermal resistivity assumed.
3. Actual native soil thermal resistivity is unknown. This value is being assumed equal to the one used for DLF=1.0 in Dominion Golden to Mars – 230-kV and 500-kV Underground Feasibility Report, Revision 4 dated 09/10/2024. When data from filed investigations are available this value may need to be revised and anlysis results in this memo may change.
4. Enamel XLPE cables from cable reference cutsheets from Prysmian and Taihan.
5. Actual site-specific geotechnical investigation for each crossing is not available for this high-level analysis. Therefore, depth may change depending on the site crossing specific conditions / rock strata quality, and results of this memo may change.
6. Actual site-specific geotechnical investigation for each crossing is not available for this high-level analysis. Therefore, depending on the site crossing specific conditions / rock strata quality, trenchless technology at each crossing and results of this memo may change.

Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	G100-230_500kV,40_DOC,60_,5000kcmilInCu,@3772_5169A DLF1
Date:	11/3/2024 11:40:46 PM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

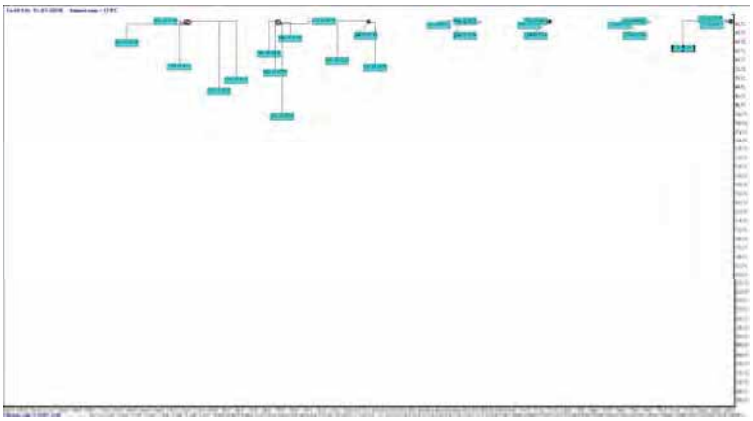
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB1	-60.0	41.933	3.517	3.517	0.8
NSTD DB2	0.0	41.429	2.6	2.6	0.8
NSTD DB3	-120.0	41.933	3.517	3.517	0.8
NSTD DB4	60.0	41.429	2.6	2.6	0.8
NSTD DB5	120.0	41.429	2.6	2.6	0.8
NSTD DB6	180.001	41.429	2.6	2.6	0.8
NSTD DB7	240.001	41.429	2.6	2.6	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	230C5.00X1	1		A	60.0	1.0	-61.08	41.88	90.0	956.0
2	230C5.00X1	1		B	60.0	1.0	-60.5	41.05	88.5	956.0
3	230C5.00X1	1		C	60.0	1.0	-59.5	41.05	87.7	956.0
4	230C5.00X1	2		A	60.0	1.0	-60.0	43.38	89.9	871.2
5	230C5.00X1	2		B	60.0	1.0	-59.22	42.88	88.4	871.2
6	230C5.00X1	2		C	60.0	1.0	-60.78	42.88	90.0	871.2
7	500C5.00X	3		A	60.0	1.0	-0.5	41.93	90.0	994.0
8	500C5.00X	3		B	60.0	1.0	-0.5	40.93	89.2	994.0
9	500C5.00X	3		C	60.0	1.0	0.5	40.93	88.4	994.0
10	230C5.00X1	4		A	60.0	1.0	-121.08	41.88	90.0	1014.5
11	230C5.00X1	4		B	60.0	1.0	-120.5	41.05	88.5	1014.5
12	230C5.00X1	4		C	60.0	1.0	-119.5	41.05	87.8	1014.5
13	230C5.00X1	5		A	60.0	1.0	-120.0	43.38	89.9	929.9
14	230C5.00X1	5		B	60.0	1.0	-119.22	42.88	88.5	929.9
15	230C5.00X1	5		C	60.0	1.0	-120.78	42.88	90.0	929.9
16	500C5.00X	6		A	60.0	1.0	59.5	41.93	90.0	1005.6
17	500C5.00X	6		B	60.0	1.0	59.5	40.93	89.2	1005.6
18	500C5.00X	6		C	60.0	1.0	60.5	40.93	88.4	1005.6
19	500C5.00X	7		A	60.0	1.0	119.5	41.93	90.0	1014.7
20	500C5.00X	7		B	60.0	1.0	119.5	40.93	89.2	1014.7
21	500C5.00X	7		C	60.0	1.0	120.5	40.93	88.4	1014.7
22	500C5.00X	8		A	60.0	1.0	179.5	41.93	90.0	1037.2
23	500C5.00X	8		B	60.0	1.0	179.5	40.93	89.3	1037.2
24	500C5.00X	8		C	60.0	1.0	180.5	40.93	88.4	1037.2
25	500C5.00X	9		A	60.0	1.0	239.5	41.93	90.0	1117.4
26	500C5.00X	9		B	60.0	1.0	239.5	40.93	89.3	1117.4
27	500C5.00X	9		C	60.0	1.0	240.5	40.93	88.2	1117.4

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	G100-230_500kV.40_DCC.60_5000kcmilInCu@3772_5169A DLF1
Date:	11/3/2024 11:40:46 PM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Variable	Description	Unit	Cables																												
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27		
General Input Data																															
Cable ID	Cable Equipment ID		230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	500C5.00X	500C5.00X	500C5.00X	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X		
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9		
Phase	Cable Phase		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C		
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0		
x	X coordinate	[ft]	-61.08	-60.5	-59.5	-60.0	-59.22	-60.78	-0.5	-0.5	0.5	-121.08	-120.5	-119.5	-120.0	-119.22	-120.78	59.5	59.5	60.5	119.5	119.5	120.5	179.5	179.5	180.5	239.5	239.5	240.5		
y	Y coordinate	[ft]	41.88	41.05	41.05	43.38	42.88	42.88	41.93	40.93	40.93	41.88	41.05	41.05	43.38	42.88	42.88	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93		
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular		
Ampacity																															
I	Steady State Ampacity	[A]	956.0	956.0	956.0	871.2	871.2	871.2	994.0	994.0	994.0	1014.5	1014.5	1014.5	929.9	929.9	929.9	1005.6	1005.6	1005.6	1014.7	1014.7	1014.7	1037.2	1037.2	1037.2	1117.4	1117.4	1117.4		
Temperatures																															
θc	Conductor temperature	[°C]	90.0	88.5	87.7	89.9	88.4	90.0	90.0	89.2	88.4	90.0	88.5	87.8	89.9	88.5	90.0	90.0	89.2	88.4	90.0	89.2	88.4	90.0	89.3	88.4	90.0	89.3	88.2		
θs	Sheath/Shield temperature	[°C]	86.6	85.1	84.3	87.0	85.5	87.1	84.5	83.8	82.9	86.2	84.8	84.0	86.7	85.2	86.8	84.4	83.7	82.9	84.4	83.6	82.8	84.2	83.4	82.6	83.4	82.8	81.7		
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
θsurf	Cable surface temperature	[°C]	86.2	84.7	83.9	86.6	85.1	86.8	83.6	82.8	82.0	85.8	84.3	83.6	86.3	84.8	86.4	83.5	82.7	81.9	83.4	82.6	81.8	83.1	82.4	81.5	82.3	81.7	80.6		
θduct	Duct surface temperature	[°C]	82.9	81.4	80.6	83.8	82.3	83.9	79.0	78.2	77.4	82.1	80.6	79.9	83.1	81.7	83.2	78.8	78.0	77.2	78.6	77.9	77.0	78.3	77.6	76.7	76.9	76.3	75.1		
Resistances																															
R_c	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116		
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01666	0.0166	0.01657	0.01668	0.01662	0.01669	0.01663	0.0166	0.01657	0.01666	0.0166	0.01658	0.01668	0.01663	0.01669	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.01661	0.01656		
ys	Skin Effect Factor		0.16157	0.16287	0.16362	0.1617	0.163	0.16157	0.16154	0.1622	0.16293	0.16157	0.16284	0.16352	0.16164	0.16281	0.16157	0.16154	0.1622	0.16293	0.16154	0.1622	0.16293	0.16154	0.1627	0.16295	0.16154	0.16212	0.1631		
yp	Proximity Effect Factor		0.00918	0.00924	0.00928	0.011	0.01108	0.01099	0.00713	0.00716	0.00718	0.00918	0.00924	0.00927	0.01099	0.01107	0.01099	0.00713	0.00716	0.00718	0.00713	0.00716	0.00718	0.00713	0.00715	0.00719	0.00713	0.00715	0.00719		
Losses																															
Wc	Conductor Losses	[W/ft]	2.88384	2.87391	2.86831	2.39758	2.38938	2.3984	3.11246	3.10693	3.10098	3.24759	3.23667	3.23096	2.73202	2.72285	2.73247	3.18557	3.17994	3.17366	3.24361	3.23795	3.23164	3.38905	3.38334	3.37836	3.93327	3.92716	3.91705		
Wd	Dielectric Losses	[W/ft]	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	2.01332	2.01332	2.01332	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332		
Ws	Metallic Screen Losses	[W/ft]	0.15465	0.15534	0.15574	0.15406	0.15475	0.15399	0.28416	0.28478	0.28545	0.17436	0.17513	0.17553	0.17767	0.17644	0.17583	0.29091	0.29154	0.29223	0.29628	0.29691	0.29762	0.30973	0.31037	0.31116	0.36021	0.3609	0.36205		
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Wt	Total Losses	[W/ft]	3.59288	3.58364	3.57844	3.10603	3.09852	3.10678	5.40994	5.40503	5.39975	3.97834	3.96619	3.96088	3.46208	3.45369	3.46249	5.48681	5.48481	5.47942	5.55321	5.54819	5.54239	5.72111	5.70704	5.70085	6.30681	6.30139	6.29242		
λ_1	Screen Loss Factor		0.05363	0.05405	0.0543	0.05426	0.05477	0.05421	0.0913	0.09166	0.09205	0.05369	0.05411	0.05433	0.0943	0.0948	0.09428	0.09132	0.09168	0.09207	0.09104	0.0917	0.0921	0.09139	0.09174	0.09216	0.09158	0.0919	0.09243		
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Thermal resistances																															
T1	Thermal resistance of insulation	[K.m/W]	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.4049	0.4049	0.4049	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049		
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
T3	Thermal resistance of outer covering	[K.m/W]	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.05408	0.05408	0.05408	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408		
T4	External thermal resistance	[K.m/W]	6.29454	6.18493	6.12304	7.32374	7.19547	7.33658	4.03221	3.99299	3.95069	5.65432	5.59806	5.50777	6.54245	6.42972	6.54672	3.96737	3.92894	3.88738	3.91723	3.87979	3.83791	3.79646	3.76133	3.71834	3.39844	3.36932	3.33097		
Others																															
ΔTint	Temperature rise due to surrounding heat sources	[°C]	59.5	58.1	57.4	61.8	60.5	62.0	49.9	49.1	48.4	57.4	56.1	55.4	59.9	58.6	60.1	49.5	48.6	48.0	49.1	48.3	47.6	48.3	47.4	46.7	44.9	44.1	43.2		
	Induced Voltage (standing) on Sheath	[V/mile]	196.89	185.41	224.59	190.28	181.43	164.72	203.39	184.1	200.57	212.35	192.09	237.64	206.24	189.62	179.58	205.44	183.8	204.77	206.73	184.19	208.05	210.52	187.2	214.18	225.29	200.15	233.31		
	Induced Voltage (standing) on Concentric Wires	[V/mile]	199.55	188.04	227.05	192.7	183.8	166.62	205.53	186.29	202.71	215.17	194.89	240.28	208.82	192.14	181.58	207.62	186.02	206.95	208.93	186.43	210.25	212.77	189.49	216.43	227.72	202.61	235.73		
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

Cables Report

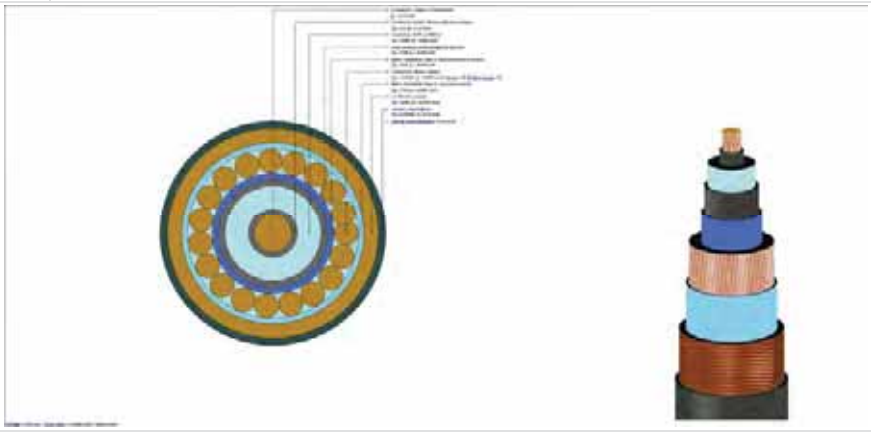
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	G100-230_500kV,40_DOC,60_,5000kcmilInCu,@3772_5169A DLF1
Date:	11/3/2024 11:40:46 PM

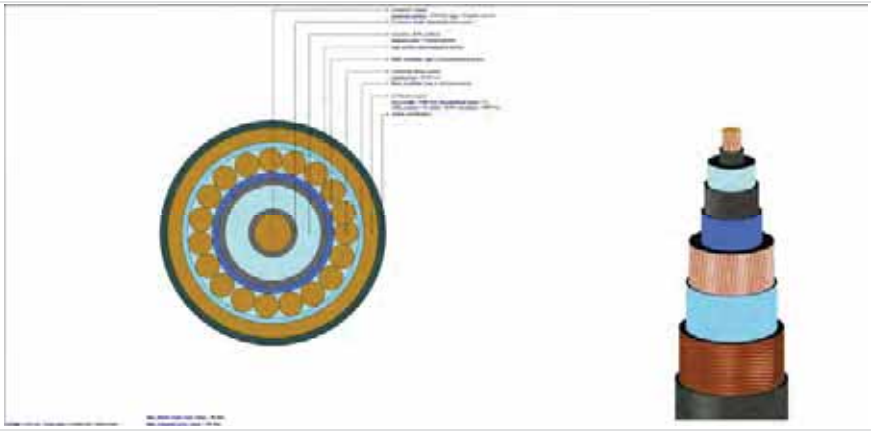
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		PVC Duct in Concrete
71	Duct material thermal resistivity	[K.m/W]	6
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	7.942
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





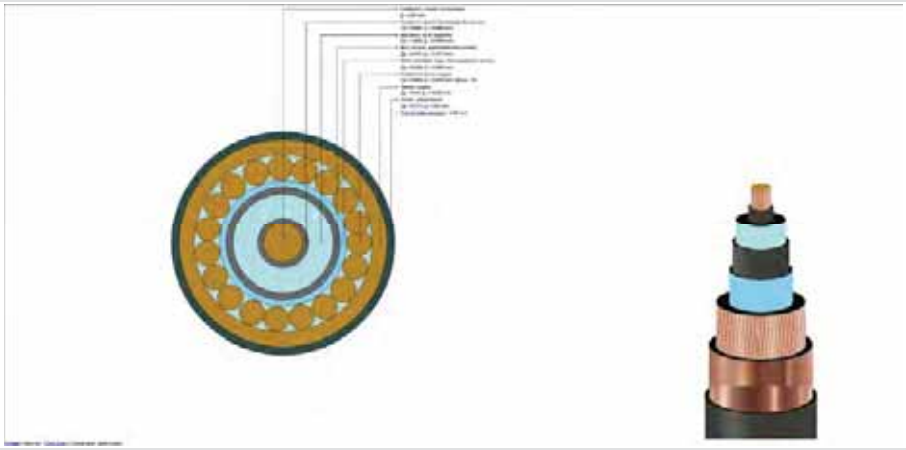
Cables Report

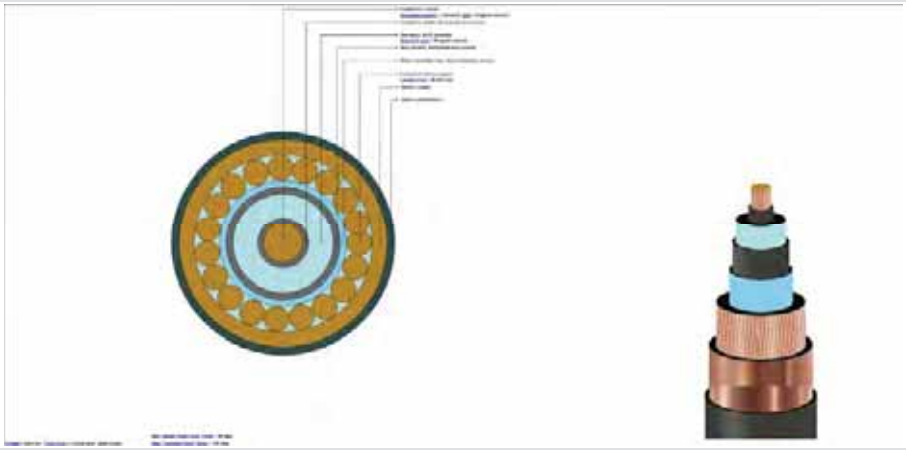
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	G100-230_500kV,40_DOC,60_,5000kcmilInCu,@3772_5169A DLF1
Date:	11/3/2024 11:40:46 PM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		PVC Duct in Concrete
66	Duct material thermal resistivity	[K.m/W]	6
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	7.942
69	Outer diameter of the conduit	[in]	8.625

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	G101-230_500kV,40_DOC,70__50_,5000kcmilInCu,@3844_4985A DLF1
Date:	11/3/2024 10:29:35 PM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

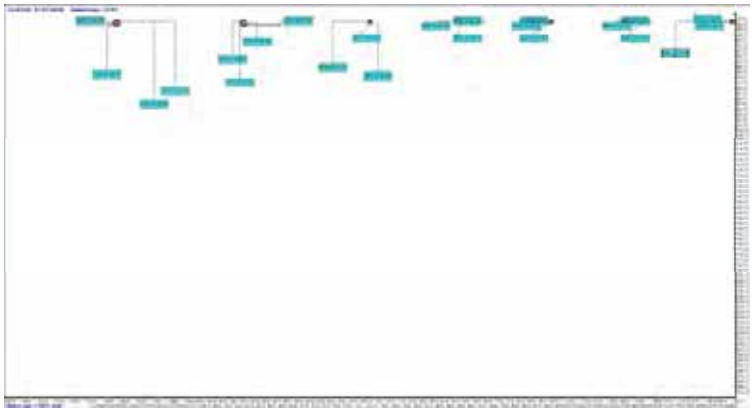
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB1	-70.0	41.933	3.517	3.517	0.8
NSTD DB2	0.0	41.429	2.6	2.6	0.8
NSTD DB3	-140.0	41.933	3.517	3.517	0.8
NSTD DB4	50.0	41.429	2.6	2.6	0.8
NSTD DB5	100.0	41.429	2.6	2.6	0.8
NSTD DB6	150.0	41.429	2.6	2.6	0.8
NSTD DB7	200.001	41.429	2.6	2.6	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	230C5.00X1	1		A	60.0	1.0	-71.08	41.88	90.0	976.5
2	230C5.00X1	1		B	60.0	1.0	-70.5	41.05	88.5	976.5
3	230C5.00X1	1		C	60.0	1.0	-69.5	41.05	87.6	976.5
4	230C5.00X1	2		A	60.0	1.0	-70.0	43.38	89.8	891.8
5	230C5.00X1	2		B	60.0	1.0	-69.22	42.88	88.3	891.8
6	230C5.00X1	2		C	60.0	1.0	-70.78	42.88	90.0	891.8
7	500C5.00X	3		A	60.0	1.0	-0.5	41.93	90.0	987.3
8	500C5.00X	3		B	60.0	1.0	-0.5	40.93	89.2	987.3
9	500C5.00X	3		C	60.0	1.0	0.5	40.93	88.5	987.3
10	230C5.00X1	4		A	60.0	1.0	-141.08	41.88	90.0	1029.8
11	230C5.00X1	4		B	60.0	1.0	-140.5	41.05	88.5	1029.8
12	230C5.00X1	4		C	60.0	1.0	-139.5	41.05	87.7	1029.8
13	230C5.00X1	5		A	60.0	1.0	-140.0	43.38	89.9	946.2
14	230C5.00X1	5		B	60.0	1.0	-139.22	42.88	88.4	946.2
15	230C5.00X1	5		C	60.0	1.0	-140.78	42.88	90.0	946.2
16	500C5.00X	6		A	60.0	1.0	49.5	41.93	90.0	959.5
17	500C5.00X	6		B	60.0	1.0	49.5	40.93	89.2	959.5
18	500C5.00X	6		C	60.0	1.0	50.5	40.93	88.5	959.5
19	500C5.00X	7		A	60.0	1.0	99.5	41.93	90.0	962.6
20	500C5.00X	7		B	60.0	1.0	99.5	40.93	89.2	962.6
21	500C5.00X	7		C	60.0	1.0	100.5	40.93	88.4	962.6
22	500C5.00X	8		A	60.0	1.0	149.5	41.93	90.0	989.3
23	500C5.00X	8		B	60.0	1.0	149.5	40.93	89.3	989.3
24	500C5.00X	8		C	60.0	1.0	150.5	40.93	88.4	989.3
25	500C5.00X	9		A	60.0	1.0	199.5	41.93	90.0	1085.9
26	500C5.00X	9		B	60.0	1.0	199.5	40.93	89.3	1085.9
27	500C5.00X	9		C	60.0	1.0	200.5	40.93	88.2	1085.9

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	G101-230_500kV,40_DOC,70__50_,5000kcmilInCu@3844_4985A DLF1
Date:	11/3/2024 10:29:35 PM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Variable	Description	Unit	Cables								
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9
General Input Data											
Cable ID	Cable Equipment ID		230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-71.08	-70.5	-69.5	-70.0	-69.22	-70.78	-0.5	-0.5	0.5
y	Y coordinate	[ft]	41.88	41.05	41.05	43.38	42.88	42.88	41.93	40.93	40.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	976.5	976.5	976.5	891.8	891.8	891.8	987.3	987.3	987.3
Temperatures											
θc	Conductor temperature	[°C]	90.0	88.5	87.6	89.8	88.3	90.0	90.0	89.2	88.5
θs	Sheath/Shield temperature	[°C]	86.5	85.0	84.1	86.8	85.3	87.0	84.6	83.8	83.1
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	86.0	84.5	83.7	86.5	85.0	86.6	83.6	82.9	82.1
θduct	Duct surface temperature	[°C]	82.6	81.1	80.2	83.5	82.0	83.7	79.1	78.3	77.6
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01666	0.0166	0.01657	0.01668	0.01662	0.01669	0.01663	0.0166	0.01657
ys	Skin Effect Factor		0.16157	0.1629	0.16366	0.1617	0.16304	0.16157	0.16154	0.16221	0.16285
yp	Proximity Effect Factor		0.00918	0.00924	0.00928	0.011	0.01108	0.01099	0.00713	0.00716	0.00718
Losses											
Wc	Conductor Losses	[W/ft]	3.00859	2.99805	2.99204	2.51271	2.50386	2.51359	3.07066	3.06515	3.05996
Wd	Dielectric Losses	[W/ft]	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.1614	0.16214	0.16257	0.16152	0.16227	0.16145	0.28029	0.28091	0.2815
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	3.72438	3.71459	3.709	3.22862	3.22052	3.22943	5.36428	5.35939	5.35478
λ_1	Screen Loss Factor		0.05365	0.05408	0.05433	0.06428	0.06481	0.06423	0.09128	0.09165	0.09199
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	6.06009	5.9527	5.8913	7.03235	6.90544	7.04397	4.07015	4.03022	3.99247
Others											
Δθint	Temperature rise due to surrounding heat sources	[°C]	58.8	57.4	56.7	61.1	59.8	61.4	50.2	49.3	48.7
	Induced Voltage (standing) on Sheath	[V/mile]	201.22	188.92	229.55	194.83	185.31	169.11	202.81	182.89	198.39
	Induced Voltage (standing) on Concentric Wires	[V/mile]	203.93	191.61	232.07	197.3	187.73	171.05	204.94	185.07	200.53
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	Description	Unit	Cables								
Cable No.	Cable Index Number		10	11	12	13	14	15	16	17	18
General Input Data											
Cable ID	Cable Equipment ID		230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		4	4	4	5	5	5	6	6	6
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-141.08	-140.5	-139.5	-140.0	-139.22	-140.78	49.5	49.5	50.5
y	Y coordinate	[ft]	41.88	41.05	41.05	43.38	42.88	42.88	41.93	40.93	40.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	1029.8	1029.8	1029.8	946.2	946.2	946.2	959.5	959.5	959.5
Temperatures											
θc	Conductor temperature	[°C]	90.0	88.5	87.7	89.9	88.4	90.0	90.0	89.2	88.5
θs	Sheath/Shield temperature	[°C]	86.1	84.6	83.8	86.5	85.0	86.7	84.8	84.0	83.3
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	85.6	84.2	83.3	86.1	84.6	86.3	83.9	83.1	82.4
θduct	Duct surface temperature	[°C]	81.9	80.4	79.6	82.9	81.3	83.0	79.5	78.7	78.0
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01666	0.0166	0.01657	0.01668	0.01662	0.01669	0.01663	0.0166	0.01657
ys	Skin Effect Factor		0.16157	0.16288	0.16361	0.16167	0.163	0.16157	0.16154	0.16222	0.16288
yp	Proximity Effect Factor		0.00918	0.00924	0.00928	0.011	0.01108	0.01099	0.00713	0.00716	0.00718
Losses											
Wc	Conductor Losses	[W/ft]	3.34627	3.33468	3.3283	2.82889	2.81897	2.82962	2.89989	2.89467	2.88956
Wd	Dielectric Losses	[W/ft]	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.17971	0.18053	0.18098	0.182	0.18283	0.18193	0.26454	0.26512	0.2657
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	4.08038	4.0696	4.06367	3.56528	3.5562	3.56594	5.17775	5.17312	5.16858
λ_1	Screen Loss Factor		0.05371	0.05414	0.05438	0.06433	0.06486	0.0643	0.09122	0.09159	0.09195
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	5.50135	5.4047	5.35162	6.33962	6.22541	6.34688	4.23208	4.19045	4.14961
Others											
Δθint	Temperature rise due to surrounding heat sources	[°C]	56.9	55.5	54.8	59.3	58.0	59.5	51.2	50.3	49.7
	Induced Voltage (standing) on Sheath	[V/mile]	215.08	195.11	241.66	209.33	193.0	182.84	196.12	175.56	195.14
	Induced Voltage (standing) on Concentric Wires	[V/mile]	217.94	197.94	244.33	211.96	195.57	184.88	198.2	177.67	197.22
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	Description	Unit	Cables								
Cable No.	Cable Index Number		19	20	21	22	23	24	25	26	27
General Input Data											
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		7	7	7	8	8	8	9	9	9
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	99.5	99.5	100.5	149.5	149.5	150.5	199.5	199.5	200.5
y	Y coordinate	[ft]	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	962.6	962.6	962.6	989.3	989.3	989.3	1085.9	1085.9	1085.9
Temperatures											
θc	Conductor temperature	[°C]	90.0	89.2	88.4	90.0	89.3	88.4	90.0	89.3	88.2
θs	Sheath/Shield temperature	[°C]	84.8	84.0	83.2	84.6	83.8	83.0	83.7	83.0	81.9
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	83.9	83.1	82.3	83.6	82.9	82.0	82.7	82.0	80.9
θduct	Duct surface temperature	[°C]	79.4	78.7	77.9	79.0	78.3	77.4	77.5	76.8	75.7
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.01661	0.01656
ys	Skin Effect Factor		0.16154	0.16221	0.1629	0.16154	0.16219	0.16293	0.16154	0.16214	0.16312
yp	Proximity Effect Factor		0.00713	0.00716	0.00718	0.00713	0.00715	0.00718	0.00713	0.00715	0.00719
Losses											
Wc	Conductor Losses	[W/ft]	2.91872	2.9135	2.9082	3.0833	3.07799	3.07193	3.71471	3.7088	3.69913
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.26627	0.26686	0.26745	0.28146	0.28206	0.28274	0.33992	0.34058	0.34167
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	5.19831	5.19368	5.18897	5.37808	5.37337	5.368	6.06795	6.06271	6.05413
λ_1	Screen Loss Factor		0.09123	0.09159	0.09197	0.09129	0.09164	0.09204	0.09151	0.09183	0.09237
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	4.21367	4.17255	4.13057	4.05863	4.0204	3.97669	3.54893	3.51786	3.46683
Others											
Δθint	Temperature rise due to surrounding heat sources	[°C]	51.1	50.2	49.6	50.1	49.2	48.5	46.2	45.4	44.4
	Induced Voltage (standing) on Sheath	[V/mile]	196.0	174.84	197.39	200.53	178.54	204.58	218.36	194.23	227.52
	Induced Voltage (standing) on Concentric Wires	[V/mile]	198.08	176.96	199.47	202.67	180.72	206.73	220.72	196.62	229.88
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cables Report

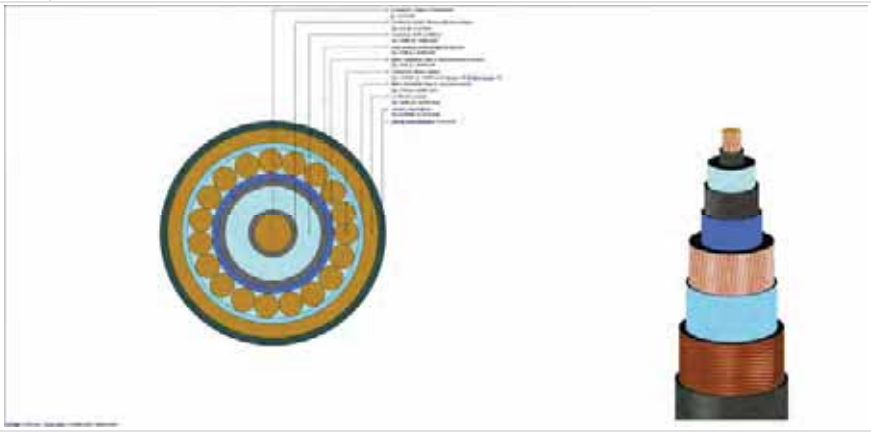
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	G101-230_500kV,40_DOC,70__50_,5000kcmilInCu,@3844_4985A DLF1
Date:	11/3/2024 10:29:35 PM

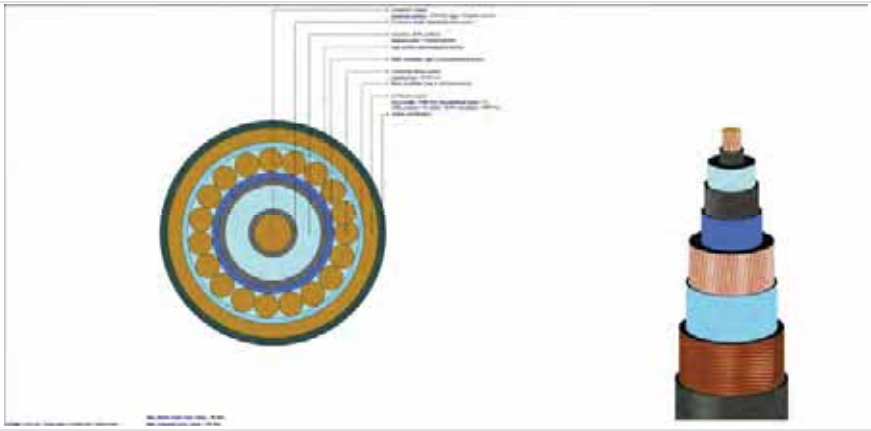
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		PVC Duct in Concrete
71	Duct material thermal resistivity	[K.m/W]	6
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	7.942
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





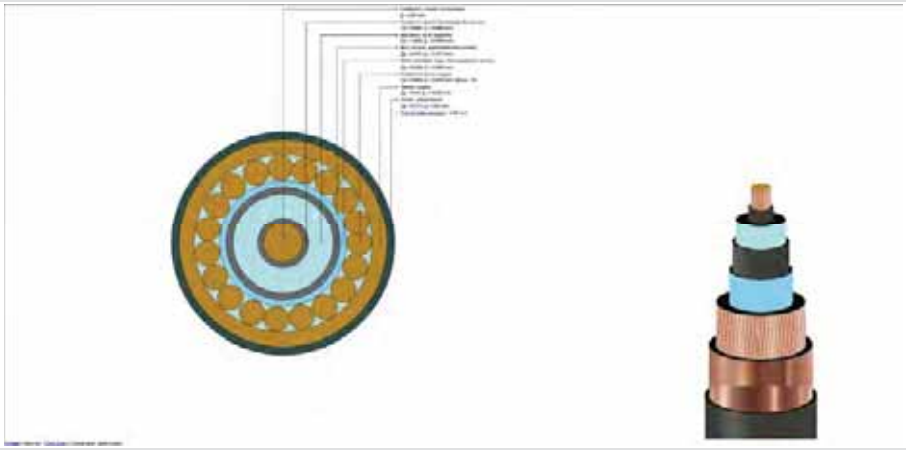
Cables Report

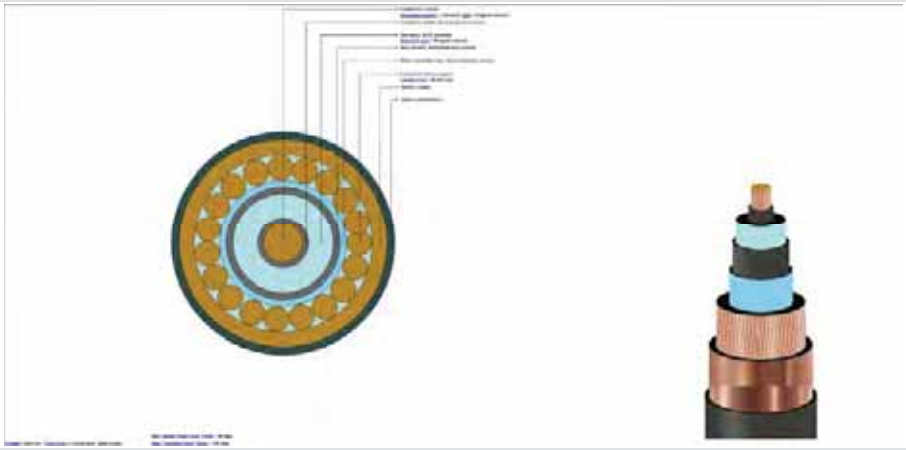
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	G101-230_500kV,40_DOC,70__50_,5000kcmilInCu,@3844_4985A DLF1
Date:	11/3/2024 10:29:35 PM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		PVC Duct in Concrete
66	Duct material thermal resistivity	[K.m/W]	6
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	7.942
69	Outer diameter of the conduit	[in]	8.625

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	G102-230_500kV,40_DOC,80__55_,5000kcmilInCu,@3919_5127A DLF1
Date:	11/3/2024 9:03:50 PM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

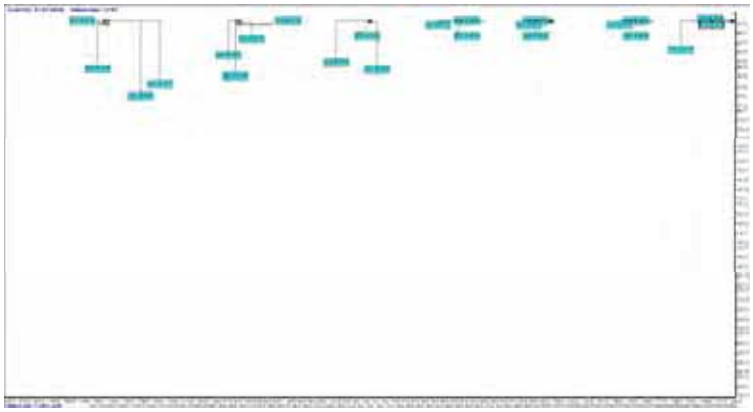
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB1	-80.0	41.933	3.517	3.517	0.8
NSTD DB2	0.0	41.429	2.6	2.6	0.8
NSTD DB3	-160.001	41.933	3.517	3.517	0.8
NSTD DB4	55.0	41.429	2.6	2.6	0.8
NSTD DB5	110.0	41.429	2.6	2.6	0.8
NSTD DB6	165.001	41.429	2.6	2.6	0.8
NSTD DB7	220.001	41.429	2.6	2.6	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	230C5.00X1	1		A	60.0	1.0	-81.08	41.88	90.0	999.0
2	230C5.00X1	1		B	60.0	1.0	-80.5	41.05	88.5	999.0
3	230C5.00X1	1		C	60.0	1.0	-79.5	41.05	87.5	999.0
4	230C5.00X1	2		A	60.0	1.0	-80.0	43.38	89.8	915.3
5	230C5.00X1	2		B	60.0	1.0	-79.22	42.88	88.2	915.3
6	230C5.00X1	2		C	60.0	1.0	-80.78	42.88	90.0	915.3
7	500C5.00X	3		A	60.0	1.0	-0.5	41.93	90.0	1022.6
8	500C5.00X	3		B	60.0	1.0	-0.5	40.93	89.2	1022.6
9	500C5.00X	3		C	60.0	1.0	0.5	40.93	88.5	1022.6
10	230C5.00X1	4		A	60.0	1.0	-161.08	41.88	90.0	1043.6
11	230C5.00X1	4		B	60.0	1.0	-160.5	41.05	88.5	1043.6
12	230C5.00X1	4		C	60.0	1.0	-159.5	41.05	87.6	1043.6
13	230C5.00X1	5		A	60.0	1.0	-160.0	43.38	89.8	961.1
14	230C5.00X1	5		B	60.0	1.0	-159.22	42.88	88.3	961.1
15	230C5.00X1	5		C	60.0	1.0	-160.78	42.88	90.0	961.1
16	500C5.00X	6		A	60.0	1.0	54.5	41.93	90.0	992.2
17	500C5.00X	6		B	60.0	1.0	54.5	40.93	89.2	992.2
18	500C5.00X	6		C	60.0	1.0	55.5	40.93	88.4	992.2
19	500C5.00X	7		A	60.0	1.0	109.5	41.93	90.0	993.1
20	500C5.00X	7		B	60.0	1.0	109.5	40.93	89.2	993.1
21	500C5.00X	7		C	60.0	1.0	110.5	40.93	88.4	993.1
22	500C5.00X	8		A	60.0	1.0	164.5	41.93	90.0	1015.8
23	500C5.00X	8		B	60.0	1.0	164.5	40.93	89.3	1015.8
24	500C5.00X	8		C	60.0	1.0	165.5	40.93	88.4	1015.8
25	500C5.00X	9		A	60.0	1.0	219.5	41.93	90.0	1103.2
26	500C5.00X	9		B	60.0	1.0	219.5	40.93	89.3	1103.2
27	500C5.00X	9		C	60.0	1.0	220.5	40.93	88.2	1103.2

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_GIM_New 3 Routes
Execution:	G102-230_500kV_40_DOC_80__55_.0000kcmilInCu@3919_5127A DLF1
Date:	1\3\2024 9:03:50 PM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Uniqually Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical Interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Variable	Description	Unit	Cables																											
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
General Input Data																														
Cable ID	Cable Equipment ID		230C5.00K1	230C5.00X1	230C5.00K1	230C5.00X1	280C5.00X1	230C5.00X1	500C5.00X	500C5.00X	500C5.00X	230C5.00K1	230C5.00X1	230C5.00K1	230C5.00X1	280C5.00X1	230C5.00X1	500C5.00X	500C5.00X	500C5.00X	500C5.00K	500C5.00X	500C5.00K	500C5.00X	500C5.00K	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9
Phase	Cable Phase		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Frq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-81.08	-80.5	-79.5	-80.0	-79.22	-80.78	-0.5	-0.5	0.5	-161.08	-160.5	-159.5	-160.0	-159.22	-160.78	54.5	54.5	55.5	109.5	109.5	110.5	164.5	164.5	165.5	219.5	219.5	220.5
y	Y coordinate	[ft]	41.88	41.05	41.05	43.38	42.88	42.88	41.93	40.93	40.93	41.88	41.05	41.05	43.38	42.88	42.88	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity																														
I	Steady State Ampacity	[A]	999.0	999.0	999.0	915.3	915.3	915.3	1022.6	1022.6	1022.6	1043.6	1043.6	1043.6	961.1	961.1	961.1	992.2	992.2	992.2	993.1	993.1	993.1	1015.8	1015.8	1015.8	1103.2	1103.2	1103.2
Temperatures																														
θc	Conductor temperature	[°C]	90.0	88.5	87.5	89.8	88.2	90.0	90.0	89.2	88.5	90.0	88.5	87.6	89.8	88.3	90.0	90.0	89.2	88.4	90.0	89.2	88.4	90.0	89.3	88.4	90.0	89.3	88.2
θs	Sheath/Shield temperature	[°C]	86.3	84.8	83.9	86.7	85.1	86.8	84.3	83.5	82.8	86.0	84.5	83.6	86.4	84.8	86.6	84.5	83.8	83.0	84.5	83.8	83.0	84.3	83.6	82.8	83.6	82.9	81.8
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	85.9	84.3	83.4	86.3	84.7	86.5	83.3	82.5	81.8	85.5	84.0	83.1	86.0	84.4	86.1	83.6	82.8	82.0	83.6	82.8	82.0	83.4	82.6	81.8	82.5	81.8	80.7
θduct	Duct surface temperature	[°C]	82.3	80.8	79.9	83.2	81.6	83.4	78.5	77.8	77.0	81.7	80.2	79.3	82.6	81.1	82.8	79.0	78.2	77.4	79.0	78.2	77.4	78.6	77.9	77.0	77.2	76.5	75.4
Resistances																														
R_c	DC Resistance of the conductor at 20°C	(Ω/mile)	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	(Ω/mile)	0.01666	0.0166	0.01657	0.01668	0.01662	0.01669	0.01663	0.0166	0.01657	0.01666	0.0166	0.01657	0.01668	0.01662	0.01669	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.01661	0.01656
ys	Skin Effect Factor		0.16157	0.16292	0.16372	0.16173	0.16311	0.16157	0.16154	0.1622	0.16287	0.16157	0.16291	0.16369	0.1617	0.16308	0.16157	0.16154	0.1622	0.16291	0.16154	0.1622	0.16291	0.16154	0.16218	0.16294	0.16154	0.16213	0.16311
yp	Proximity Effect Factor		0.00918	0.00924	0.00929	0.011	0.01109	0.01099	0.00713	0.00716	0.00718	0.00918	0.00924	0.00928	0.011	0.01108	0.01099	0.00713	0.00716	0.00718	0.00713	0.00716	0.00718	0.00713	0.00715	0.00718	0.00713	0.00715	0.00719
Losses																														
Wc	Conductor Losses	[W/ft]	3.14876	3.13751	3.13092	2.64631	2.63669	2.64739	3.29397	3.28819	3.28234	3.43673	3.42456	3.41759	2.91833	2.90774	2.91933	3.10087	3.0954	3.08969	3.10669	3.10123	3.09538	3.2506	3.24507	3.23853	3.83374	3.82771	3.81781
Wd	Dielectric Losses	[W/ft]	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	2.01332	2.01332	2.01332	0.55439	0.55439	0.55439	0.85439	0.55439	0.55439	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.169	0.16979	0.17036	0.17021	0.17102	0.17012	0.30093	0.30158	0.30224	0.18448	0.18548	0.18598	0.18784	0.18874	0.18776	0.28308	0.2857	0.28434	0.28392	0.28423	0.28489	0.28692	0.29754	0.29828	0.35097	0.35164	0.35276
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	3.87215	3.86169	3.85557	3.37091	3.36211	3.3719	5.60822	5.6031	5.59791	4.17575	4.16444	4.15796	3.66056	3.65087	3.66148	5.39728	5.39342	5.38736	5.40364	5.39879	5.3936	5.56085	5.55594	5.55013	6.19803	6.19268	6.1839
λ_1	Screen Loss Factor		0.05367	0.05412	0.05438	0.06432	0.06486	0.06426	0.09136	0.09172	0.09208	0.05372	0.05416	0.05442	0.06437	0.06491	0.06432	0.09129	0.09165	0.09203	0.09129	0.09165	0.09204	0.09134	0.09169	0.0921	0.09155	0.09187	0.0924
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances																														
T1	Thermal resistance of insulation	[K.m/W]	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.4049	0.4049	0.4049	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.05408	0.05408	0.05408	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	5.81566	5.71032	5.64858	6.71884	6.59354	6.73187	3.87462	3.83737	3.79956	5.3678	5.2713	5.21599	6.16251	6.04752	6.17235	4.04267	4.00365	3.96283	4.03742	3.9986	3.95686	3.91128	3.87483	3.83155	3.46554	3.43351	3.38602
Others																														
ΔθInt	Temperature rise due to surrounding heat sources	[°C]	58.1	56.6	55.8	60.4	59.0	60.6	48.8	48.0	47.4	56.4	54.9	54.2	58.8	57.4	59.0	50.0	49.1	48.5	50.0	49.1	48.4	49.1	48.2	47.5	45.5	44.7	43.7
	Induced Voltage (standing) on Sheath	[V/mile]	205.82	192.84	235.14	199.83	189.74	174.08	210.1	188.86	205.79	217.57	197.78	245.3	212.17	196.02	185.85	202.87	181.25	201.91	202.32	180.23	203.63	206.07	183.27	209.91	222.16	197.44	250.72
	Induced Voltage (standing) on Concentric Wires	[V/mile]	208.6	195.59	237.71	202.37	192.23	176.07	212.31	191.11	208.0	220.47	200.66	248.0	214.84	198.63	187.92	205.02	183.44	204.06	204.47	182.41	205.79	208.28	185.51	212.11	224.56	199.87	253.11
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cables Report

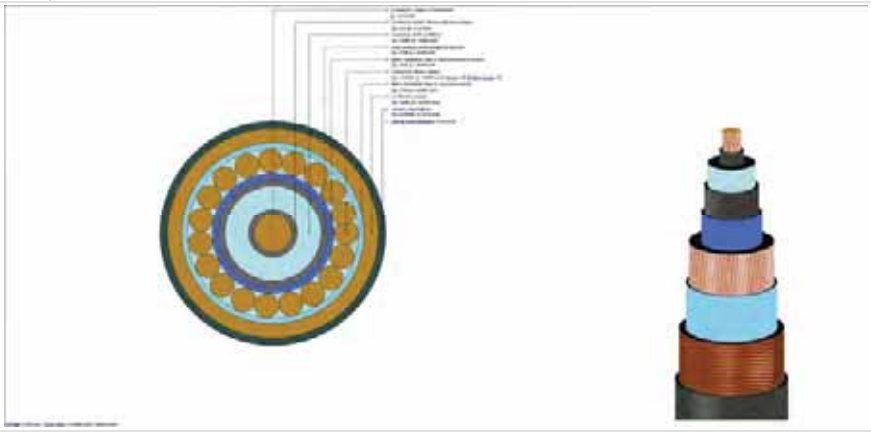
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	G102-230_500kV,40_DOC,80__55_,5000kcmilInCu,@3919_5127A DLF1
Date:	11/3/2024 9:03:50 PM

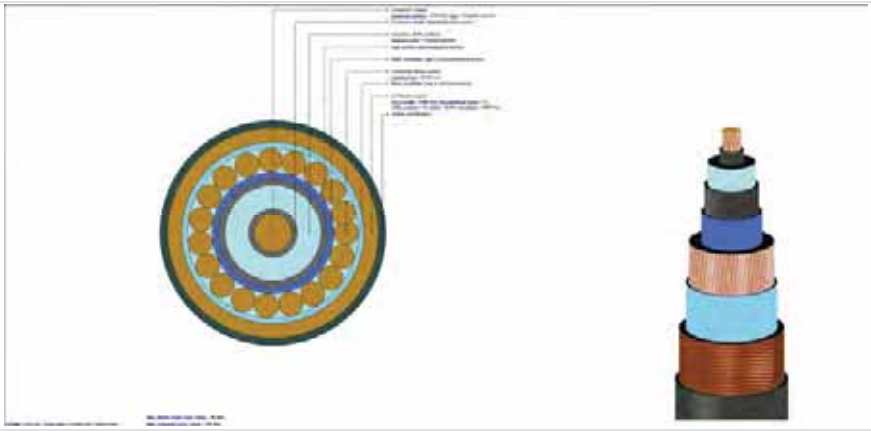
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		PVC Duct in Concrete
71	Duct material thermal resistivity	[K.m/W]	6
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	7.942
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





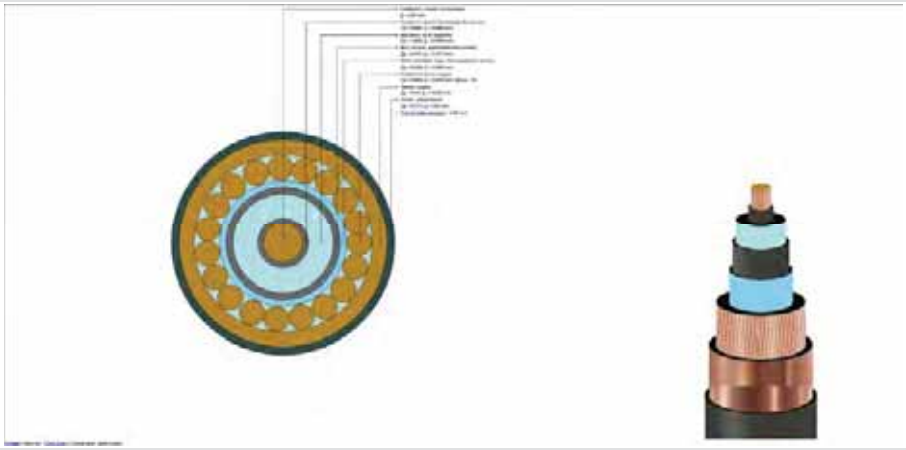
Cables Report

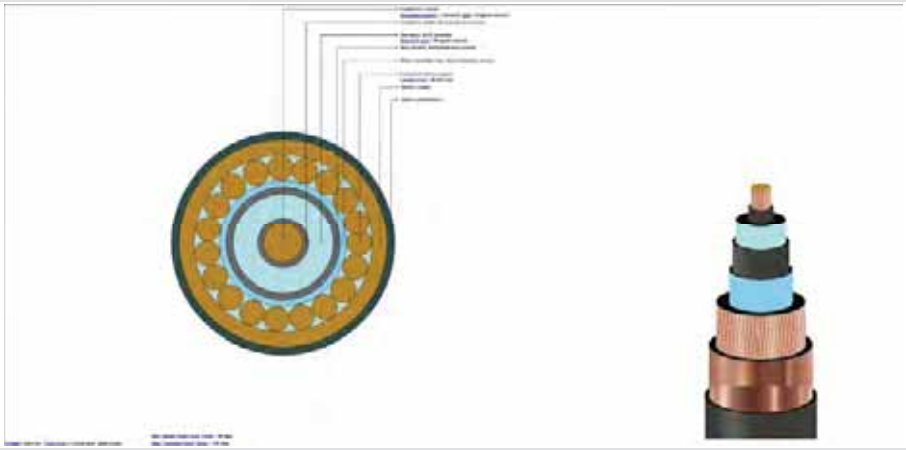
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	G102-230_500kV,40_DOC,80__55_,5000kcmilInCu,@3919_5127A DLF1
Date:	11/3/2024 9:03:50 PM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		PVC Duct in Concrete
66	Duct material thermal resistivity	[K.m/W]	6
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	7.942
69	Outer diameter of the conduit	[in]	8.625

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	G103-230_500kV,40_DOC,85__52_,5000kcmilInCu,@3946_5072A DLF1
Date:	11/3/2024 7:30:44 PM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

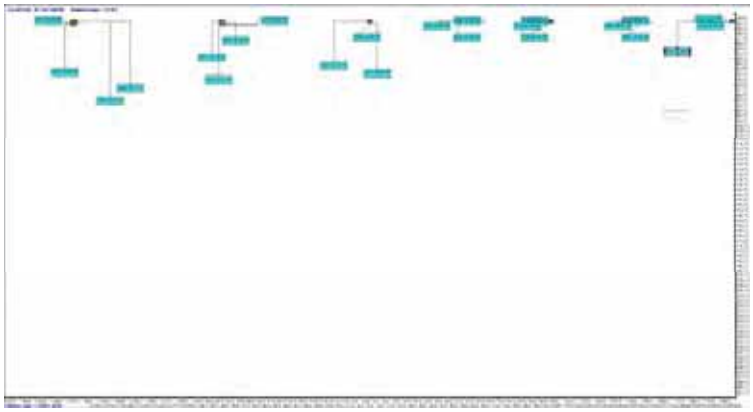
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB1	-85.0	41.933	3.517	3.517	0.8
NSTD DB2	0.0	41.429	2.6	2.6	0.8
NSTD DB3	-170.001	41.933	3.517	3.517	0.8
NSTD DB4	52.0	41.429	2.6	2.6	0.8
NSTD DB5	104.0	41.429	2.6	2.6	0.8
NSTD DB6	156.001	41.429	2.6	2.6	0.8
NSTD DB7	208.001	41.429	2.6	2.6	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	230C5.00X1	1		A	60.0	1.0	-86.08	41.88	90.0	1006.8
2	230C5.00X1	1		B	60.0	1.0	-85.5	41.05	88.4	1006.8
3	230C5.00X1	1		C	60.0	1.0	-84.5	41.05	87.5	1006.8
4	230C5.00X1	2		A	60.0	1.0	-85.0	43.38	89.8	923.4
5	230C5.00X1	2		B	60.0	1.0	-84.22	42.88	88.2	923.4
6	230C5.00X1	2		C	60.0	1.0	-85.78	42.88	90.0	923.4
7	500C5.00X	3		A	60.0	1.0	-0.5	41.93	90.0	1021.3
8	500C5.00X	3		B	60.0	1.0	-0.5	40.93	89.2	1021.3
9	500C5.00X	3		C	60.0	1.0	0.5	40.93	88.5	1021.3
10	230C5.00X1	4		A	60.0	1.0	-171.08	41.88	90.0	1049.1
11	230C5.00X1	4		B	60.0	1.0	-170.5	41.05	88.5	1049.1
12	230C5.00X1	4		C	60.0	1.0	-169.5	41.05	87.5	1049.1
13	230C5.00X1	5		A	60.0	1.0	-170.0	43.38	89.8	967.0
14	230C5.00X1	5		B	60.0	1.0	-169.22	42.88	88.2	967.0
15	230C5.00X1	5		C	60.0	1.0	-170.78	42.88	90.0	967.0
16	500C5.00X	6		A	60.0	1.0	51.5	41.93	90.0	978.8
17	500C5.00X	6		B	60.0	1.0	51.5	40.93	89.2	978.8
18	500C5.00X	6		C	60.0	1.0	52.5	40.93	88.5	978.8
19	500C5.00X	7		A	60.0	1.0	103.5	41.93	90.0	977.4
20	500C5.00X	7		B	60.0	1.0	103.5	40.93	89.2	977.4
21	500C5.00X	7		C	60.0	1.0	104.5	40.93	88.4	977.4
22	500C5.00X	8		A	60.0	1.0	155.5	41.93	90.0	1001.2
23	500C5.00X	8		B	60.0	1.0	155.5	40.93	89.3	1001.2
24	500C5.00X	8		C	60.0	1.0	156.5	40.93	88.4	1001.2
25	500C5.00X	9		A	60.0	1.0	207.5	41.93	90.0	1093.5
26	500C5.00X	9		B	60.0	1.0	207.5	40.93	89.3	1093.5
27	500C5.00X	9		C	60.0	1.0	208.5	40.93	88.2	1093.5

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution :	G103-230_500kV_40_DOC_85__52_.0000kcmilInCu@3946_5072A DLF1
Date:	11/3/2024 7:30:44 PM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Uniqually Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Variable	Description	Unit	Cables																											
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
General Input Data																														
Cable ID	Cable Equipment ID		230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	500C5.00X	500C5.00X	500C5.00X	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9
Phase	Cable Phase		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-86.08	-85.5	-84.5	-85.0	-84.22	-85.78	-0.5	-0.5	0.5	-171.08	-170.5	-169.5	-170.0	-169.22	-170.78	51.5	51.5	52.5	103.5	103.5	104.5	155.5	155.5	156.5	207.5	207.5	208.5
y	Y coordinate	[ft]	41.88	41.05	41.05	43.38	42.88	42.88	41.93	40.93	40.93	41.88	41.05	41.05	43.38	42.88	42.88	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity																														
I	Steady State Ampacity	[A]	1006.8	1006.8	1006.8	923.4	923.4	923.4	1021.3	1021.3	1021.3	1049.1	1049.1	1049.1	967.0	967.0	967.0	978.8	978.8	978.8	977.4	977.4	977.4	1001.2	1001.2	1001.2	1093.5	1093.5	1093.5
Temperatures																														
θc	Conductor temperature	[°C]	90.0	88.4	87.5	89.8	88.2	90.0	90.0	89.2	88.5	90.0	88.5	87.5	89.8	88.2	90.0	90.0	89.2	88.5	90.0	89.2	88.4	90.0	89.3	88.4	90.0	89.3	88.2
θs	Sheath/Shield temperature	[°C]	86.3	84.7	83.8	86.6	85.0	86.8	84.3	83.5	82.8	86.0	84.4	83.5	86.4	84.8	86.5	84.7	83.9	83.1	84.7	83.9	83.1	84.5	83.7	82.9	83.7	83.0	81.9
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	85.8	84.3	83.4	86.2	84.6	86.4	83.3	82.6	81.8	85.5	84.0	83.1	85.9	84.4	86.1	83.7	83.0	82.2	83.7	83.0	82.2	83.5	82.8	81.9	82.6	81.9	80.8
θduct	Duct surface temperature	[°C]	82.2	80.7	79.7	83.1	81.5	83.3	78.5	77.8	77.0	81.6	80.1	79.2	82.5	80.9	82.7	79.2	78.4	77.7	79.2	78.5	77.7	78.9	78.1	77.3	77.3	76.7	75.5
Resistances																														
R_o	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01666	0.0166	0.01657	0.01668	0.01662	0.01669	0.01683	0.0166	0.01658	0.01666	0.0166	0.01657	0.01668	0.01662	0.01669	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.01661	0.01656
ys	Skin Effect Factor		0.16157	0.16293	0.16374	0.16173	0.16313	0.16157	0.16154	0.1622	0.16284	0.16157	0.16292	0.16372	0.16171	0.16311	0.16157	0.16154	0.16293	0.16289	0.16154	0.1622	0.1629	0.16154	0.16218	0.16283	0.16154	0.16213	0.16312
yp	Proximity Effect Factor		0.00918	0.00924	0.00929	0.011	0.01109	0.01099	0.00713	0.00716	0.00718	0.00917	0.00924	0.00929	0.011	0.01109	0.01099	0.00713	0.00716	0.00718	0.00713	0.00716	0.00718	0.00713	0.00715	0.00718	0.00713	0.00715	0.00719
Losses																														
Wc	Conductor Losses	[W/ft]	3.19835	3.18685	3.18007	2.69868	2.6838	2.69482	3.28577	3.28002	3.27441	3.47269	3.46027	3.45306	2.95383	2.94295	2.95493	3.01827	3.01292	3.00749	3.00938	3.00406	2.99851	3.15761	3.1522	3.14593	3.76649	3.76053	3.75076
Wd	Dielectric Losses	[W/ft]	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	2.01332	2.01332	2.01332	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.17169	0.1725	0.17288	0.17329	0.17412	0.17319	0.30018	0.30082	0.30145	0.18658	0.18745	0.18796	0.19016	0.19108	0.19007	0.27546	0.27696	0.27667	0.27494	0.27823	0.27586	0.28833	0.28893	0.28964	0.34472	0.34539	0.3465
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	3.92443	3.91374	3.90744	3.42136	3.41232	3.42241	5.59927	5.59417	5.58919	4.21366	4.20212	4.19542	3.69838	3.68842	3.69939	5.30705	5.3023	5.29749	5.29734	5.29262	5.28769	5.45926	5.45446	5.4489	6.12454	6.11925	6.11058
$λ_s$	Screen Loss Factor		0.05368	0.05413	0.05439	0.06433	0.06488	0.06427	0.09136	0.09171	0.09206	0.05373	0.05417	0.05443	0.06438	0.06493	0.06432	0.09126	0.09162	0.09199	0.09136	0.09162	0.092	0.09131	0.09166	0.09207	0.09152	0.09185	0.09238
$λ_a$	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances																														
T1	Thermal resistance of insulation	[K.m/W]	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.4049	0.4049	0.4049	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.05408	0.05408	0.05408	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	5.7336	5.62906	5.56745	6.6141	6.48957	6.62746	3.8815	3.84429	3.80788	5.3164	5.21989	5.16081	6.09502	5.97946	6.1066	4.11862	4.07867	4.03811	4.12696	4.08705	4.0453	3.99197	3.95454	3.91105	3.51222	3.48162	3.4313
Others																														
ΔΘint	Temperature rise due to surrounding heat sources	[°C]	57.8	56.3	55.6	60.1	58.7	60.4	48.9	48.0	47.5	56.2	54.7	54.0	58.5	57.1	58.8	50.5	49.6	49.0	50.5	49.7	49.0	49.6	48.8	48.1	45.9	45.1	44.1
	Induced Voltage (standing) on Sheath	[V/mile]	207.45	194.2	237.06	201.6	191.29	175.81	210.1	188.63	205.28	218.55	198.85	246.73	213.28	197.22	187.02	200.2	178.86	199.13	199.11	177.4	200.43	203.02	180.61	206.98	220.03	195.6	228.93
	Induced Voltage (standing) on Concentric Wires	[V/mile]	210.24	196.97	239.66	204.16	193.8	177.82	212.3	190.88	207.48	221.46	201.74	249.45	215.96	199.84	189.11	202.32	181.01	201.25	201.22	179.55	202.55	205.2	182.82	209.15	222.41	198.01	231.3
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cables Report

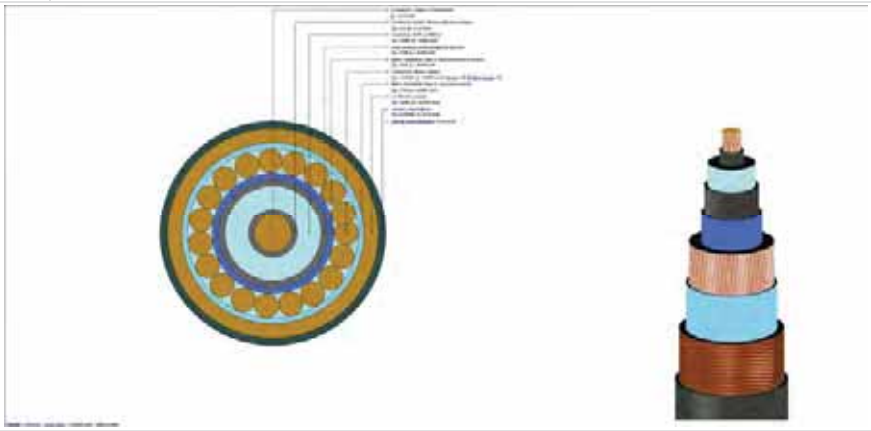
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	G103-230_500kV,40_DOC,85__52_,5000kcmilInCu,@3946_5072A DLF1
Date:	11/3/2024 7:30:44 PM

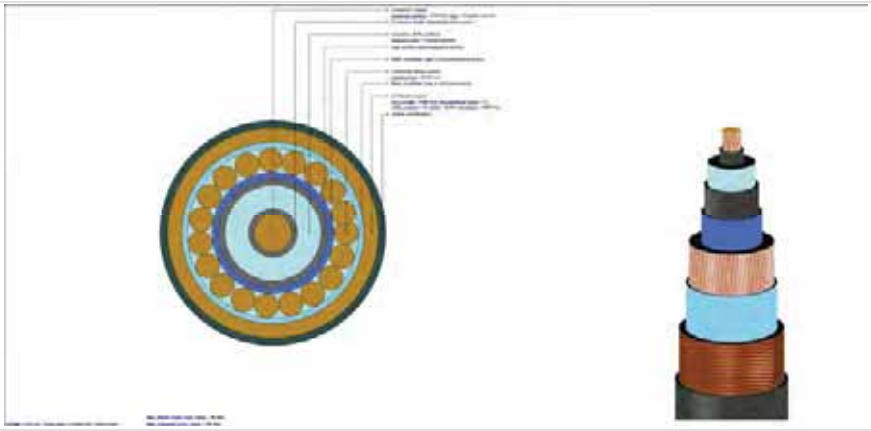
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		PVC Duct in Concrete
71	Duct material thermal resistivity	[K.m/W]	6
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	7.942
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





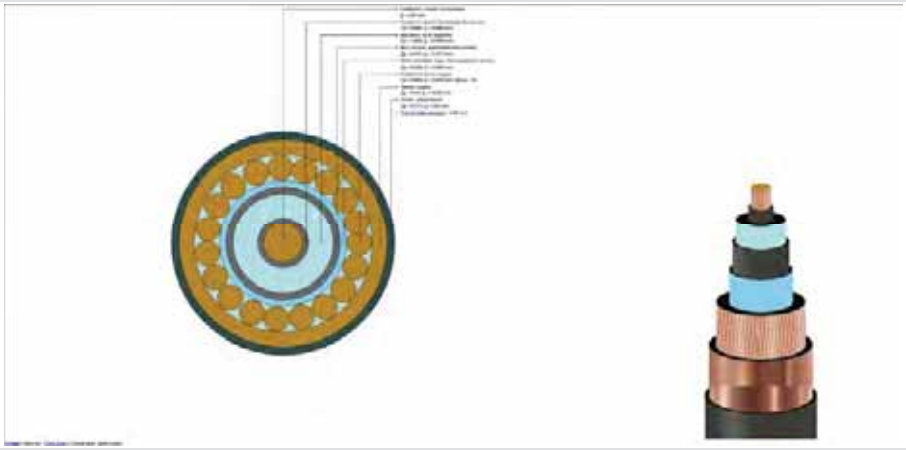
Cables Report

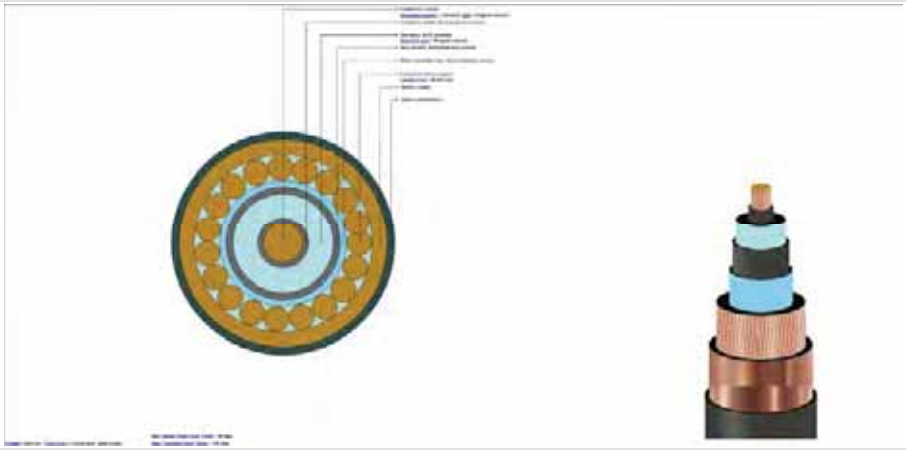
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	G103-230_500kV,40_DOC,85__52_,5000kcmilInCu,@3946_5072A DLF1
Date:	11/3/2024 7:30:44 PM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		PVC Duct in Concrete
66	Duct material thermal resistivity	[K.m/W]	6
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	7.942
69	Outer diameter of the conduit	[in]	8.625

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	G104-230_500kV,40_DOC,90__52_,5000kcmilInCu,@3974_5084A DLF1
Date:	11/3/2024 5:42:47 PM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

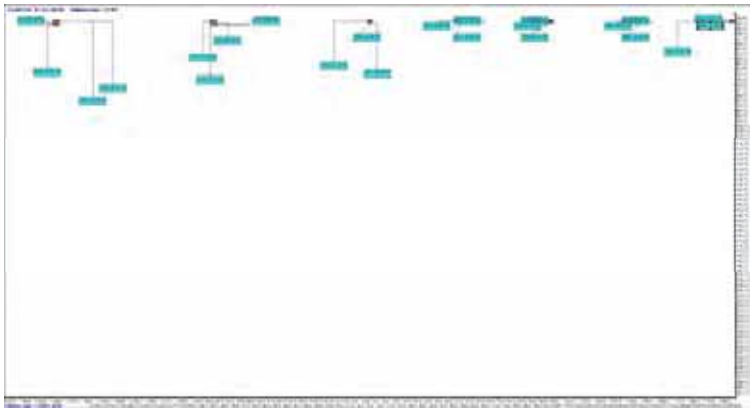
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB1	-90.0	41.933	3.517	3.517	0.8
NSTD DB2	0.0	41.429	2.6	2.6	0.8
NSTD DB3	-180.001	41.933	3.517	3.517	0.8
NSTD DB4	52.0	41.429	2.6	2.6	0.8
NSTD DB5	104.0	41.429	2.6	2.6	0.8
NSTD DB6	156.001	41.429	2.6	2.6	0.8
NSTD DB7	208.001	41.429	2.6	2.6	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	230C5.00X1	1		A	60.0	1.0	-91.08	41.88	90.0	1014.9
2	230C5.00X1	1		B	60.0	1.0	-90.5	41.05	88.4	1014.9
3	230C5.00X1	1		C	60.0	1.0	-89.5	41.05	87.5	1014.9
4	230C5.00X1	2		A	60.0	1.0	-90.0	43.38	89.8	931.9
5	230C5.00X1	2		B	60.0	1.0	-89.22	42.88	88.2	931.9
6	230C5.00X1	2		C	60.0	1.0	-90.78	42.88	90.0	931.9
7	500C5.00X	3		A	60.0	1.0	-0.5	41.93	90.0	1028.6
8	500C5.00X	3		B	60.0	1.0	-0.5	40.93	89.2	1028.6
9	500C5.00X	3		C	60.0	1.0	0.5	40.93	88.5	1028.6
10	230C5.00X1	4		A	60.0	1.0	-181.08	41.88	90.0	1054.2
11	230C5.00X1	4		B	60.0	1.0	-180.5	41.05	88.4	1054.2
12	230C5.00X1	4		C	60.0	1.0	-179.5	41.05	87.5	1054.2
13	230C5.00X1	5		A	60.0	1.0	-180.0	43.38	89.8	972.5
14	230C5.00X1	5		B	60.0	1.0	-179.22	42.88	88.2	972.5
15	230C5.00X1	5		C	60.0	1.0	-180.78	42.88	90.0	972.5
16	500C5.00X	6		A	60.0	1.0	51.5	41.93	90.0	981.1
17	500C5.00X	6		B	60.0	1.0	51.5	40.93	89.2	981.1
18	500C5.00X	6		C	60.0	1.0	52.5	40.93	88.5	981.1
19	500C5.00X	7		A	60.0	1.0	103.5	41.93	90.0	978.3
20	500C5.00X	7		B	60.0	1.0	103.5	40.93	89.2	978.3
21	500C5.00X	7		C	60.0	1.0	104.5	40.93	88.4	978.3
22	500C5.00X	8		A	60.0	1.0	155.5	41.93	90.0	1001.5
23	500C5.00X	8		B	60.0	1.0	155.5	40.93	89.3	1001.5
24	500C5.00X	8		C	60.0	1.0	156.5	40.93	88.4	1001.5
25	500C5.00X	9		A	60.0	1.0	207.5	41.93	90.0	1093.6
26	500C5.00X	9		B	60.0	1.0	207.5	40.93	89.3	1093.6
27	500C5.00X	9		C	60.0	1.0	208.5	40.93	88.2	1093.6

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	G104-230_500kV,40_DOC,90__52_,5000kcmilInCu,@3974_5084A DLF1
Date:	11/3/2024 5:42:47 PM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Variable	Description	Unit	Cables																										
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
General Input Data																													
Cable ID	Cable Equipment ID		230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	500C5.00X	500C5.00X	500C5.00X	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9
Phase	Cable Phase		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-91.08	-90.5	-89.5	-90.0	-89.22	-90.78	-0.5	-0.5	0.5	-181.08	-180.5	-179.5	-180.0	-179.22	-180.78	51.5	51.5	52.5	103.5	103.5	104.5	155.5	155.5	156.5	207.5	207.5	208.5
y	Y coordinate	[ft]	41.88	41.05	41.05	43.38	42.88	42.88	41.93	40.93	40.93	41.88	41.05	41.05	43.38	42.88	42.88	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity																													
I	Steady State Ampacity	[A]	1014.9	1014.9	1014.9	931.9	931.9	931.9	1028.6	1028.6	1028.6	1054.2	1054.2	1054.2	972.5	972.5	972.5	981.1	981.1	981.1	978.3	978.3	978.3	1001.5	1001.5	1001.5	1093.6	1093.6	1093.6
Temperatures																													
θc	Conductor temperature	[°C]	90.0	88.4	87.5	89.8	88.2	90.0	90.0	89.2	88.5	90.0	88.4	87.5	89.8	88.2	90.0	90.0	89.2	88.5	90.0	89.2	88.4	90.0	89.3	88.4	90.0	89.3	88.2
θs	Sheath/Shield temperature	[°C]	86.2	84.6	83.7	86.5	84.9	86.7	84.2	83.5	82.8	85.9	84.4	83.5	86.3	84.7	86.5	84.6	83.9	83.1	84.7	83.9	83.1	84.5	83.7	82.9	83.7	83.0	81.9
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	85.8	84.2	83.3	86.2	84.6	86.4	83.2	82.5	81.8	85.5	83.9	83.0	85.9	84.3	86.1	83.7	82.9	82.2	83.7	83.0	82.2	83.5	82.8	81.9	82.6	81.9	80.8
θduct	Duct surface temperature	[°C]	82.1	80.5	79.6	83.0	81.4	83.2	78.4	77.7	76.9	81.5	80.0	79.1	82.5	80.8	82.6	79.2	78.4	77.6	79.2	78.4	77.6	78.9	78.1	77.2	77.3	76.7	75.5
Resistances																													
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01666	0.0166	0.01656	0.01668	0.01662	0.01669	0.01663	0.0166	0.01658	0.01666	0.0166	0.01657	0.01668	0.01662	0.01669	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.01661	0.01656
ys	Skin Effect Factor		0.16157	0.16294	0.16376	0.16174	0.16315	0.16157	0.16154	0.16219	0.16284	0.16157	0.16293	0.16375	0.16173	0.16314	0.16157	0.16154	0.1622	0.16288	0.16154	0.1622	0.1629	0.16154	0.16218	0.16293	0.16154	0.16213	0.16312
yp	Proximity Effect Factor		0.00918	0.00925	0.00929	0.011	0.01109	0.01099	0.00713	0.00716	0.00718	0.00917	0.00924	0.00929	0.011	0.01109	0.01099	0.00713	0.00716	0.00718	0.00713	0.00716	0.00718	0.00713	0.00715	0.00718	0.00713	0.00715	0.00719
Losses																													
Wc	Conductor Losses	[W/ft]	3.25038	3.23861	3.23163	2.74348	2.73332	2.74471	3.33286	3.32706	3.3214	3.50669	3.49407	3.48662	2.98762	2.97652	2.98887	3.03237	3.02701	3.02157	3.01466	3.00934	3.00378	3.15958	3.15417	3.1479	3.76745	3.76148	3.75171
Wd	Dielectric Losses	[W/ft]	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	2.01332	2.01332	2.01332	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.17451	0.17534	0.17583	0.17653	0.17739	0.17643	0.30453	0.30518	0.30582	0.18843	0.18932	0.18984	0.19238	0.19332	0.19227	0.27676	0.27736	0.27797	0.27512	0.27572	0.27635	0.28851	0.28912	0.28982	0.34481	0.34548	0.34659
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	3.97928	3.96834	3.96185	3.4744	3.4651	3.47553	5.65072	5.64557	5.64055	4.24952	4.23778	4.23086	3.7344	3.72424	3.73554	5.32245	5.3177	5.31286	5.30311	5.29839	5.29345	5.46141	5.45661	5.45104	6.12559	6.12029	6.11162
λ_1	Screen Loss Factor		0.05369	0.05414	0.05441	0.06434	0.0649	0.06428	0.09137	0.09173	0.09208	0.05373	0.05418	0.05445	0.06439	0.06495	0.06433	0.09127	0.09163	0.092	0.09126	0.09162	0.092	0.09131	0.09166	0.09207	0.09152	0.09185	0.09238
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances																													
T1	Thermal resistance of insulation	[K.m/W]	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.4049	0.4049	0.4049	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.05408	0.05408	0.05408	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	5.64982	5.54612	5.48446	6.50703	6.38321	6.52093	3.84229	3.8056	3.76973	5.26864	5.17225	5.11538	6.03132	5.91592	6.0432	4.10547	4.06579	4.02537	4.12201	4.08223	4.04051	3.99022	3.95283	3.90932	3.51155	3.48088	3.43059
Others																													
Δθint	Temperature rise due to surrounding heat sources	[°C]	57.5	56.0	55.3	59.8	58.4	60.1	48.6	47.8	47.2	56.0	54.5	53.8	58.3	56.9	58.6	50.4	49.5	48.9	50.5	49.6	49.0	49.6	48.8	48.1	45.9	45.1	44.1
	Induced Voltage (standing) on Sheath	[V/mile]	209.13	195.62	239.08	203.42	192.9	177.62	211.7	189.86	206.71	219.47	199.84	248.08	214.33	198.34	188.14	200.71	179.22	199.59	199.3	177.53	200.6	203.1	180.65	207.04	220.06	195.62	228.96
	Induced Voltage (standing) on Concentric Wires	[V/mile]	211.94	198.41	241.7	206.0	195.43	179.65	213.92	192.12	208.94	222.39	202.75	250.82	217.03	200.98	190.25	202.83	181.38	201.71	201.42	179.68	202.72	205.27	182.86	209.21	222.44	198.02	231.34
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cables Report

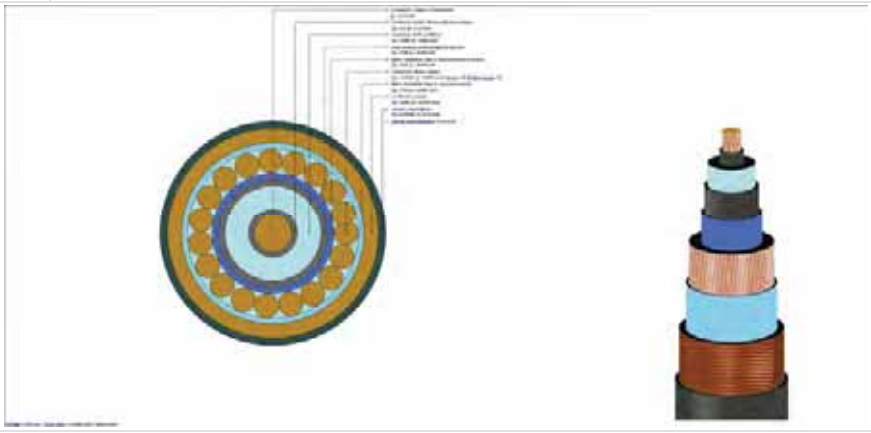
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	G104-230_500kV,40_DOC,90__52_,5000kcmilInCu,@3974_5084A DLF1
Date:	11/3/2024 5:42:47 PM

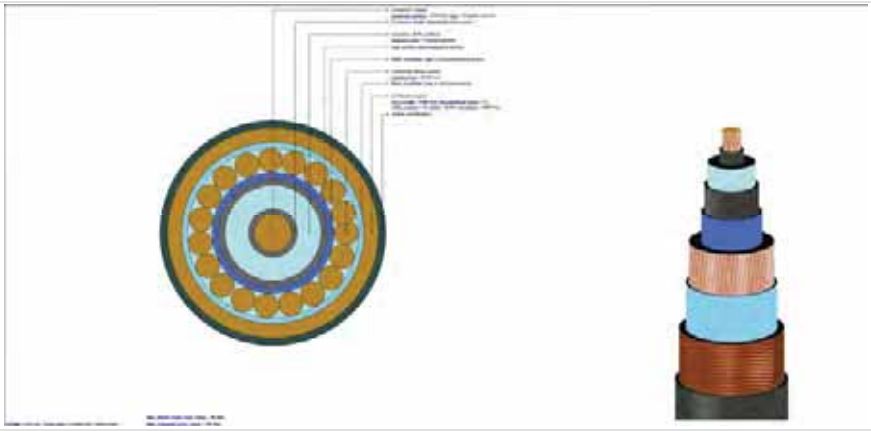
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		PVC Duct in Concrete
71	Duct material thermal resistivity	[K.m/W]	6
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	7.942
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





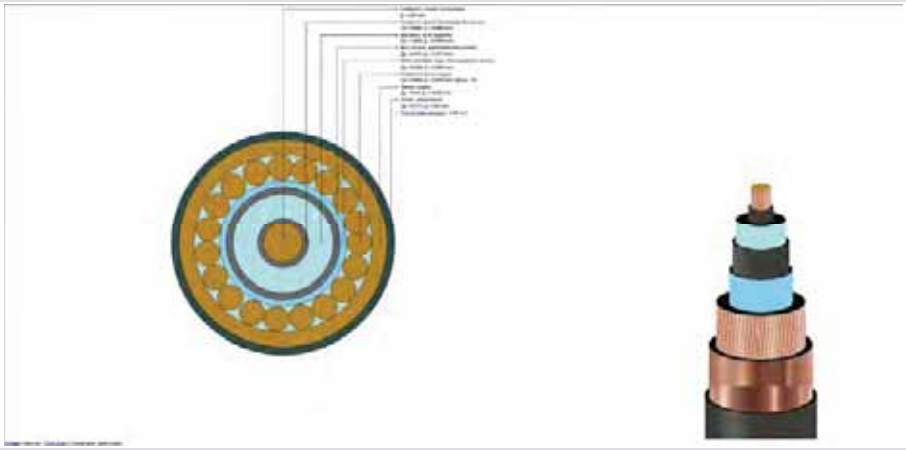
Cables Report

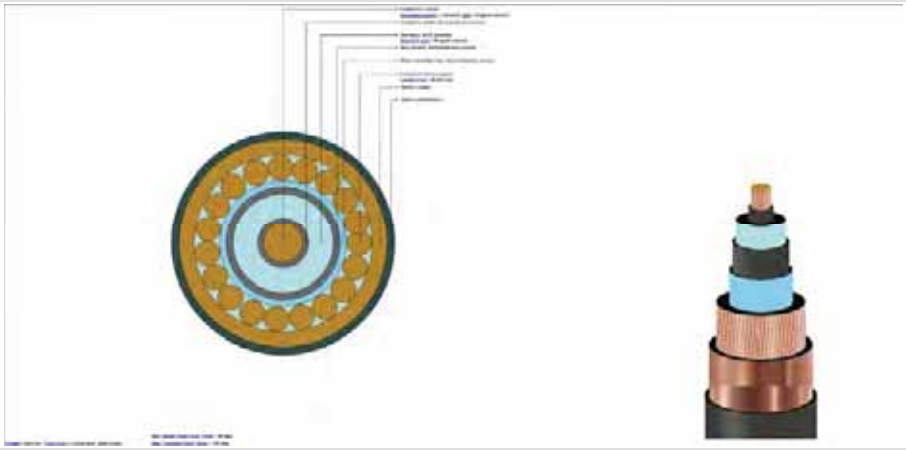
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	G104-230_500kV,40_DOC,90__52_,5000kcmilInCu,@3974_5084A DLF1
Date:	11/3/2024 5:42:47 PM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		PVC Duct in Concrete
66	Duct material thermal resistivity	[K.m/W]	6
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	7.942
69	Outer diameter of the conduit	[in]	8.625

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H101-230_500kV,40_DOC,30__50_,5000kcmilInCu,@4369_4789A DLF1
Date:	11/4/2024 5:04:45 PM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

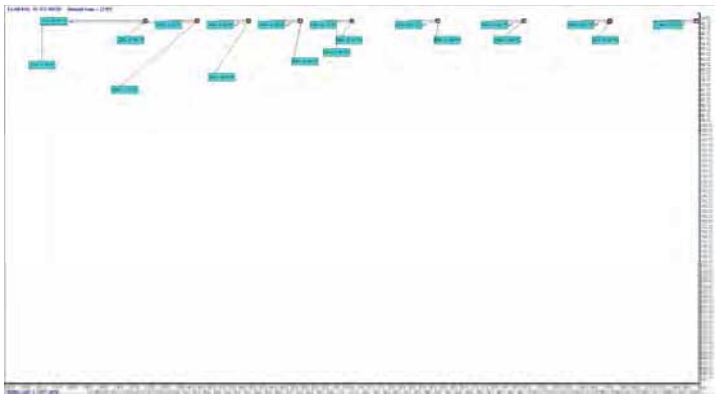
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB2	0.0	41.429	2.6	2.6	0.8
NSTD DB4	50.0	41.429	2.6	2.6	0.8
NSTD DB5	100.0	41.429	2.6	2.6	0.8
NSTD DB6	150.0	41.429	2.6	2.6	0.8
NSTD DB7	200.001	41.429	2.6	2.6	0.8
NSTD DB6	-30.0	41.429	2.6	2.6	0.8
NSTD DB7	-60.0	41.429	2.6	2.6	0.8
NSTD DB8	-90.0	41.429	2.6	2.6	0.8
NSTD DB9	-120.0	41.429	2.6	2.6	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	500C5.00X	1		A	60.0	1.0	-0.5	41.93	90.0	845.6
2	500C5.00X	1		B	60.0	1.0	-0.5	40.93	89.2	845.6
3	500C5.00X	1		C	60.0	1.0	0.5	40.93	88.3	845.6
4	500C5.00X	2		A	60.0	1.0	49.5	41.93	90.0	925.6
5	500C5.00X	2		B	60.0	1.0	49.5	40.93	89.2	925.6
6	500C5.00X	2		C	60.0	1.0	50.5	40.93	88.4	925.6
7	500C5.00X	3		A	60.0	1.0	99.5	41.93	90.0	950.4
8	500C5.00X	3		B	60.0	1.0	99.5	40.93	89.2	950.4
9	500C5.00X	3		C	60.0	1.0	100.5	40.93	88.4	950.4
10	500C5.00X	4		A	60.0	1.0	149.5	41.93	90.0	984.2
11	500C5.00X	4		B	60.0	1.0	149.5	40.93	89.3	984.2
12	500C5.00X	4		C	60.0	1.0	150.5	40.93	88.4	984.2
13	500C5.00X	5		A	60.0	1.0	199.5	41.93	90.0	1083.6
14	500C5.00X	5		B	60.0	1.0	199.5	40.93	89.3	1083.6
15	500C5.00X	5		C	60.0	1.0	200.5	40.93	88.2	1083.6
16	230C5.00X1	6		A	60.0	1.0	-30.5	41.93	90.0	1039.9
17	230C5.00X1	6		B	60.0	1.0	-30.5	40.93	89.0	1039.9
18	230C5.00X1	6		C	60.0	1.0	-29.5	40.93	88.4	1039.9
19	230C5.00X1	7		A	60.0	1.0	-60.5	41.93	90.0	1042.3
20	230C5.00X1	7		B	60.0	1.0	-60.5	40.93	89.0	1042.3
21	230C5.00X1	7		C	60.0	1.0	-59.5	40.93	88.5	1042.3
22	230C5.00X1	8		A	60.0	1.0	-90.5	41.93	90.0	1080.1
23	230C5.00X1	8		B	60.0	1.0	-90.5	40.93	89.1	1080.1
24	230C5.00X1	8		C	60.0	1.0	-89.5	40.93	88.5	1080.1
25	230C5.00X1	9		A	60.0	1.0	-120.5	41.93	90.0	1206.5
26	230C5.00X1	9		B	60.0	1.0	-120.5	40.93	89.1	1206.5
27	230C5.00X1	9		C	60.0	1.0	-119.5	40.93	88.7	1206.5

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H101-230_500kV,40_DOC,30__50_,5000kcmilInCu,@4369_4789A DLF1
Date:	11/4/2024 5:04:45 PM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Cables (1–9)

Variable	Description	Unit	1	2	3	4	5	6	7	8	9
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9
General Input Data											
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-0.5	-0.5	0.5	49.5	49.5	50.5	99.5	99.5	100.5
y	Y coordinate	[ft]	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	845.6	845.6	845.6	925.6	925.6	925.6	950.4	950.4	950.4
Temperatures											
θc	Conductor temperature	[°C]	90.0	89.2	88.3	90.0	89.2	88.4	90.0	89.2	88.4
θs	Sheath/Shield temperature	[°C]	85.7	84.9	84.0	85.1	84.3	83.5	84.9	84.1	83.3
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	84.9	84.1	83.2	84.2	83.4	82.6	84.0	83.2	82.4
θduct	Duct surface temperature	[°C]	81.1	80.3	79.4	80.0	79.2	78.4	79.6	78.8	78.1
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657
ys	Skin Effect Factor		0.16155	0.16225	0.16298	0.16154	0.16224	0.16291	0.16153	0.16222	0.16291
yp	Proximity Effect Factor		0.00713	0.00716	0.00719	0.00713	0.00716	0.00718	0.00713	0.00716	0.00718
Losses											
Wc	Conductor Losses	[W/ft]	2.25218	2.24795	2.24361	2.69906	2.69399	2.68921	2.84533	2.84012	2.83495
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.20495	0.20543	0.20591	0.24602	0.24659	0.24713	0.25949	0.26008	0.26066
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	4.47046	4.4667	4.46285	4.95841	4.95391	4.94966	5.11814	5.11352	5.10893
$λ_1$	Screen Loss Factor		0.091	0.09138	0.09178	0.09115	0.09153	0.0919	0.0912	0.09157	0.09194
$λ_2$	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	4.96824	4.91745	4.86527	4.43791	4.39255	4.34964	4.28635	4.24366	4.20117
Others											
Δθint	Temperature rise due to surrounding heat sources	[°C]	55.0	54.1	53.4	52.3	51.5	50.8	51.5	50.6	50.0
	Induced Voltage (standing) on Sheath	[V/mile]	170.52	150.55	177.14	188.12	165.94	191.65	192.88	170.17	197.2
	Induced Voltage (standing) on Concentric Wires	[V/mile]	172.36	152.42	178.98	190.13	167.98	193.66	194.94	172.26	199.26
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cables (10–18)

Variable	Description	Unit	10	11	12	13	14	15	16	17	18
Cable No.	Cable Index Number		10	11	12	13	14	15	16	17	18
General Input Data											
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	230C5.00X1	230C5.00X1	230C5.00X1
Circuit No.	Circuit No.		4	4	4	5	5	5	6	6	6
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	149.5	149.5	150.5	199.5	199.5	200.5	-30.5	-30.5	-29.5
y	Y coordinate	[ft]	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	984.2	984.2	984.2	1083.6	1083.6	1083.6	1039.9	1039.9	1039.9
Temperatures											
θc	Conductor temperature	[°C]	90.0	89.3	88.4	90.0	89.3	88.2	90.0	89.0	88.4
θs	Sheath/Shield temperature	[°C]	84.6	83.9	83.0	83.8	83.1	82.0	86.0	85.1	84.5
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	83.7	82.9	82.1	82.7	82.0	80.9	85.6	84.6	84.0
θduct	Duct surface temperature	[°C]	79.1	78.4	77.5	77.5	76.8	75.7	81.8	80.8	80.2
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.0166	0.01657	0.01663	0.01661	0.01656	0.01663	0.0166	0.01657
ys	Skin Effect Factor		0.16153	0.16219	0.16293	0.16153	0.16214	0.16313	0.16159	0.16242	0.16295
yp	Proximity Effect Factor		0.00713	0.00715	0.00718	0.00713	0.00715	0.00719	0.00742	0.00746	0.00748
Losses											
Wc	Conductor Losses	[W/ft]	3.05116	3.04582	3.03982	3.69909	3.69313	3.68346	3.40717	3.39962	3.39485
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	0.55439	0.55439	0.55439
Ws	Metallic Screen Losses	[W/ft]	0.27848	0.27908	0.27975	0.33845	0.33912	0.34021	0.14787	0.1483	0.14857
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	5.34296	5.33822	5.3329	6.05087	6.04557	6.03699	4.10944	4.10231	4.09781
$λ_1$	Screen Loss Factor		0.09127	0.09163	0.09203	0.09149	0.09182	0.09236	0.0434	0.04362	0.04376
$λ_2$	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.32843	0.32843	0.32843
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.03387	0.03387	0.03387
T4	External thermal resistance	[K.m/W]	4.08823	4.04931	4.00541	3.56031	3.52892	3.47772	5.45609	5.39475	5.35579
Others											
Δθint	Temperature rise due to surrounding heat sources	[°C]	50.2	49.4	48.7	46.2	45.4	44.5	56.8	55.8	55.3
	Induced Voltage (standing) on Sheath	[V/mile]	199.03	175.68	205.29	217.57	192.25	228.49	225.8	200.83	227.43
	Induced Voltage (standing) on Concentric Wires	[V/mile]	201.17	177.85	207.42	219.93	194.64	230.84	228.64	203.72	230.27
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cables (19–27)

Variable	Description	Unit	19	20	21	22	23	24	25	26	27
Cable No.	Cable Index Number		19	20	21	22	23	24	25	26	27
General Input Data											
Cable ID	Cable Equipment ID		230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1
Circuit No.	Circuit No.		7	7	7	8	8	8	9	9	9
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-60.5	-60.5	-59.5	-90.5	-90.5	-89.5	-120.5	-120.5	-119.5
y	Y coordinate	[ft]	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	1042.3	1042.3	1042.3	1080.1	1080.1	1080.1	1206.5	1206.5	1206.5
Temperatures											
θc	Conductor temperature	[°C]	90.0	89.0	88.5	90.0	89.1	88.5	90.0	89.1	88.7
θs	Sheath/Shield temperature	[°C]	86.0	85.1	84.5	85.7	84.8	84.3	84.8	83.8	83.5
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	85.5	84.6	84.0	85.3	84.3	83.8	84.2	83.2	82.9
θduct	Duct surface temperature	[°C]	81.7	80.8	80.2	81.2	80.3	79.7	79.2	78.3	77.9
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.0166	0.01658	0.01664	0.0166	0.01658	0.01664	0.0166	0.01658
ys	Skin Effect Factor		0.16158	0.16241	0.1629	0.16157	0.16238	0.16285	0.16157	0.16239	0.16272
yp	Proximity Effect Factor		0.00742	0.00746	0.00748	0.00742	0.00745	0.00747	0.00742	0.00745	0.00747
Losses											
Wc	Conductor Losses	[W/ft]	3.42271	3.41519	3.41076	3.67549	3.66757	3.6631	4.58635	4.57629	4.57234
Wd	Dielectric Losses	[W/ft]	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439
Ws	Metallic Screen Losses	[W/ft]	0.14855	0.14897	0.14922	0.15964	0.16009	0.16034	0.19979	0.20036	0.20059
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	4.12565	4.11855	4.11438	4.38952	4.38206	4.37784	5.34053	5.33104	5.32732
$λ_1$	Screen Loss Factor		0.0434	0.04362	0.04375	0.04343	0.04365	0.04377	0.04356	0.04378	0.04387
$λ_2$	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387
T4	External thermal resistance	[K.m/W]	5.4335	5.37294	5.33718	5.08622	5.0307	4.99922	4.11874	4.07259	4.05455
Others											
Δθint	Temperature rise due to surrounding heat sources	[°C]	56.7	55.7	55.3	55.3	54.3	53.9	50.2	49.2	49.0
	Induced Voltage (standing) on Sheath	[V/mile]	228.23	202.79	224.98	238.41	211.65	230.23	269.72	239.18	252.04
	Induced Voltage (standing) on Concentric Wires	[V/mile]	231.08	205.68	227.83	241.35	214.64	233.19	273.0	242.53	255.34
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

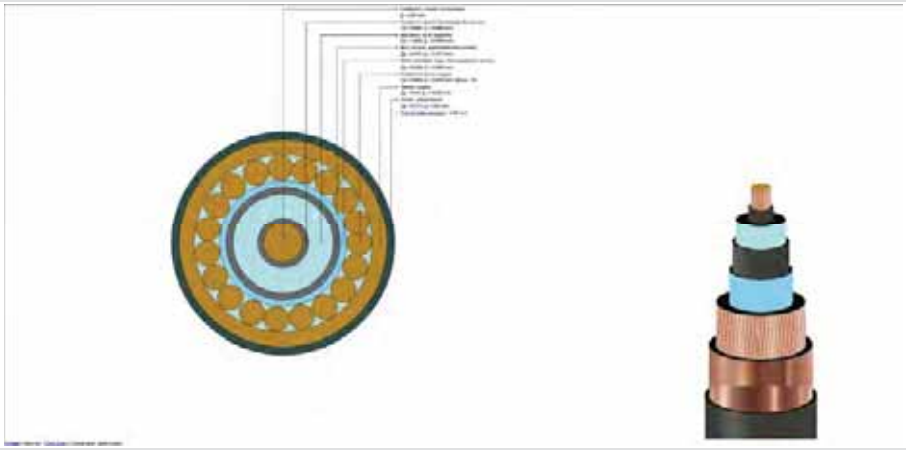
Cables Report

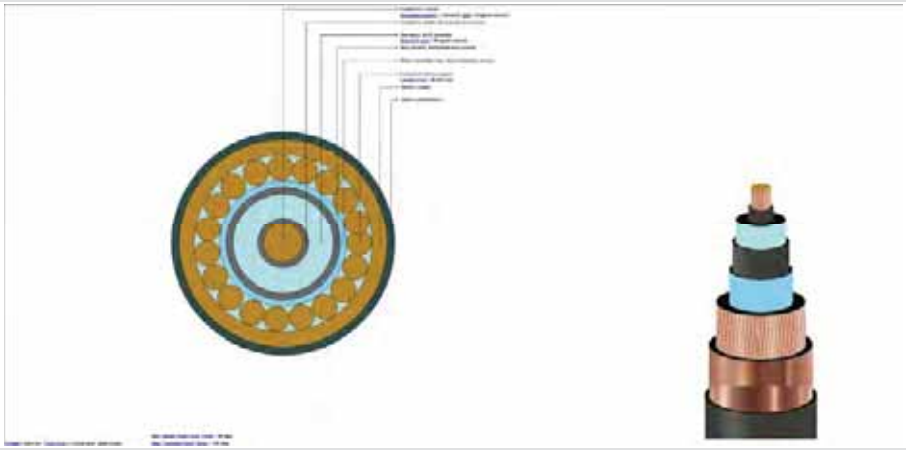
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H101-230_500kV,40_DOC,30__50_,5000kcmilInCu,@4369_4789A DLF1
Date:	11/4/2024 5:04:45 PM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		PVC Duct in Concrete
66	Duct material thermal resistivity	[K.m/W]	6
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	7.942
69	Outer diameter of the conduit	[in]	8.625

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Cables Report

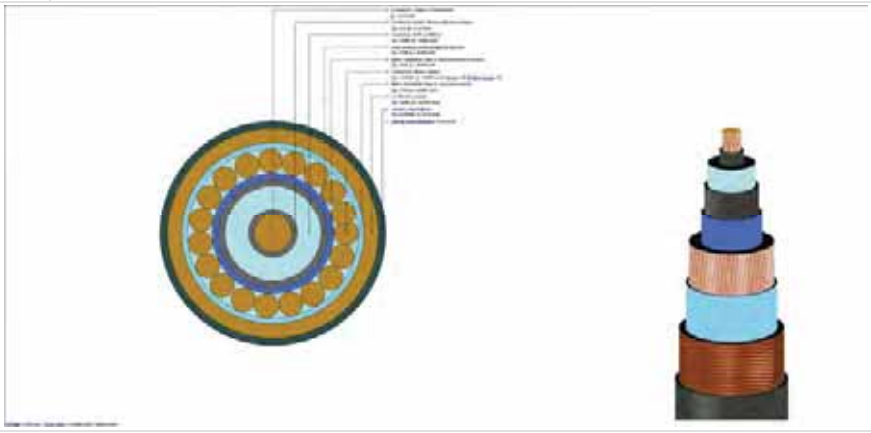
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H101-230_500kV,40_DOC,30__50_,5000kcmilInCu,@4369_4789A DLF1
Date:	11/4/2024 5:04:45 PM

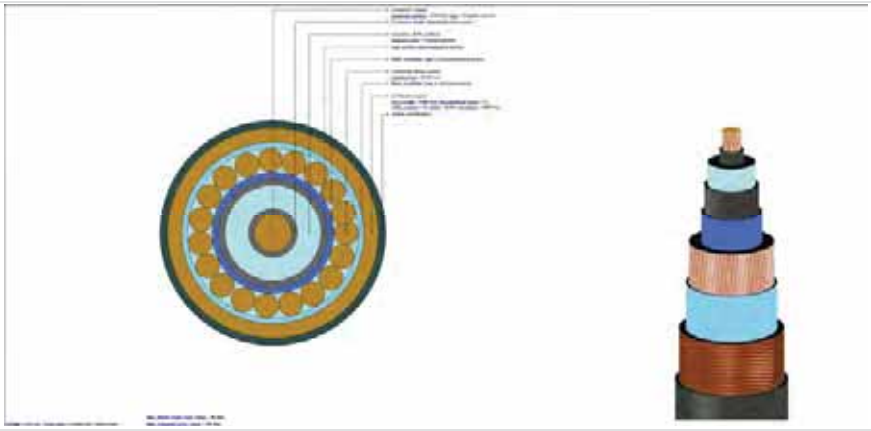
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		PVC Duct in Concrete
71	Duct material thermal resistivity	[K.m/W]	6
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	7.942
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H102-230_500kV,40_DOC,30__50_,5000kcmilInCu,@4454_4893A DLF1
Date:	11/4/2024 2:45:57 PM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

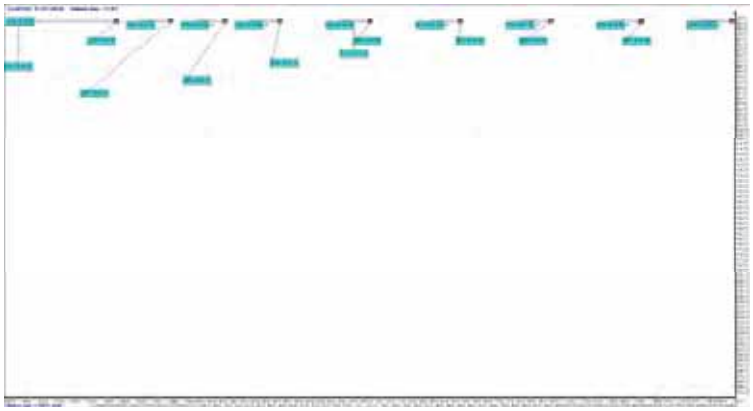
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB2	0.0	41.429	2.6	2.6	0.8
NSTD DB4	50.0	41.429	2.6	2.6	0.8
NSTD DB5	100.0	41.429	2.6	2.6	0.8
NSTD DB6	150.0	41.429	2.6	2.6	0.8
NSTD DB7	200.001	41.429	2.6	2.6	0.8
NSTD DB6	-50.0	41.429	2.6	2.6	0.8
NSTD DB7	-80.0	41.429	2.6	2.6	0.8
NSTD DB8	-110.0	41.429	2.6	2.6	0.8
NSTD DB9	-140.0	41.429	2.6	2.6	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	500C5.00X	1		A	60.0	1.0	-0.5	41.93	90.0	926.3
2	500C5.00X	1		B	60.0	1.0	-0.5	40.93	89.2	926.3
3	500C5.00X	1		C	60.0	1.0	0.5	40.93	88.4	926.3
4	500C5.00X	2		A	60.0	1.0	49.5	41.93	90.0	941.4
5	500C5.00X	2		B	60.0	1.0	49.5	40.93	89.2	941.4
6	500C5.00X	2		C	60.0	1.0	50.5	40.93	88.4	941.4
7	500C5.00X	3		A	60.0	1.0	99.5	41.93	90.0	955.4
8	500C5.00X	3		B	60.0	1.0	99.5	40.93	89.2	955.4
9	500C5.00X	3		C	60.0	1.0	100.5	40.93	88.4	955.4
10	500C5.00X	4		A	60.0	1.0	149.5	41.93	90.0	986.0
11	500C5.00X	4		B	60.0	1.0	149.5	40.93	89.3	986.0
12	500C5.00X	4		C	60.0	1.0	150.5	40.93	88.4	986.0
13	500C5.00X	5		A	60.0	1.0	199.5	41.93	90.0	1084.3
14	500C5.00X	5		B	60.0	1.0	199.5	40.93	89.3	1084.3
15	500C5.00X	5		C	60.0	1.0	200.5	40.93	88.2	1084.3
16	230C5.00X1	6		A	60.0	1.0	-50.5	41.93	90.0	1098.2
17	230C5.00X1	6		B	60.0	1.0	-50.5	40.93	89.0	1098.2
18	230C5.00X1	6		C	60.0	1.0	-49.5	40.93	88.2	1098.2
19	230C5.00X1	7		A	60.0	1.0	-80.5	41.93	90.0	1059.5
20	230C5.00X1	7		B	60.0	1.0	-80.5	40.93	89.0	1059.5
21	230C5.00X1	7		C	60.0	1.0	-79.5	40.93	88.4	1059.5
22	230C5.00X1	8		A	60.0	1.0	-110.5	41.93	90.0	1087.0
23	230C5.00X1	8		B	60.0	1.0	-110.5	40.93	89.1	1087.0
24	230C5.00X1	8		C	60.0	1.0	-109.5	40.93	88.5	1087.0
25	230C5.00X1	9		A	60.0	1.0	-140.5	41.93	90.0	1209.9
26	230C5.00X1	9		B	60.0	1.0	-140.5	40.93	89.1	1209.9
27	230C5.00X1	9		C	60.0	1.0	-139.5	40.93	88.7	1209.9

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_GIM_New 3 Routes
Execution:	H103-230_500kV.40_DOC.30__50_5000kcmilInCu@4454_4893A.DLF1
Date:	11/4/2024 2:45:57 PM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Uniqually Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical Interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Variable	Description	Unit	Cables																											
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
General Input Data																														
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	230C5.00K1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00K1	230C5.00X1	230C5.00X1	230C5.00X1
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9
Phase	Cable Phase		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Frq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-0.5	-0.5	0.5	49.5	49.5	50.5	99.5	99.5	100.5	149.5	149.5	150.5	199.5	199.5	200.5	-50.5	-50.5	-49.5	-80.5	-80.5	-79.5	-110.5	-110.5	-109.5	-140.5	-140.5	-139.5
y	Y coordinate	[ft]	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity																														
I	Steady State Ampacity	[A]	926.3	926.3	926.3	941.4	941.4	941.4	955.4	955.4	955.4	986.0	986.0	986.0	1084.3	1084.3	1084.3	1098.2	1098.2	1098.2	1059.5	1059.5	1059.5	1087.0	1087.0	1087.0	1209.9	1209.9	1209.9
Temperatures																														
θc	Conductor temperature	[°C]	90.0	89.2	88.4	90.0	89.2	88.4	90.0	89.2	88.4	90.0	89.3	88.4	90.0	89.3	88.2	90.0	89.0	88.2	90.0	89.0	88.4	90.0	89.1	88.5	90.0	89.1	88.7
θs	Sheath/Shield temperature	[°C]	85.1	84.3	83.5	85.0	84.2	83.4	84.9	84.1	83.3	84.6	83.9	83.0	83.8	83.1	81.9	85.6	84.6	83.8	85.9	84.9	84.3	85.7	84.8	84.2	84.7	83.8	83.4
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	84.2	83.4	82.6	84.1	83.3	82.5	83.9	83.2	82.4	83.7	82.9	82.1	82.7	82.0	80.9	85.1	84.1	83.3	85.4	84.5	83.9	85.2	84.3	83.7	84.1	83.2	82.8
θduct	Duct surface temperature	[°C]	80.0	79.2	78.4	79.8	79.0	78.2	79.6	78.8	78.0	79.1	78.3	77.5	77.5	76.8	75.7	80.9	80.0	79.1	81.5	80.6	80.0	81.1	80.2	79.6	79.2	78.2	77.8
Resistances																														
R_0	DC Resistance of the conductor at 20°C	(Ω/mile)	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	(Ω/mile)	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.01661	0.01656	0.01663	0.0166	0.01657	0.01663	0.0166	0.01658	0.01664	0.0166	0.01658	0.01664	0.0166	0.01658
ys	Skin Effect Factor		0.16154	0.16225	0.16291	0.16153	0.16223	0.1629	0.16153	0.16222	0.1629	0.16153	0.16219	0.16283	0.16153	0.16214	0.16313	0.16159	0.16243	0.16314	0.16158	0.1624	0.16293	0.16157	0.16228	0.16286	0.16157	0.16239	0.16272
yp	Proximity Effect Factor		0.00713	0.00716	0.00718	0.00713	0.00716	0.00718	0.00713	0.00716	0.00718	0.00713	0.00715	0.00718	0.00713	0.00715	0.00719	0.00742	0.00746	0.00749	0.00742	0.00745	0.00748	0.00742	0.00745	0.00747	0.00742	0.00745	0.00747
Losses																														
Wc	Conductor Losses	[W/ft]	2.70261	2.69755	2.69281	2.7915	2.78632	2.78139	2.8755	2.87026	2.86503	3.06235	3.057	3.05096	3.70355	3.69756	3.6879	3.79932	3.79086	3.78373	3.53636	3.52867	3.52372	3.72253	3.71457	3.70989	4.6118	4.60171	4.59769
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439
Ws	Metallic Screen Losses	[W/ft]	0.24636	0.24693	0.24746	0.25454	0.25512	0.25567	0.26227	0.26286	0.26345	0.27951	0.28011	0.28079	0.33886	0.33953	0.34063	0.1651	0.16558	0.16599	0.15354	0.15397	0.15425	0.16771	0.16816	0.16848	0.20091	0.20149	0.20172
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	4.9623	4.9578	4.9536	5.05936	5.05476	5.05039	5.1511	5.14645	5.14181	5.35518	5.35043	5.34508	6.09574	6.05062	6.04185	4.51882	4.51084	4.50412	4.2443	4.23704	4.23237	4.43864	4.43112	4.42671	5.36711	5.35759	5.3538
λ_1	Screen Loss Factor		0.09116	0.09154	0.0919	0.09118	0.09156	0.09192	0.09121	0.09158	0.09195	0.09127	0.09163	0.09203	0.0915	0.09183	0.09236	0.04346	0.04368	0.04387	0.04342	0.04363	0.04378	0.04344	0.04366	0.04378	0.04357	0.04379	0.04387
λ_2	Armour Loss Factor = Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances																														
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387
T4	External thermal resistance	[K.m/W]	4.43378	4.38848	4.346	4.34094	4.29715	4.25532	4.25923	4.21405	4.17184	4.07794	4.03916	3.9953	3.95711	3.53567	3.4746	4.93005	4.87407	4.82668	5.27181	5.21357	5.17594	5.03606	4.97149	4.93084	4.09661	4.05081	4.03262
Others																														
ΔθInt	Temperature rise due to surrounding heat sources	[°C]	52.3	51.4	50.8	51.8	50.9	50.3	51.3	50.4	49.8	50.2	49.3	48.6	46.2	45.4	44.5	54.7	53.6	52.9	56.1	55.1	54.6	55.0	54.0	53.6	50.1	49.0	48.8
	Induced Voltage (standing) on Sheath	(V/mile)	188.62	166.33	191.21	191.61	168.98	194.45	194.0	171.14	198.09	199.44	176.03	205.6	217.72	192.38	228.6	237.35	211.24	241.84	231.71	205.91	229.12	239.81	212.9	231.89	270.4	239.79	252.84
	Induced Voltage (standing) on Concentric Wires	(V/mile)	190.63	168.37	193.21	193.66	171.06	196.49	196.07	173.25	200.16	201.58	178.21	207.74	220.08	194.77	230.95	240.37	214.29	244.85	234.6	208.85	232.01	242.77	215.92	234.86	273.7	243.15	256.14
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

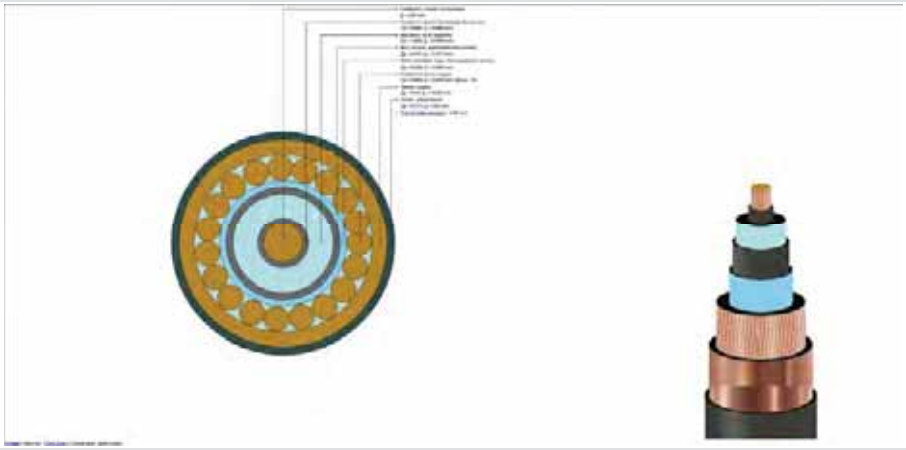
Cables Report

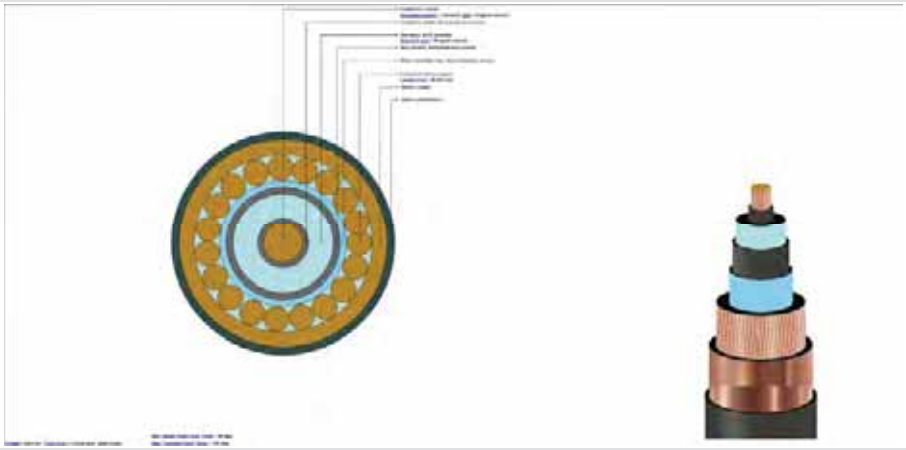
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H102-230_500kV,40_DOC,30__50_,5000kcmilInCu,@4454_4893A DLF1
Date:	11/4/2024 2:45:57 PM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		PVC Duct in Concrete
66	Duct material thermal resistivity	[K.m/W]	6
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	7.942
69	Outer diameter of the conduit	[in]	8.625

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Cables Report

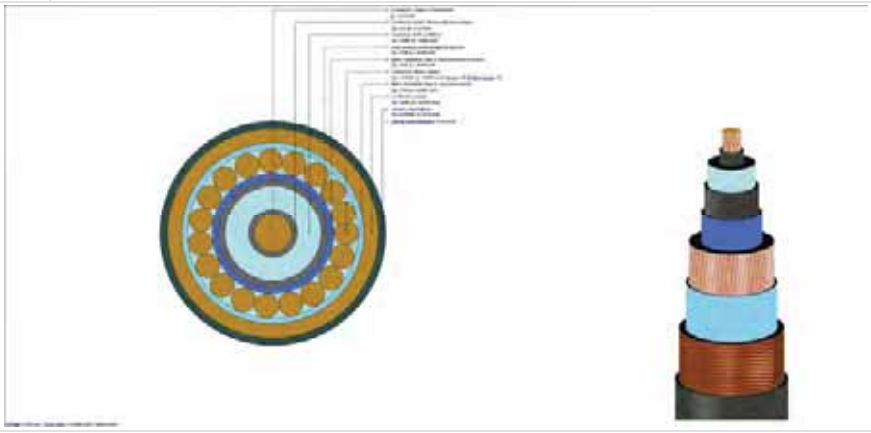
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H102-230_500kV,40_DOC,30__50_,5000kcmilInCu,@4454_4893A DLF1
Date:	11/4/2024 2:45:57 PM

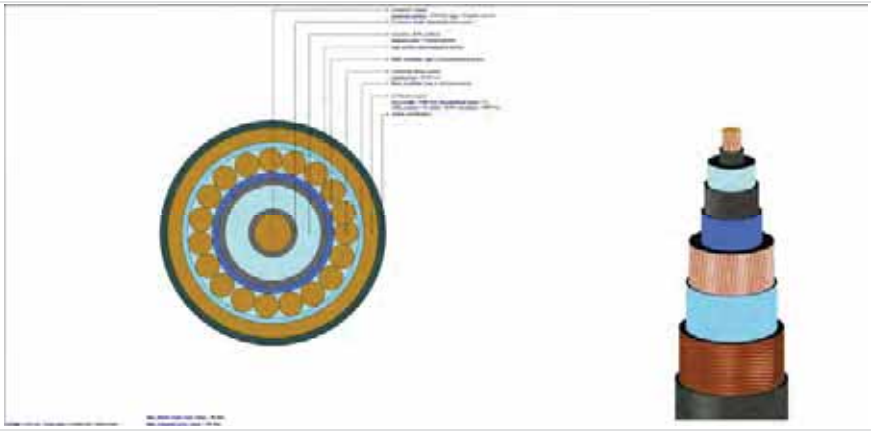
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		PVC Duct in Concrete
71	Duct material thermal resistivity	[K.m/W]	6
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	7.942
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H103-230_500kV,40_DOC,30__60_,5000kcmilInCu,@4499_5152A DLF1
Date:	11/4/2024 12:54:32 PM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

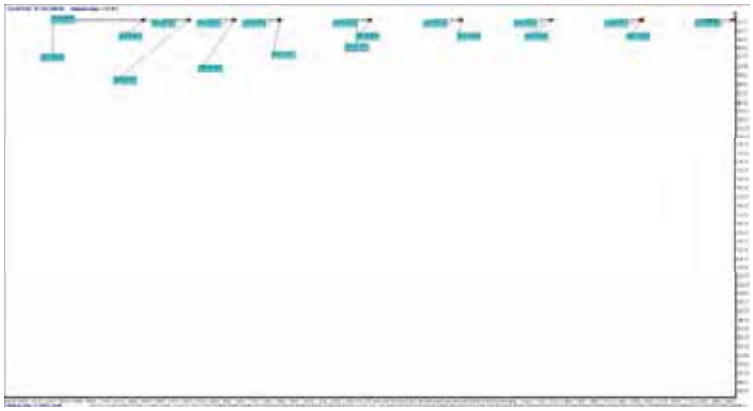
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB2	0.0	41.429	2.6	2.6	0.8
NSTD DB4	60.0	41.429	2.6	2.6	0.8
NSTD DB5	120.0	41.429	2.6	2.6	0.8
NSTD DB6	180.001	41.429	2.6	2.6	0.8
NSTD DB7	240.001	41.429	2.6	2.6	0.8
NSTD DB6	-60.0	41.429	2.6	2.6	0.8
NSTD DB7	-90.0	41.429	2.6	2.6	0.8
NSTD DB8	-120.0	41.429	2.6	2.6	0.8
NSTD DB9	-150.0	41.429	2.6	2.6	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	500C5.00X	1		A	60.0	1.0	-0.5	41.93	90.0	984.9
2	500C5.00X	1		B	60.0	1.0	-0.5	40.93	89.2	984.9
3	500C5.00X	1		C	60.0	1.0	0.5	40.93	88.4	984.9
4	500C5.00X	2		A	60.0	1.0	59.5	41.93	90.0	1001.9
5	500C5.00X	2		B	60.0	1.0	59.5	40.93	89.2	1001.9
6	500C5.00X	2		C	60.0	1.0	60.5	40.93	88.4	1001.9
7	500C5.00X	3		A	60.0	1.0	119.5	41.93	90.0	1013.0
8	500C5.00X	3		B	60.0	1.0	119.5	40.93	89.2	1013.0
9	500C5.00X	3		C	60.0	1.0	120.5	40.93	88.4	1013.0
10	500C5.00X	4		A	60.0	1.0	179.5	41.93	90.0	1036.1
11	500C5.00X	4		B	60.0	1.0	179.5	40.93	89.3	1036.1
12	500C5.00X	4		C	60.0	1.0	180.5	40.93	88.4	1036.1
13	500C5.00X	5		A	60.0	1.0	239.5	41.93	90.0	1116.6
14	500C5.00X	5		B	60.0	1.0	239.5	40.93	89.3	1116.6
15	500C5.00X	5		C	60.0	1.0	240.5	40.93	88.2	1116.6
16	230C5.00X1	6		A	60.0	1.0	-60.5	41.93	90.0	1125.0
17	230C5.00X1	6		B	60.0	1.0	-60.5	40.93	89.0	1125.0
18	230C5.00X1	6		C	60.0	1.0	-59.5	40.93	88.1	1125.0
19	230C5.00X1	7		A	60.0	1.0	-90.5	41.93	90.0	1069.9
20	230C5.00X1	7		B	60.0	1.0	-90.5	40.93	89.1	1069.9
21	230C5.00X1	7		C	60.0	1.0	-89.5	40.93	88.4	1069.9
22	230C5.00X1	8		A	60.0	1.0	-120.5	41.93	90.0	1091.8
23	230C5.00X1	8		B	60.0	1.0	-120.5	40.93	89.1	1091.8
24	230C5.00X1	8		C	60.0	1.0	-119.5	40.93	88.5	1091.8
25	230C5.00X1	9		A	60.0	1.0	-150.5	41.93	90.0	1212.4
26	230C5.00X1	9		B	60.0	1.0	-150.5	40.93	89.1	1212.4
27	230C5.00X1	9		C	60.0	1.0	-149.5	40.93	88.7	1212.4

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H103-230_500kV.40_DOC.30__60_5000kcmilInCu@4499_5152A.DLF1
Date:	11/4/2024 12:54:32 PM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Uniqually Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical Interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Variable	Description	Unit	Cables																											
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
General Input Data																														
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	230C5.00K1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00K1	230C5.00X1	230C5.00X1	230C5.00X1
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9
Phase	Cable Phase		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Frq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-0.5	-0.5	0.5	59.5	59.5	60.5	119.5	119.5	120.5	179.5	179.5	180.5	239.5	239.5	240.5	-60.5	-60.5	-59.5	-90.5	-90.5	-89.5	-120.5	-120.5	-119.5	-150.5	-150.5	-149.5
y	Y coordinate	[ft]	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity																														
I	Steady State Ampacity	[A]	984.9	984.9	984.9	1001.9	1001.9	1001.9	1013.0	1013.0	1013.0	1036.1	1036.1	1036.1	1116.6	1116.6	1116.6	1125.0	1125.0	1125.0	1089.9	1089.9	1089.9	1091.8	1091.8	1091.8	1212.4	1212.4	1212.4
Temperatures																														
θc	Conductor temperature	[°C]	90.0	89.2	88.4	90.0	89.2	88.4	90.0	89.2	88.4	90.0	89.3	88.4	90.0	89.3	88.2	90.0	89.0	88.1	90.0	89.1	88.4	90.0	89.1	88.5	90.0	89.1	88.7
θs	Sheath/Shield temperature	[°C]	84.6	83.8	83.0	84.5	83.7	82.9	84.4	83.6	82.8	84.2	83.5	82.6	83.5	82.8	81.7	85.4	84.4	83.5	85.8	84.9	84.3	85.7	84.7	84.2	84.7	83.8	83.4
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	83.7	82.9	82.1	83.5	82.7	81.9	83.4	82.6	81.8	83.2	82.4	81.6	82.3	81.7	80.6	84.9	83.9	83.0	85.3	84.4	83.8	85.2	84.2	83.7	84.1	83.2	82.8
θduct	Duct surface temperature	[°C]	79.1	78.3	77.5	78.9	78.1	77.2	78.7	77.9	77.1	78.3	77.6	76.7	77.0	76.3	75.2	80.5	79.5	78.7	81.3	80.4	79.8	81.0	80.1	79.6	79.1	78.2	77.8
Resistances																														
R_0	DC Resistance of the conductor at 20°C	(Ω/mile)	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	(Ω/mile)	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.01661	0.01656	0.01663	0.0166	0.01656	0.01663	0.0166	0.01657	0.01664	0.0166	0.01658	0.01664	0.0166	0.01658
ys	Skin Effect Factor		0.16154	0.16223	0.16295	0.16153	0.16221	0.16293	0.16133	0.16219	0.16293	0.16153	0.16217	0.16295	0.16153	0.16212	0.1631	0.16159	0.16243	0.16321	0.16158	0.1624	0.16295	0.16157	0.16238	0.16286	0.16157	0.16239	0.16272
yp	Proximity Effect Factor		0.00713	0.00716	0.00719	0.00713	0.00716	0.00718	0.00713	0.00716	0.00718	0.00713	0.00715	0.00719	0.00713	0.00715	0.00719	0.00742	0.00746	0.00749	0.00742	0.00745	0.00748	0.00742	0.00745	0.00747	0.00742	0.00745	0.00747
Losses																														
Wc	Conductor Losses	[W/ft]	3.05546	3.0499	3.04409	3.16216	3.15649	3.15044	3.23295	3.22723	3.22093	3.38156	3.37578	3.36979	3.92769	3.9215	3.91136	3.98705	3.97826	3.97003	3.60625	3.59848	3.59323	3.73536	3.74737	3.74295	4.631	4.62091	4.61682
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439
Ws	Metallic Screen Losses	[W/ft]	0.2789	0.27952	0.28018	0.28874	0.28938	0.29006	0.29527	0.29592	0.29663	0.30902	0.30967	0.31046	0.35847	0.36037	0.36152	0.17337	0.17387	0.17434	0.15661	0.15705	0.15735	0.16315	0.16361	0.16388	0.20176	0.20234	0.20257
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	5.34769	5.34275	5.33759	5.46422	5.45919	5.45382	5.54154	5.53647	5.53088	5.70391	5.69877	5.69257	6.30069	6.2952	6.2892	4.71482	4.70652	4.69877	4.31726	4.30992	4.30497	4.47291	4.46637	4.46084	5.38716	5.37764	5.37378
λ_1	Screen Loss Factor		0.09128	0.09165	0.09204	0.09131	0.09168	0.09207	0.09133	0.09169	0.09209	0.09138	0.09173	0.09216	0.09157	0.0919	0.09243	0.04348	0.04371	0.04391	0.04343	0.04364	0.04379	0.04345	0.04366	0.04379	0.04357	0.04379	0.04388
λ_2	Armour Loss Factor = Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances																														
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387
T4	External thermal resistance	[K.m/W]	4.08367	4.04302	4.00048	3.98787	3.94886	3.90715	3.92645	3.88864	3.84677	3.80268	3.76722	3.7242	3.49233	3.37294	3.32454	4.71052	4.65734	4.60739	5.17679	5.12003	5.08155	4.99486	4.93102	4.89854	4.08006	4.03464	4.01624
Others																														
ΔθInt	Temperature rise due to surrounding heat sources	[°C]	50.2	49.4	48.7	49.6	48.7	48.1	49.2	48.3	47.6	48.3	47.4	46.7	44.9	44.1	43.2	53.6	52.6	51.9	55.7	54.7	54.2	54.9	53.9	53.4	50.0	48.9	48.7
	Induced Voltage (standing) on Sheath	(V/mile)	200.7	176.97	203.08	204.12	180.0	206.67	205.96	181.67	209.63	209.95	185.27	215.46	234.86	198.61	234.39	242.76	216.1	248.35	233.83	207.81	231.62	240.78	213.77	233.03	270.92	240.25	253.43
	Induced Voltage (standing) on Concentric Wires	(V/mile)	202.84	179.14	205.22	206.3	182.21	208.84	208.16	183.91	211.82	212.2	187.56	217.7	237.29	201.07	236.82	245.85	219.22	251.43	236.75	210.78	234.54	243.76	216.8	236.02	274.22	243.62	256.75
	Induced current on Metallic Screen	(A)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

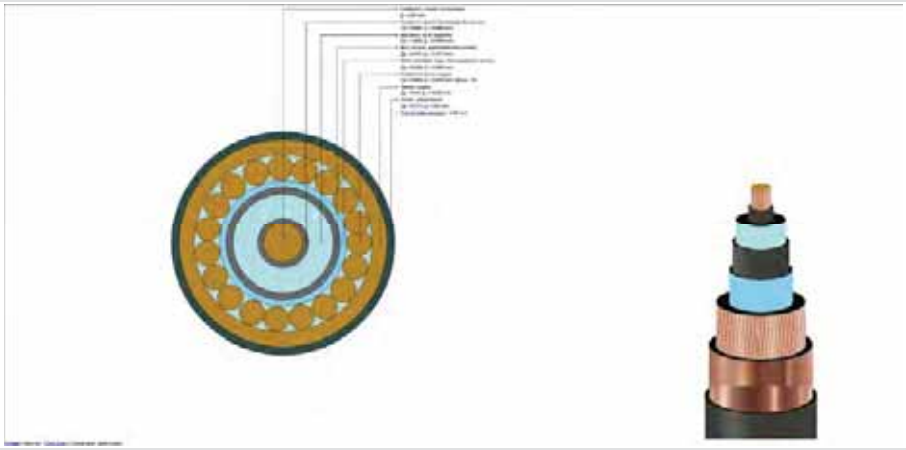
Cables Report

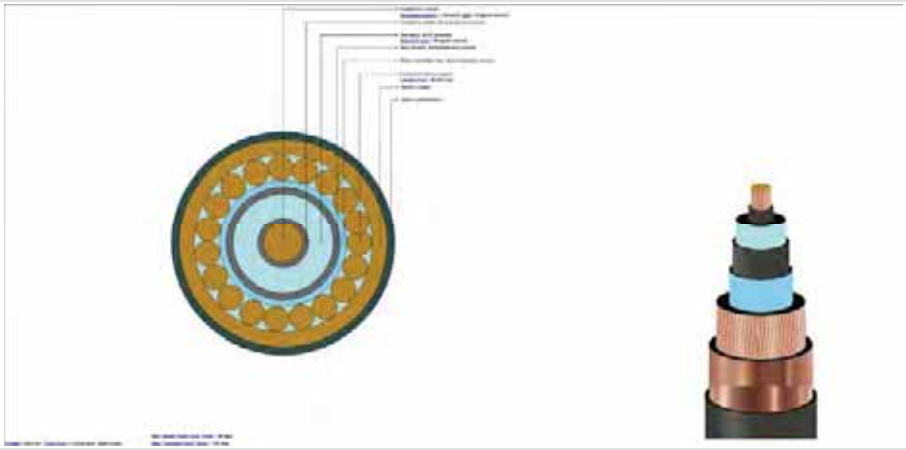
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H103-230_500kV,40_DOC,30__60_,5000kcmilInCu,@4499_5152A DLF1
Date:	11/4/2024 12:54:32 PM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		PVC Duct in Concrete
66	Duct material thermal resistivity	[K.m/W]	6
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	7.942
69	Outer diameter of the conduit	[in]	8.625

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Cables Report

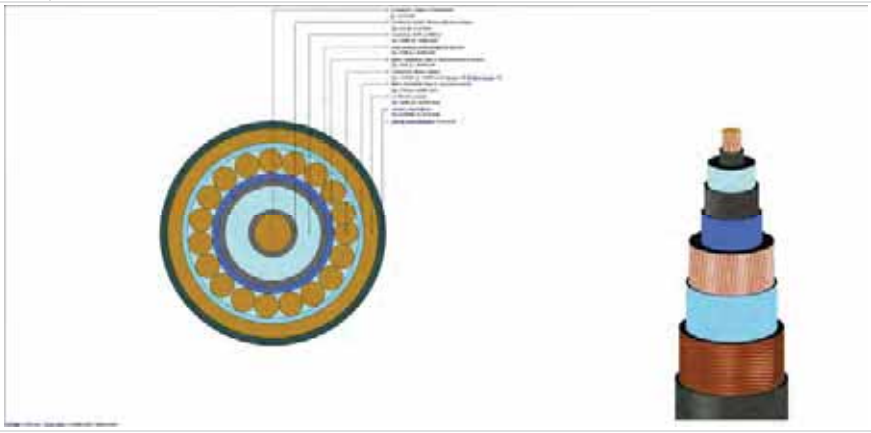
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H103-230_500kV,40_DOC,30__60_,5000kcmilInCu,@4499_5152A DLF1
Date:	11/4/2024 12:54:32 PM

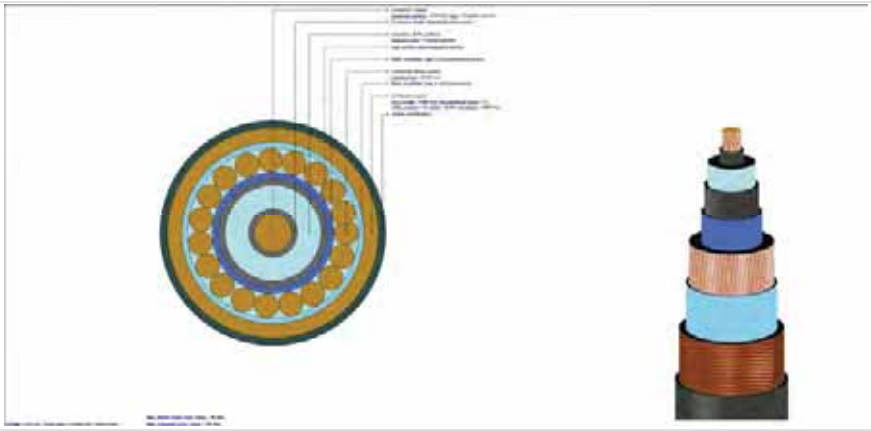
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		PVC Duct in Concrete
71	Duct material thermal resistivity	[K.m/W]	6
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	7.942
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H104-230_500kV,40_DOC,25__60_,5000kcmillnCu,@4355_5147A DLF1
Date:	11/4/2024 10:35:02 AM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

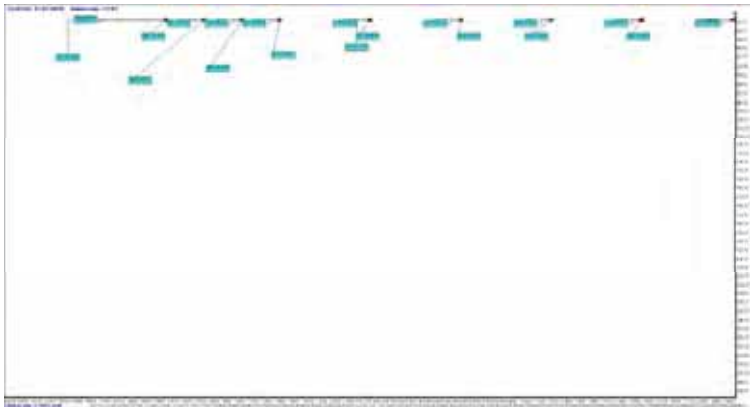
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB2	0.0	41.429	2.6	2.6	0.8
NSTD DB4	60.0	41.429	2.6	2.6	0.8
NSTD DB5	120.0	41.429	2.6	2.6	0.8
NSTD DB6	180.001	41.429	2.6	2.6	0.8
NSTD DB7	240.001	41.429	2.6	2.6	0.8
NSTD DB6	-60.0	41.429	2.6	2.6	0.8
NSTD DB7	-85.0	41.429	2.6	2.6	0.8
NSTD DB8	-110.0	41.429	2.6	2.6	0.8
NSTD DB9	-135.0	41.429	2.6	2.6	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	500C5.00X	1		A	60.0	1.0	-0.5	41.93	90.0	981.0
2	500C5.00X	1		B	60.0	1.0	-0.5	40.93	89.2	981.0
3	500C5.00X	1		C	60.0	1.0	0.5	40.93	88.4	981.0
4	500C5.00X	2		A	60.0	1.0	59.5	41.93	90.0	1000.9
5	500C5.00X	2		B	60.0	1.0	59.5	40.93	89.2	1000.9
6	500C5.00X	2		C	60.0	1.0	60.5	40.93	88.4	1000.9
7	500C5.00X	3		A	60.0	1.0	119.5	41.93	90.0	1012.7
8	500C5.00X	3		B	60.0	1.0	119.5	40.93	89.2	1012.7
9	500C5.00X	3		C	60.0	1.0	120.5	40.93	88.4	1012.7
10	500C5.00X	4		A	60.0	1.0	179.5	41.93	90.0	1035.9
11	500C5.00X	4		B	60.0	1.0	179.5	40.93	89.3	1035.9
12	500C5.00X	4		C	60.0	1.0	180.5	40.93	88.4	1035.9
13	500C5.00X	5		A	60.0	1.0	239.5	41.93	90.0	1116.5
14	500C5.00X	5		B	60.0	1.0	239.5	40.93	89.3	1116.5
15	500C5.00X	5		C	60.0	1.0	240.5	40.93	88.2	1116.5
16	230C5.00X1	6		A	60.0	1.0	-60.5	41.93	90.0	1096.7
17	230C5.00X1	6		B	60.0	1.0	-60.5	40.93	89.0	1096.7
18	230C5.00X1	6		C	60.0	1.0	-59.5	40.93	88.1	1096.7
19	230C5.00X1	7		A	60.0	1.0	-85.5	41.93	90.0	1027.6
20	230C5.00X1	7		B	60.0	1.0	-85.5	40.93	89.1	1027.6
21	230C5.00X1	7		C	60.0	1.0	-84.5	40.93	88.5	1027.6
22	230C5.00X1	8		A	60.0	1.0	-110.5	41.93	90.0	1049.4
23	230C5.00X1	8		B	60.0	1.0	-110.5	40.93	89.1	1049.4
24	230C5.00X1	8		C	60.0	1.0	-109.5	40.93	88.6	1049.4
25	230C5.00X1	9		A	60.0	1.0	-135.5	41.93	90.0	1180.8
26	230C5.00X1	9		B	60.0	1.0	-135.5	40.93	89.1	1180.8
27	230C5.00X1	9		C	60.0	1.0	-134.5	40.93	88.8	1180.8

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H104-230_500kV,40_DOC,25__60_5000kcmilInCu,@4355_5147A DLF1
Date:	11/4/2024 10:35:02 AM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Cables 1–14

Variable	Description	Unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14
General Input Data																
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3	4	4	4	5	5
Phase	Cable Phase		A	B	C	A	B	C	A	B	C	A	B	C	A	B
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-0.5	-0.5	0.5	59.5	59.5	60.5	119.5	119.5	120.5	179.5	179.5	180.5	239.5	239.5
y	Y coordinate	[ft]	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity																
I	Steady State Ampacity	[A]	981.0	981.0	981.0	1000.9	1000.9	1000.9	1012.7	1012.7	1012.7	1035.9	1035.9	1035.9	1116.5	1116.5
Temperatures																
θc	Conductor temperature	[°C]	90.0	89.2	88.4	90.0	89.2	88.4	90.0	89.2	88.4	90.0	89.3	88.4	90.0	89.3
θs	Sheath/Shield temperature	[°C]	84.6	83.8	83.0	84.5	83.7	82.9	84.4	83.6	82.8	84.2	83.5	82.6	83.5	82.8
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	83.7	82.9	82.1	83.5	82.7	81.9	83.4	82.6	81.8	83.2	82.4	81.6	82.3	81.7
θduct	Duct surface temperature	[°C]	79.2	78.4	77.5	78.9	78.1	77.3	78.7	77.9	77.1	78.3	77.6	76.7	77.0	76.3
Resistances																
R_o	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.01661
ys	Skin Effect Factor		0.16154	0.16223	0.16295	0.16153	0.16221	0.16293	0.16153	0.16219	0.16293	0.16153	0.16217	0.16295	0.16153	0.16212
yp	Proximity Effect Factor		0.00713	0.00716	0.00719	0.00713	0.00716	0.00718	0.00713	0.00716	0.00718	0.00713	0.00715	0.00719	0.00713	0.00715
Losses																
Wc	Conductor Losses	[W/ft]	3.03134	3.02581	3.02004	3.15582	3.15017	3.14413	3.2308	3.22509	3.21878	3.38068	3.37489	3.36791	3.92728	3.92109
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.27667	0.27729	0.27794	0.28815	0.28879	0.28947	0.29508	0.29572	0.29643	0.30894	0.30959	0.31037	0.35963	0.36033
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	5.32134	5.31643	5.31131	5.4573	5.45228	5.44692	5.5392	5.53413	5.52853	5.70294	5.6978	5.69161	6.30024	6.29475
λ_1	Screen Loss Factor		0.09127	0.09164	0.09203	0.09131	0.09167	0.09207	0.09133	0.09169	0.09209	0.09138	0.09173	0.09216	0.09157	0.0919
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances																
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	4.10598	4.06506	4.0222	3.99346	3.95441	3.91262	3.92829	3.89043	3.84849	3.8034	3.76789	3.72492	3.4026	3.37322
Others																
Δθint	Temperature rise due to surrounding heat sources	[°C]	50.4	49.5	48.8	49.6	48.8	48.1	49.2	48.3	47.7	48.3	47.5	46.7	44.9	44.1
	Induced Voltage (standing) on Sheath	[V/mile]	199.84	176.22	202.39	203.92	179.82	206.47	205.91	181.62	209.54	209.94	185.26	215.41	224.86	198.61
	Induced Voltage (standing) on Concentric Wires	[V/mile]	201.97	178.38	204.51	206.09	182.02	208.64	208.11	183.85	211.74	212.19	187.54	217.65	227.29	201.07
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cables 15–27

Variable	Description	Unit	15	16	17	18	19	20	21	22	23	24	25	26	27
Cable No.	Cable Index Number		15	16	17	18	19	20	21	22	23	24	25	26	27
General Input Data															
Cable ID	Cable Equipment ID		500C5.00X	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1
Circuit No.	Circuit No.		5	6	6	6	7	7	7	8	8	8	9	9	9
Phase	Cable Phase		C	A	B	C	A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	240.5	-60.5	-60.5	-59.5	-85.5	-85.5	-84.5	-110.5	-110.5	-109.5	-135.5	-135.5	-134.5
y	Y coordinate	[ft]	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity															
I	Steady State Ampacity	[A]	1116.5	1096.7	1096.7	1096.7	1027.6	1027.6	1027.6	1049.4	1049.4	1049.4	1180.8	1180.8	1180.8
Temperatures															
θc	Conductor temperature	[°C]	88.2	90.0	89.0	88.1	90.0	89.1	88.5	90.0	89.1	88.6	90.0	89.1	88.8
θs	Sheath/Shield temperature	[°C]	81.7	85.6	84.7	83.7	86.1	85.2	84.6	86.0	85.1	84.6	85.0	84.0	83.8
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	80.6	85.1	84.2	83.2	85.7	84.8	84.2	85.5	84.6	84.1	84.4	83.5	83.2
θduct	Duct surface temperature	[°C]	75.2	80.9	80.0	79.1	82.0	81.0	80.4	81.7	80.8	80.3	79.6	78.7	78.4
Resistances															
R_o	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01656	0.01663	0.0166	0.01656	0.01663	0.0166	0.01658	0.01664	0.0166	0.01658	0.01664	0.0166	0.01659
ys	Skin Effect Factor		0.1631	0.16159	0.16241	0.16324	0.16158	0.16238	0.1629	0.16157	0.16236	0.16279	0.16157	0.16239	0.16262
yp	Proximity Effect Factor		0.00719	0.00742	0.00746	0.00749	0.00742	0.00745	0.00748	0.00742	0.00745	0.00747	0.00742	0.00745	0.00746
Losses															
Wc	Conductor Losses	[W/ft]	3.91094	3.78908	3.78084	3.77264	3.3266	3.31958	3.31499	3.46942	3.4622	3.45825	4.39326	4.38372	4.38104
Wd	Dielectric Losses	[W/ft]	2.01332	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439
Ws	Metallic Screen Losses	[W/ft]	0.36148	0.16466	0.16512	0.16559	0.14433	0.14473	0.14499	0.15059	0.151	0.15122	0.19126	0.1918	0.19195
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	6.28575	4.50813	4.50036	4.49263	4.02532	4.0187	4.01437	4.17441	4.16759	4.16387	5.13891	5.12991	5.12739
λ_1	Screen Loss Factor		0.09243	0.04346	0.04367	0.04389	0.04339	0.0436	0.04374	0.0434	0.04361	0.04373	0.04353	0.04375	0.04381
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances															
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387
T4	External thermal resistance	[K.m/W]	3.32479	4.94244	4.88759	4.83275	5.57755	5.51796	5.47873	5.36629	5.30975	5.27879	4.29401	4.24649	4.23325
Others															
Δθint	Temperature rise due to surrounding heat sources	[°C]	43.2	54.7	53.7	52.9	57.2	56.2	55.8	56.4	55.4	55.1	51.3	50.2	50.1
	Induced Voltage (standing) on Sheath	[V/mile]	234.36	235.81	210.0	243.44	224.51	199.52	222.56	231.83	205.77	223.4	265.03	234.93	245.13
	Induced Voltage (standing) on Concentric Wires	[V/mile]	236.78	238.82	213.05	246.45	227.32	202.37	225.38	234.69	208.68	226.27	268.24	238.2	248.35
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

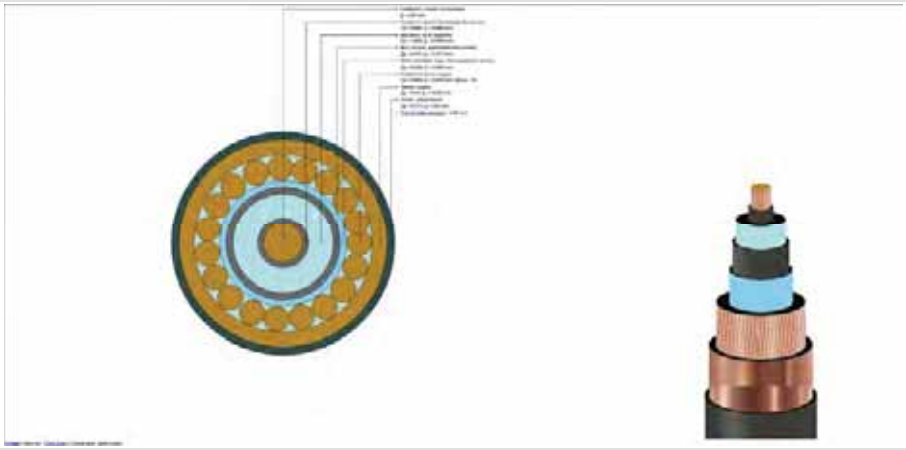
Cables Report

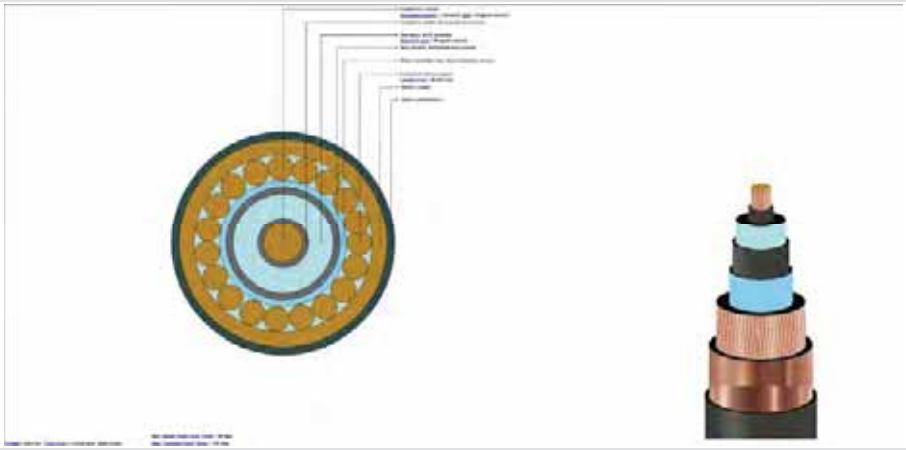
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H104-230_500kV,40_DOC,25__60_,5000kcmilInCu,@4355_5147A DLF1
Date:	11/4/2024 10:35:02 AM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		PVC Duct in Concrete
66	Duct material thermal resistivity	[K.m/W]	6
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	7.942
69	Outer diameter of the conduit	[in]	8.625

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Cables Report

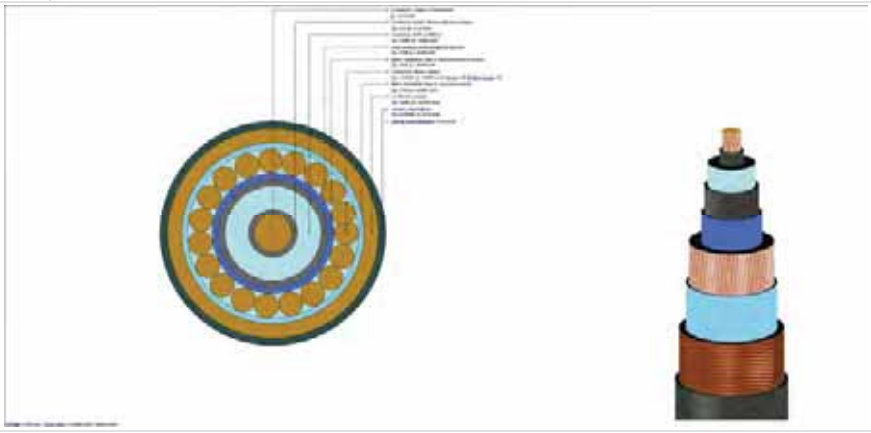
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H104-230_500kV,40_DOC,25__60_,5000kcmilInCu,@4355_5147A DLF1
Date:	11/4/2024 10:35:02 AM

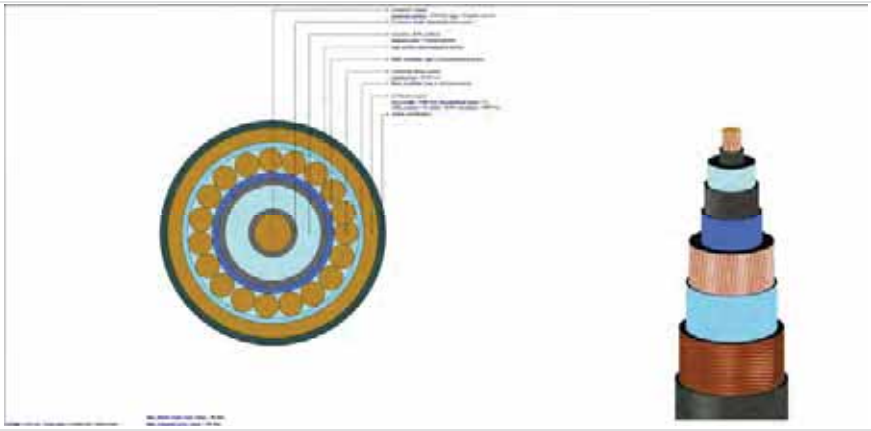
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		PVC Duct in Concrete
71	Duct material thermal resistivity	[K.m/W]	6
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	7.942
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H105-230_500kV,40_DOC,15__60_,5000kcmilInCu,@3972_5140A DLF1
Date:	11/4/2024 8:26:44 AM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

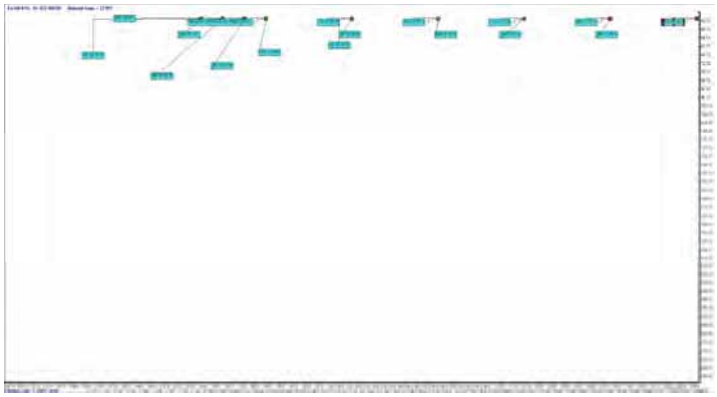
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB2	0.0	41.429	2.6	2.6	0.8
NSTD DB4	60.0	41.429	2.6	2.6	0.8
NSTD DB5	120.0	41.429	2.6	2.6	0.8
NSTD DB6	180.001	41.429	2.6	2.6	0.8
NSTD DB7	240.001	41.429	2.6	2.6	0.8
NSTD DB6	-60.0	41.429	2.6	2.6	0.8
NSTD DB7	-75.0	41.429	2.6	2.6	0.8
NSTD DB8	-90.0	41.429	2.6	2.6	0.8
NSTD DB9	-105.0	41.429	2.6	2.6	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	500C5.00X	1		A	60.0	1.0	-0.5	41.93	90.0	975.5
2	500C5.00X	1		B	60.0	1.0	-0.5	40.93	89.2	975.5
3	500C5.00X	1		C	60.0	1.0	0.5	40.93	88.4	975.5
4	500C5.00X	2		A	60.0	1.0	59.5	41.93	90.0	999.8
5	500C5.00X	2		B	60.0	1.0	59.5	40.93	89.2	999.8
6	500C5.00X	2		C	60.0	1.0	60.5	40.93	88.4	999.8
7	500C5.00X	3		A	60.0	1.0	119.5	41.93	90.0	1012.4
8	500C5.00X	3		B	60.0	1.0	119.5	40.93	89.2	1012.4
9	500C5.00X	3		C	60.0	1.0	120.5	40.93	88.4	1012.4
10	500C5.00X	4		A	60.0	1.0	179.5	41.93	90.0	1035.9
11	500C5.00X	4		B	60.0	1.0	179.5	40.93	89.3	1035.9
12	500C5.00X	4		C	60.0	1.0	180.5	40.93	88.4	1035.9
13	500C5.00X	5		A	60.0	1.0	239.5	41.93	90.0	1116.5
14	500C5.00X	5		B	60.0	1.0	239.5	40.93	89.3	1116.5
15	500C5.00X	5		C	60.0	1.0	240.5	40.93	88.2	1116.5
16	230C5.00X1	6		A	60.0	1.0	-60.5	41.93	90.0	1020.1
17	230C5.00X1	6		B	60.0	1.0	-60.5	40.93	89.1	1020.1
18	230C5.00X1	6		C	60.0	1.0	-59.5	40.93	88.0	1020.1
19	230C5.00X1	7		A	60.0	1.0	-75.5	41.93	90.0	918.1
20	230C5.00X1	7		B	60.0	1.0	-75.5	40.93	89.2	918.1
21	230C5.00X1	7		C	60.0	1.0	-74.5	40.93	88.6	918.1
22	230C5.00X1	8		A	60.0	1.0	-90.5	41.93	90.0	938.2
23	230C5.00X1	8		B	60.0	1.0	-90.5	40.93	89.2	938.2
24	230C5.00X1	8		C	60.0	1.0	-89.5	40.93	88.8	938.2
25	230C5.00X1	9		A	60.0	1.0	-105.5	41.93	90.0	1095.4
26	230C5.00X1	9		B	60.0	1.0	-105.5	40.93	89.1	1095.4
27	230C5.00X1	9		C	60.0	1.0	-104.5	40.93	89.2	1095.4

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H105-230_500kV,40_DOC,15__60_,5000kcmilInCu,@3972_5140A DLF1
Date:	11/4/2024 8:26:44 AM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Variable	Description	Unit	Cables													
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14
General Input Data																
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3	4	4	4	5	5
Phase	Cable Phase		A	B	C	A	B	C	A	B	C	A	B	C	A	B
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-0.5	-0.5	0.5	59.5	59.5	60.5	119.5	119.5	120.5	179.5	179.5	180.5	239.5	239.5
y	Y coordinate	[ft]	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity																
I	Steady State Ampacity	[A]	975.5	975.5	975.5	999.8	999.8	999.8	1012.4	1012.4	1012.4	1035.9	1035.9	1035.9	1116.5	1116.5
Temperatures																
θc	Conductor temperature	[°C]	90.0	89.2	88.4	90.0	89.2	88.4	90.0	89.2	88.4	90.0	89.3	88.4	90.0	89.3
θs	Sheath/Shield temperature	[°C]	84.7	83.9	83.1	84.5	83.7	82.9	84.4	83.6	82.8	84.2	83.5	82.6	83.5	82.8
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	83.7	83.0	82.1	83.5	82.8	81.9	83.4	82.6	81.8	83.2	82.4	81.6	82.3	81.7
θduct	Duct surface temperature	[°C]	79.2	78.5	77.6	78.9	78.1	77.3	78.7	77.9	77.1	78.3	77.6	76.7	77.0	76.3
Resistances																
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.01661
ys	Skin Effect Factor		0.16154	0.16223	0.16295	0.16153	0.16221	0.16293	0.16153	0.16219	0.16293	0.16153	0.16217	0.16295	0.16153	0.16212
yp	Proximity Effect Factor		0.00713	0.00716	0.00719	0.00713	0.00716	0.00718	0.00713	0.00716	0.00718	0.00713	0.00715	0.00719	0.00713	0.00715
Losses																
Wc	Conductor Losses	[W/ft]	2.9977	2.99222	2.98649	3.1489	3.14325	3.13722	3.22857	3.22286	3.21657	3.38034	3.37456	3.36757	3.92682	3.92062
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.27356	0.27418	0.27483	0.28751	0.28815	0.28883	0.29487	0.29551	0.29622	0.3089	0.30955	0.31034	0.35959	0.36029
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	5.28459	5.27972	5.27464	5.44974	5.44472	5.43937	5.53676	5.53169	5.52611	5.70257	5.69744	5.69123	6.29974	6.29424
λ_1	Screen Loss Factor		0.09126	0.09163	0.09202	0.09131	0.09167	0.09206	0.09133	0.09169	0.09209	0.09138	0.09173	0.09216	0.09157	0.0919
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances																
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	4.13754	4.09618	4.05292	3.99962	3.96045	3.91857	3.93022	3.89233	3.85047	3.80367	3.76823	3.72517	3.40291	3.37349
Others																
Δθint	Temperature rise due to surrounding heat sources	[°C]	50.6	49.7	49.0	49.7	48.8	48.1	49.2	48.4	47.7	48.3	47.5	46.7	44.9	44.1
	Induced Voltage (standing) on Sheath	[V/mile]	198.61	175.15	201.44	203.72	179.64	206.2	205.88	181.6	209.39	209.98	185.29	215.31	224.9	198.63
	Induced Voltage (standing) on Concentric Wires	[V/mile]	200.72	177.3	203.56	205.89	181.84	208.37	208.08	183.83	211.59	212.23	187.57	217.56	227.33	201.09
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	Description	Unit	Cables												
Cable No.	Cable Index Number		15	16	17	18	19	20	21	22	23	24	25	26	27
General Input Data															
Cable ID	Cable Equipment ID		500C5.00X	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1
Circuit No.	Circuit No.		5	6	6	6	7	7	7	8	8	8	9	9	9
Phase	Cable Phase		C	A	B	C	A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	240.5	-60.5	-60.5	-59.5	-75.5	-75.5	-74.5	-90.5	-90.5	-89.5	-105.5	-105.5	-104.5
y	Y coordinate	[ft]	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93	41.93	40.93	40.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity															
I	Steady State Ampacity	[A]	1116.5	1020.1	1020.1	1020.1	918.1	918.1	918.1	938.2	938.2	938.2	1095.4	1095.4	1095.4
Temperatures															
θc	Conductor temperature	[°C]	88.2	90.0	89.1	88.0	90.0	89.2	88.6	90.0	89.2	88.8	90.0	89.1	89.2
θs	Sheath/Shield temperature	[°C]	81.7	86.1	85.3	84.2	86.8	86.0	85.5	86.7	85.9	85.6	85.6	84.7	84.8
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	80.6	85.7	84.8	83.7	86.5	85.6	85.1	86.3	85.5	85.2	85.1	84.2	84.3
θduct	Duct surface temperature	[°C]	75.2	82.0	81.2	80.1	83.4	82.6	82.0	83.2	82.3	82.0	81.0	80.1	80.2
Resistances															
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01656	0.01663	0.0166	0.01656	0.01664	0.0166	0.01658	0.01664	0.0166	0.01659	0.01664	0.0166	0.0166
ys	Skin Effect Factor		0.1631	0.16159	0.16236	0.16334	0.16158	0.16231	0.16278	0.16157	0.1623	0.16259	0.16157	0.16236	0.16227
yp	Proximity Effect Factor		0.00719	0.00742	0.00745	0.00749	0.00742	0.00745	0.00747	0.00742	0.00745	0.00746	0.00742	0.00745	0.00745
Losses															
Wc	Conductor Losses	[W/ft]	3.91049	3.27853	3.27185	3.26341	2.65541	2.65024	2.64696	2.77343	2.76805	2.76594	3.78021	3.77223	3.77317
Wd	Dielectric Losses	[W/ft]	2.01332	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439
Ws	Metallic Screen Losses	[W/ft]	0.36144	0.14223	0.14261	0.14309	0.11495	0.11525	0.11543	0.1201	0.12041	0.12053	0.16424	0.16469	0.16464
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	6.28525	3.97516	3.96885	3.96089	3.32476	3.31988	3.31679	3.44793	3.44285	3.44086	4.49884	4.49131	4.4922
λ_1	Screen Loss Factor		0.09243	0.04338	0.04359	0.04385	0.04329	0.04348	0.04361	0.04331	0.0435	0.04358	0.04345	0.04366	0.04363
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances															
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387
T4	External thermal resistance	[K.m/W]	3.3251	5.65198	5.59347	5.5194	6.82656	6.75971	6.71718	6.57066	6.50663	6.48149	4.95452	4.90151	4.90792
Others															
Δθint	Temperature rise due to surrounding heat sources	[°C]	43.2	57.5	56.5	55.6	60.9	60.0	59.6	60.2	59.3	59.1	54.7	53.7	53.9
	Induced Voltage (standing) on Sheath	[V/mile]	234.27	216.31	192.96	231.37	200.27	177.9	199.42	208.55	184.86	197.88	249.97	221.22	221.35
	Induced Voltage (standing) on Concentric Wires	[V/mile]	236.69	219.12	195.79	234.17	202.79	180.45	201.93	211.1	187.46	200.45	252.93	224.25	224.34
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

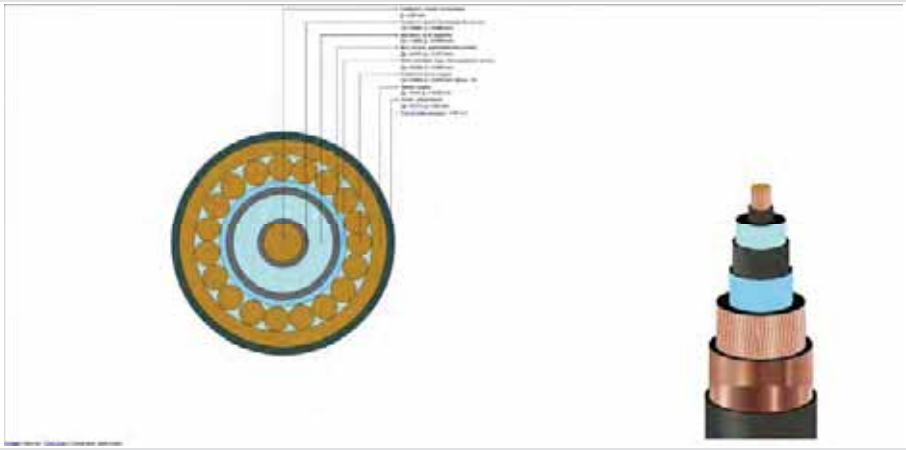
Cables Report

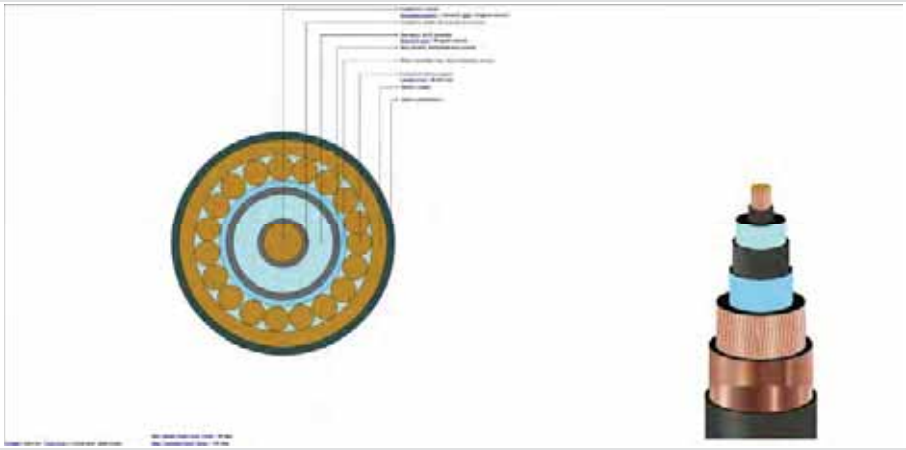
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H105-230_500kV,40_DOC,15__60_,5000kcmilInCu,@3972_5140A DLF1
Date:	11/4/2024 8:26:44 AM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		PVC Duct in Concrete
66	Duct material thermal resistivity	[K.m/W]	6
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	7.942
69	Outer diameter of the conduit	[in]	8.625

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Cables Report

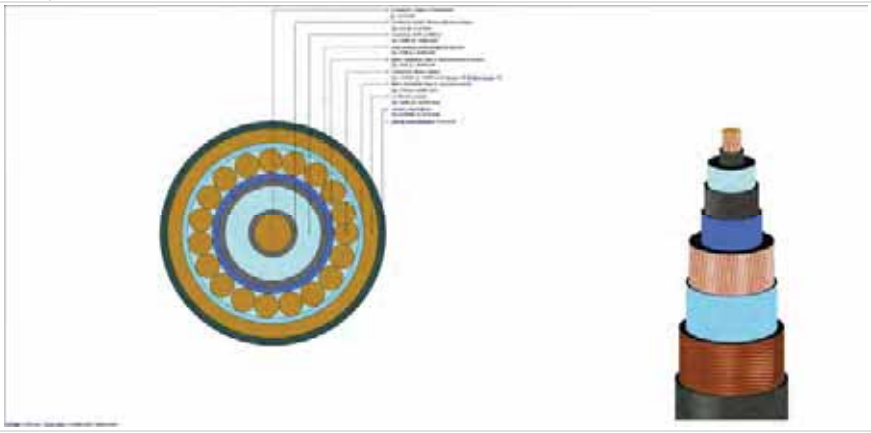
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	H105-230_500kV,40_DOC,15__60_,5000kcmilInCu,@3972_5140A DLF1
Date:	11/4/2024 8:26:44 AM

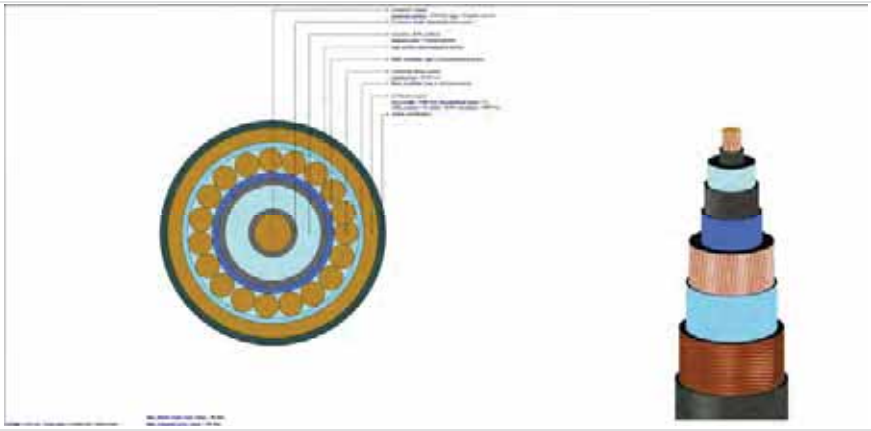
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		PVC Duct in Concrete
71	Duct material thermal resistivity	[K.m/W]	6
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	7.942
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	I100-230_500kV,30_DOC,90__52_,5000kcmilInCu,@4222_5590A DLF1
Date:	11/3/2024 3:21:12 PM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

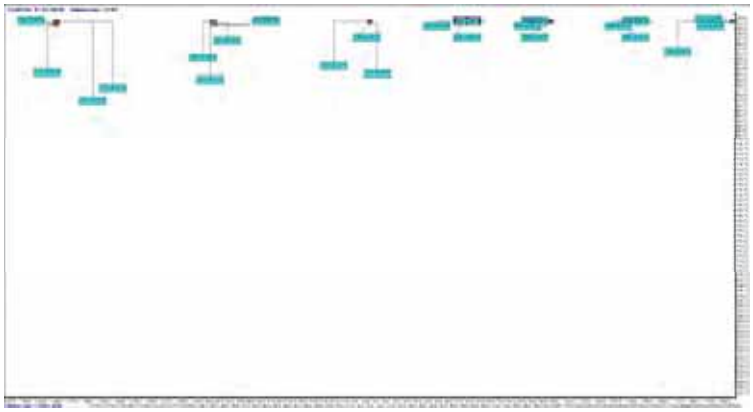
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB1	-90.0	31.933	3.517	3.517	0.8
NSTD DB2	0.0	31.429	2.6	2.6	0.8
NSTD DB3	-180.001	31.933	3.517	3.517	0.8
NSTD DB4	52.0	31.429	2.6	2.6	0.8
NSTD DB5	104.0	31.429	2.6	2.6	0.8
NSTD DB6	156.001	31.429	2.6	2.6	0.8
NSTD DB7	208.001	31.429	2.6	2.6	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	230C5.00X1	1		A	60.0	1.0	-91.08	31.88	90.0	1086.9
2	230C5.00X1	1		B	60.0	1.0	-90.5	31.05	88.2	1086.9
3	230C5.00X1	1		C	60.0	1.0	-89.5	31.05	87.2	1086.9
4	230C5.00X1	2		A	60.0	1.0	-90.0	33.38	89.8	999.1
5	230C5.00X1	2		B	60.0	1.0	-89.22	32.88	88.0	999.1
6	230C5.00X1	2		C	60.0	1.0	-90.78	32.88	90.0	999.1
7	500C5.00X	3		A	60.0	1.0	-0.5	31.93	90.0	1133.7
8	500C5.00X	3		B	60.0	1.0	-0.5	30.93	89.1	1133.7
9	500C5.00X	3		C	60.0	1.0	0.5	30.93	88.3	1133.7
10	230C5.00X1	4		A	60.0	1.0	-181.08	31.88	90.0	1111.5
11	230C5.00X1	4		B	60.0	1.0	-180.5	31.05	88.2	1111.5
12	230C5.00X1	4		C	60.0	1.0	-179.5	31.05	87.2	1111.5
13	230C5.00X1	5		A	60.0	1.0	-180.0	33.38	89.8	1024.9
14	230C5.00X1	5		B	60.0	1.0	-179.22	32.88	88.0	1024.9
15	230C5.00X1	5		C	60.0	1.0	-180.78	32.88	90.0	1024.9
16	500C5.00X	6		A	60.0	1.0	51.5	31.93	90.0	1091.9
17	500C5.00X	6		B	60.0	1.0	51.5	30.93	89.1	1091.9
18	500C5.00X	6		C	60.0	1.0	52.5	30.93	88.2	1091.9
19	500C5.00X	7		A	60.0	1.0	103.5	31.93	90.0	1087.5
20	500C5.00X	7		B	60.0	1.0	103.5	30.93	89.1	1087.5
21	500C5.00X	7		C	60.0	1.0	104.5	30.93	88.2	1087.5
22	500C5.00X	8		A	60.0	1.0	155.5	31.93	90.0	1102.7
23	500C5.00X	8		B	60.0	1.0	155.5	30.93	89.1	1102.7
24	500C5.00X	8		C	60.0	1.0	156.5	30.93	88.2	1102.7
25	500C5.00X	9		A	60.0	1.0	207.5	31.93	90.0	1173.9
26	500C5.00X	9		B	60.0	1.0	207.5	30.93	89.2	1173.9
27	500C5.00X	9		C	60.0	1.0	208.5	30.93	88.0	1173.9

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	I100-230_500kV,30_DOC,90__52_,5000kcmilnCu,@4222_5590A DLF1
Date:	11/3/2024 3:21:12 PM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Variable	Description	Unit	Cables													
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14
General Input Data																
Cable ID	Cable Equipment ID		230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	500C5.00X	500C5.00X	500C5.00X	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3	4	4	4	5	5
Phase	Cable Phase		A	B	C	A	B	C	A	B	C	A	B	C	A	B
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-91.08	-90.5	-89.5	-90.0	-89.22	-90.78	-0.5	-0.5	0.5	-181.08	-180.5	-179.5	-180.0	-179.22
y	Y coordinate	[ft]	31.88	31.05	31.05	33.38	32.88	32.88	31.93	30.93	30.93	31.88	31.05	31.05	33.38	32.88
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity																
I	Steady State Ampacity	[A]	1086.9	1086.9	1086.9	999.1	999.1	999.1	1133.7	1133.7	1133.7	1111.5	1111.5	1111.5	1024.9	1024.9
Temperatures																
θc	Conductor temperature	[°C]	90.0	88.2	87.2	89.8	88.0	90.0	90.0	89.1	88.3	90.0	88.2	87.2	89.8	88.0
θs	Sheath/Shield temperature	[°C]	85.7	83.9	82.9	86.1	84.3	86.3	83.3	82.4	81.6	85.5	83.8	82.7	85.9	84.1
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	85.2	83.4	82.4	85.7	83.8	85.9	82.1	81.3	80.4	85.0	83.2	82.2	85.5	83.7
θduct	Duct surface temperature	[°C]	81.1	79.3	78.2	82.1	80.2	82.3	76.6	75.8	74.9	80.7	78.9	77.9	81.7	79.9
Resistances																
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01666	0.01659	0.01655	0.01668	0.01661	0.01669	0.01663	0.0166	0.01657	0.01666	0.01659	0.01655	0.01668	0.01661
ys	Skin Effect Factor		0.16157	0.16313	0.16407	0.16176	0.16336	0.16157	0.16154	0.1623	0.16304	0.16157	0.16311	0.16403	0.16175	0.16334
yp	Proximity Effect Factor		0.00918	0.00926	0.00931	0.011	0.0111	0.01099	0.00713	0.00716	0.00719	0.00918	0.00926	0.0093	0.011	0.0111
Losses																
Wc	Conductor Losses	[W/ft]	3.72793	3.71257	3.70346	3.15306	3.1398	3.15463	4.04901	4.04087	4.0329	3.89806	3.88219	3.87281	3.3182	3.30429
Wd	Dielectric Losses	[W/ft]	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	2.01332	2.01332	2.01332	0.55439	0.55439	0.55439	0.55439	0.55439
Ws	Metallic Screen Losses	[W/ft]	0.20051	0.2016	0.20224	0.20318	0.2043	0.20305	0.37098	0.3719	0.3728	0.20978	0.2109	0.21157	0.21392	0.2151
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	4.48284	4.46856	4.4601	3.91064	3.89849	3.91207	6.43331	6.4261	6.41902	4.66223	4.64749	4.63877	4.08651	4.07378
λ_1	Screen Loss Factor		0.05379	0.0543	0.05461	0.06444	0.06507	0.06436	0.09162	0.09203	0.09244	0.05382	0.05432	0.05463	0.06447	0.0651
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances																
T1	Thermal resistance of insulation	[K.m/W]	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.4049	0.4049	0.4049	0.32843	0.32843	0.32843	0.32843	0.32843
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.05408	0.05408	0.05408	0.03387	0.03387	0.03387	0.03387	0.03387
T4	External thermal resistance	[K.m/W]	4.97638	4.87176	4.80957	5.74123	5.61668	5.75507	3.32324	3.28633	3.25	4.77166	4.67247	4.61371	5.48051	5.36187
Others																
Δθint	Temperature rise due to surrounding heat sources	[°C]	55.6	54.0	53.1	58.1	56.5	58.4	45.4	44.5	43.8	54.6	53.0	52.1	57.1	55.5
	Induced Voltage (standing) on Sheath	[V/mile]	224.0	209.49	255.91	218.11	206.88	190.35	233.43	209.21	227.79	231.45	210.7	261.43	225.96	209.08
	Induced Voltage (standing) on Concentric Wires	[V/mile]	227.02	212.49	258.71	220.89	209.6	192.52	235.87	211.7	230.24	234.54	213.76	264.31	228.8	211.86
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	Description	Unit	Cables												
Cable No.	Cable Index Number		15	16	17	18	19	20	21	22	23	24	25	26	27
General Input Data															
Cable ID	Cable Equipment ID		230C5.00X1	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		5	6	6	6	7	7	7	8	8	8	9	9	9
Phase	Cable Phase		C	A	B	C	A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-180.78	51.5	51.5	52.5	103.5	103.5	104.5	155.5	155.5	156.5	207.5	207.5	208.5
y	Y coordinate	[ft]	32.88	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity															
I	Steady State Ampacity	[A]	1024.9	1091.9	1091.9	1091.9	1087.5	1087.5	1087.5	1102.7	1102.7	1102.7	1173.9	1173.9	1173.9
Temperatures															
θc	Conductor temperature	[°C]	90.0	90.0	89.1	88.2	90.0	89.1	88.2	90.0	89.1	88.2	90.0	89.2	88.0
θs	Sheath/Shield temperature	[°C]	86.1	83.7	82.8	81.9	83.7	82.8	81.9	83.6	82.7	81.8	82.9	82.1	80.9
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	85.7	82.6	81.7	80.8	82.6	81.7	80.8	82.5	81.6	80.7	81.7	80.9	79.7
θduct	Duct surface temperature	[°C]	81.9	77.4	76.5	75.6	77.4	76.5	75.6	77.2	76.3	75.3	75.9	75.1	73.9
Resistances															
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01669	0.01663	0.0166	0.01656	0.01663	0.0166	0.01656	0.01663	0.0166	0.01656	0.01663	0.0166	0.01656
ys	Skin Effect Factor		0.16157	0.16154	0.16232	0.16311	0.16154	0.16233	0.16313	0.16154	0.16231	0.16315	0.16154	0.16224	0.16328
yp	Proximity Effect Factor		0.01099	0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00716	0.0072
Losses															
Wc	Conductor Losses	[W/ft]	3.31974	3.75542	3.74761	3.73984	3.72566	3.71785	3.71002	3.83022	3.82241	3.81392	4.34081	4.33275	4.32079
Wd	Dielectric Losses	[W/ft]	0.55439	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.21379	0.3437	0.34457	0.34545	0.34093	0.34181	0.3427	0.35064	0.35152	0.35248	0.39816	0.39906	0.40042
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	4.08793	6.11244	6.10551	6.09862	6.07991	6.07298	6.06604	6.19418	6.18725	6.17972	6.75229	6.74514	6.73454
λ_1	Screen Loss Factor		0.0644	0.09152	0.09195	0.09237	0.09151	0.09194	0.09237	0.09155	0.09196	0.09242	0.09172	0.0921	0.09267
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances															
T1	Thermal resistance of insulation	[K.m/W]	0.32843	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.03387	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	5.49277	3.51999	3.47965	3.4394	3.54109	3.5002	3.45907	3.46794	3.42897	3.38644	3.14623	3.11382	3.06557
Others															
Δθint	Temperature rise due to surrounding heat sources	[°C]	57.4	47.1	46.2	45.4	47.3	46.3	45.6	46.7	45.7	44.9	43.6	42.7	41.7
	Induced Voltage (standing) on Sheath	[V/mile]	198.2	223.41	199.38	222.11	221.57	197.28	223.05	223.58	198.82	228.05	236.13	209.89	245.92
	Induced Voltage (standing) on Concentric Wires	[V/mile]	200.42	225.78	201.78	224.47	223.92	199.67	225.41	225.97	201.25	230.44	238.68	212.48	248.47
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cables Report

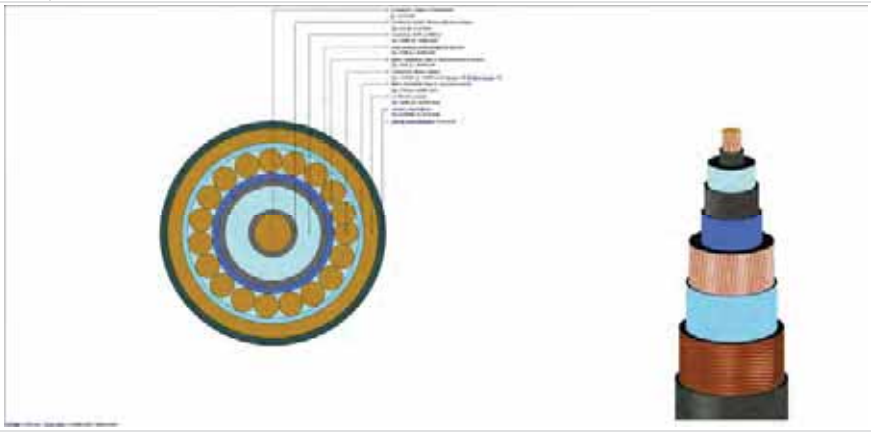
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	I100-230_500kV,30_DOC,90__52_,5000kcmilInCu,@4222_5590A DLF1
Date:	11/3/2024 3:21:12 PM

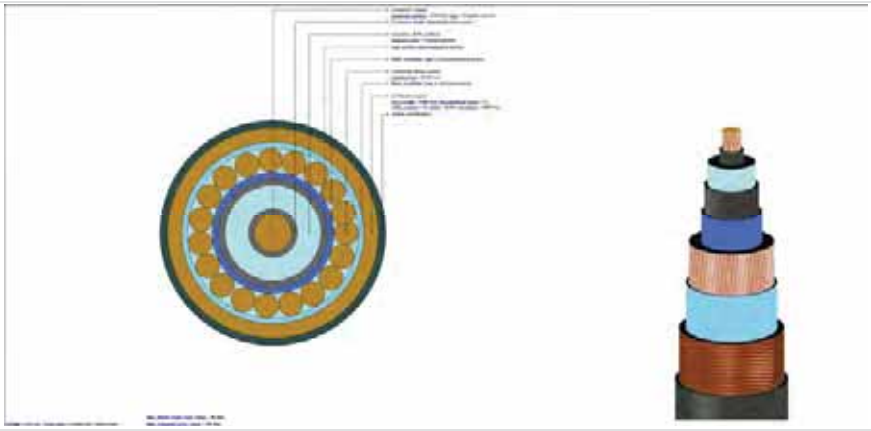
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		PVC Duct in Concrete
71	Duct material thermal resistivity	[K.m/W]	6
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	7.942
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





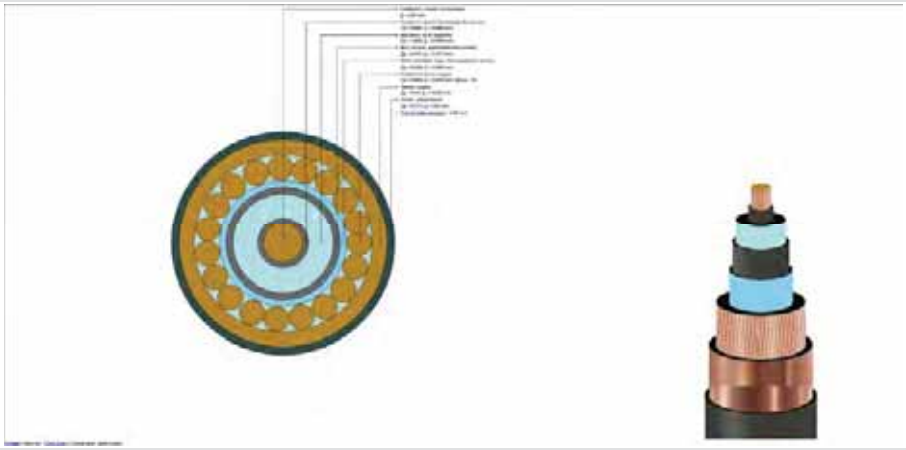
Cables Report

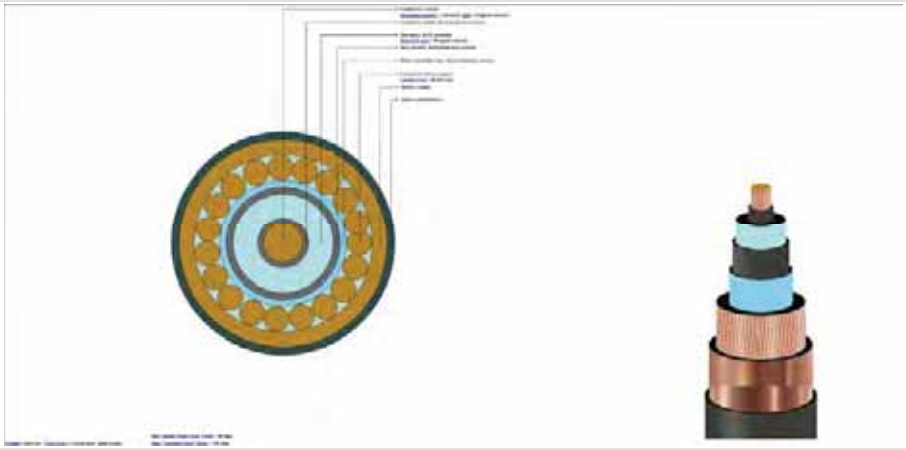
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	I100-230_500kV,30_DOC,90__52_,5000kcmilInCu,@4222_5590A DLF1
Date:	11/3/2024 3:21:12 PM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		PVC Duct in Concrete
66	Duct material thermal resistivity	[K.m/W]	6
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	7.942
69	Outer diameter of the conduit	[in]	8.625

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	I101-230_500kV,30_DOC,85__45_,5000kcmilInCu,@4195_5420A DLF1
Date:	11/3/2024 2:11:08 PM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

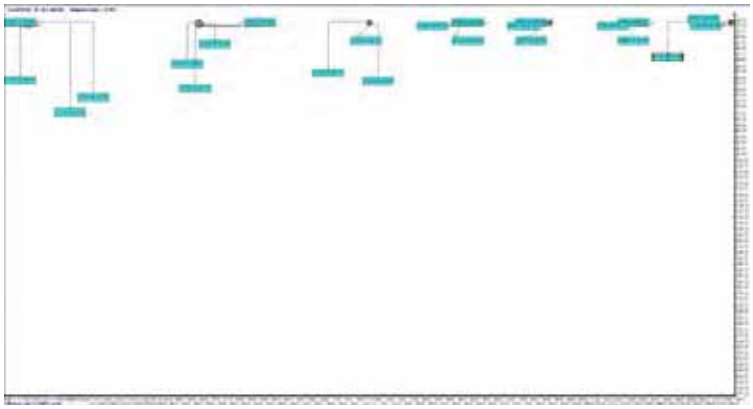
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB1	-85.0	31.933	3.517	3.517	0.8
NSTD DB2	0.0	31.429	2.6	2.6	0.8
NSTD DB3	-170.001	31.933	3.517	3.517	0.8
NSTD DB4	45.0	31.429	2.6	2.6	0.8
NSTD DB5	90.0	31.429	2.6	2.6	0.8
NSTD DB6	135.0	31.429	2.6	2.6	0.8
NSTD DB7	180.001	31.429	2.6	2.6	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	230C5.00X1	1		A	60.0	1.0	-86.08	31.88	90.0	1078.3
2	230C5.00X1	1		B	60.0	1.0	-85.5	31.05	88.2	1078.3
3	230C5.00X1	1		C	60.0	1.0	-84.5	31.05	87.2	1078.3
4	230C5.00X1	2		A	60.0	1.0	-85.0	33.38	89.8	989.7
5	230C5.00X1	2		B	60.0	1.0	-84.22	32.88	88.0	989.7
6	230C5.00X1	2		C	60.0	1.0	-85.78	32.88	90.0	989.7
7	500C5.00X	3		A	60.0	1.0	-0.5	31.93	90.0	1105.1
8	500C5.00X	3		B	60.0	1.0	-0.5	30.93	89.1	1105.1
9	500C5.00X	3		C	60.0	1.0	0.5	30.93	88.3	1105.1
10	230C5.00X1	4		A	60.0	1.0	-171.08	31.88	90.0	1107.1
11	230C5.00X1	4		B	60.0	1.0	-170.5	31.05	88.2	1107.1
12	230C5.00X1	4		C	60.0	1.0	-169.5	31.05	87.2	1107.1
13	230C5.00X1	5		A	60.0	1.0	-170.0	33.38	89.8	1020.1
14	230C5.00X1	5		B	60.0	1.0	-169.22	32.88	88.0	1020.1
15	230C5.00X1	5		C	60.0	1.0	-170.78	32.88	90.0	1020.1
16	500C5.00X	6		A	60.0	1.0	44.5	31.93	90.0	1052.4
17	500C5.00X	6		B	60.0	1.0	44.5	30.93	89.1	1052.4
18	500C5.00X	6		C	60.0	1.0	45.5	30.93	88.2	1052.4
19	500C5.00X	7		A	60.0	1.0	89.5	31.93	90.0	1046.8
20	500C5.00X	7		B	60.0	1.0	89.5	30.93	89.1	1046.8
21	500C5.00X	7		C	60.0	1.0	90.5	30.93	88.2	1046.8
22	500C5.00X	8		A	60.0	1.0	134.5	31.93	90.0	1065.9
23	500C5.00X	8		B	60.0	1.0	134.5	30.93	89.1	1065.9
24	500C5.00X	8		C	60.0	1.0	135.5	30.93	88.2	1065.9
25	500C5.00X	9		A	60.0	1.0	179.5	31.93	90.0	1150.4
26	500C5.00X	9		B	60.0	1.0	179.5	30.93	89.2	1150.4
27	500C5.00X	9		C	60.0	1.0	180.5	30.93	88.0	1150.4

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	I101-230_500kV,30_DOC,85__45_,5000kcmilInCu,@4195_5420A DLF1
Date:	11/3/2024 2:11:08 PM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Cables 1–9

Variable	Description	Unit	1	2	3	4	5	6	7	8	9
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9
General Input Data											
Cable ID	Cable Equipment ID		230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-86.08	-85.5	-84.5	-85.0	-84.22	-85.78	-0.5	-0.5	0.5
y	Y coordinate	[ft]	31.88	31.05	31.05	33.38	32.88	32.88	31.93	30.93	30.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	1078.3	1078.3	1078.3	989.7	989.7	989.7	1105.1	1105.1	1105.1
Temperatures											
θc	Conductor temperature	[°C]	90.0	88.2	87.2	89.8	88.0	90.0	90.0	89.1	88.3
θs	Sheath/Shield temperature	[°C]	85.8	84.0	83.0	86.2	84.4	86.4	83.6	82.7	81.9
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	85.3	83.5	82.5	85.7	83.9	85.9	82.5	81.6	80.8
θduct	Duct surface temperature	[°C]	81.2	79.4	78.4	82.2	80.4	82.4	77.1	76.2	75.5
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01666	0.01659	0.01655	0.01668	0.01661	0.01669	0.01663	0.0166	0.01657
ys	Skin Effect Factor		0.16157	0.16312	0.16405	0.16175	0.16333	0.16157	0.16154	0.16232	0.16301
yp	Proximity Effect Factor		0.00918	0.00926	0.0093	0.011	0.0111	0.01099	0.00713	0.00716	0.00719
Losses											
Wc	Conductor Losses	[W/ft]	3.66871	3.65366	3.64486	3.09384	3.08096	3.09527	3.84723	3.83925	3.8323
Wd	Dielectric Losses	[W/ft]	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.19729	0.19835	0.19898	0.19931	0.2004	0.19919	0.35222	0.35312	0.35391
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	4.4204	4.40641	4.39823	3.84754	3.83575	3.84885	6.21277	6.20569	6.19953
λ_1	Screen Loss Factor		0.05378	0.05429	0.05459	0.06442	0.06504	0.06435	0.09155	0.09198	0.09235
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	5.05154	4.94589	4.88393	5.84219	5.71689	5.85523	3.45627	3.41673	3.38217
Others											
Δθint	Temperature rise due to surrounding heat sources	[°C]	56.0	54.3	53.4	58.4	56.9	58.8	46.6	45.6	45.0
	Induced Voltage (standing) on Sheath	[V/mile]	222.28	208.02	253.67	216.15	205.15	188.27	227.87	204.46	221.37
	Induced Voltage (standing) on Concentric Wires	[V/mile]	225.27	210.99	256.46	218.9	207.84	190.43	230.26	206.89	223.76
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cables 10–18

Variable	Description	Unit	10	11	12	13	14	15	16	17	18
Cable No.	Cable Index Number		10	11	12	13	14	15	16	17	18
General Input Data											
Cable ID	Cable Equipment ID		230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		4	4	4	5	5	5	6	6	6
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-171.08	-170.5	-169.5	-170.0	-169.22	-170.78	44.5	44.5	45.5
y	Y coordinate	[ft]	31.88	31.05	31.05	33.38	32.88	32.88	31.93	30.93	30.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	1107.1	1107.1	1107.1	1020.1	1020.1	1020.1	1052.4	1052.4	1052.4
Temperatures											
θc	Conductor temperature	[°C]	90.0	88.2	87.2	89.8	88.0	90.0	90.0	89.1	88.2
θs	Sheath/Shield temperature	[°C]	85.5	83.8	82.8	86.0	84.2	86.2	84.0	83.1	82.3
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	85.0	83.3	82.3	85.5	83.7	85.7	83.0	82.1	81.2
θduct	Duct surface temperature	[°C]	80.7	79.0	78.0	81.8	80.0	82.0	78.0	77.1	76.3
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01666	0.01659	0.01655	0.01668	0.01661	0.01669	0.01663	0.0166	0.01656
ys	Skin Effect Factor		0.16157	0.1631	0.16401	0.16173	0.16332	0.16157	0.16154	0.16235	0.16309
yp	Proximity Effect Factor		0.00918	0.00926	0.0093	0.011	0.0111	0.01099	0.00713	0.00716	0.00719
Losses											
Wc	Conductor Losses	[W/ft]	3.86762	3.85195	3.84283	3.28723	3.27358	3.28864	3.48858	3.4811	3.4743
Wd	Dielectric Losses	[W/ft]	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.20812	0.20923	0.20988	0.21188	0.21304	0.21176	0.31895	0.31979	0.32056
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	4.63014	4.61557	4.6071	4.05351	4.04101	4.0548	5.82086	5.81422	5.80819
λ_1	Screen Loss Factor		0.05381	0.05432	0.05461	0.06446	0.06508	0.06439	0.09143	0.09187	0.09227
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	4.80713	4.70768	4.64966	5.52917	5.41062	5.54044	3.71758	3.67376	3.63385
Others											
Δθint	Temperature rise due to surrounding heat sources	[°C]	54.8	53.1	52.3	57.3	55.7	57.6	48.7	47.7	47.0
	Induced Voltage (standing) on Sheath	[V/mile]	230.72	209.86	260.23	225.09	208.13	197.19	215.36	192.46	213.85
	Induced Voltage (standing) on Concentric Wires	[V/mile]	233.79	212.91	263.1	227.92	210.89	199.4	217.63	194.78	216.13
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cables 19–27

Variable	Description	Unit	19	20	21	22	23	24	25	26	27
Cable No.	Cable Index Number		19	20	21	22	23	24	25	26	27
General Input Data											
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		7	7	7	8	8	8	9	9	9
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	89.5	89.5	90.5	134.5	134.5	135.5	179.5	179.5	180.5
y	Y coordinate	[ft]	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	1046.8	1046.8	1046.8	1065.9	1065.9	1065.9	1150.4	1150.4	1150.4
Temperatures											
θc	Conductor temperature	[°C]	90.0	89.1	88.2	90.0	89.1	88.2	90.0	89.2	88.0
θs	Sheath/Shield temperature	[°C]	84.1	83.2	82.3	83.9	83.0	82.1	83.1	82.3	81.1
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	83.1	82.1	81.3	82.9	82.0	81.0	82.0	81.2	80.0
θduct	Duct surface temperature	[°C]	78.1	77.2	76.3	77.8	76.9	76.0	76.3	75.5	74.3
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.0166	0.01656	0.01663	0.0166	0.01656	0.01663	0.0166	0.01655
ys	Skin Effect Factor		0.16154	0.16235	0.16311	0.16154	0.16233	0.16314	0.16154	0.16225	0.16331
yp	Proximity Effect Factor		0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00716	0.0072
Losses											
Wc	Conductor Losses	[W/ft]	3.45184	3.44439	3.43749	3.57908	3.57158	3.56392	4.16889	4.16097	4.14932
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.31555	0.31638	0.31716	0.32734	0.32818	0.32904	0.38214	0.38303	0.38435
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	5.78071	5.7741	5.76797	5.91974	5.91309	5.90629	6.56435	6.55732	6.547
λ_1	Screen Loss Factor		0.09141	0.09185	0.09227	0.09146	0.09189	0.09233	0.09166	0.09205	0.09263
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	3.74636	3.70195	3.66068	3.64841	3.60639	3.56331	3.24846	3.21429	3.16389
Others											
Δθint	Temperature rise due to surrounding heat sources	[°C]	48.9	47.9	47.2	48.1	47.1	46.4	44.6	43.7	42.6
	Induced Voltage (standing) on Sheath	[V/mile]	213.14	190.03	214.73	215.85	192.19	220.74	230.84	205.44	241.76
	Induced Voltage (standing) on Concentric Wires	[V/mile]	215.41	192.34	217.0	218.16	194.53	223.05	233.34	207.97	244.25
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cables Report

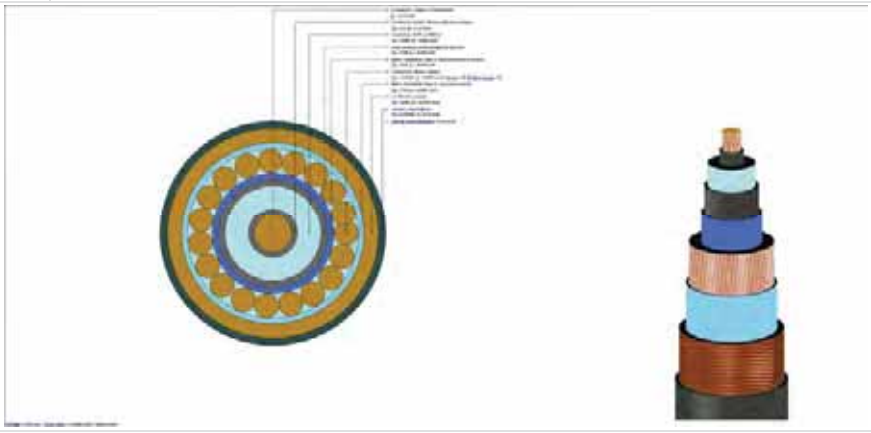
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	I101-230_500kV,30_DOC,85__45_,5000kcmilInCu,@4195_5420A DLF1
Date:	11/3/2024 2:11:08 PM

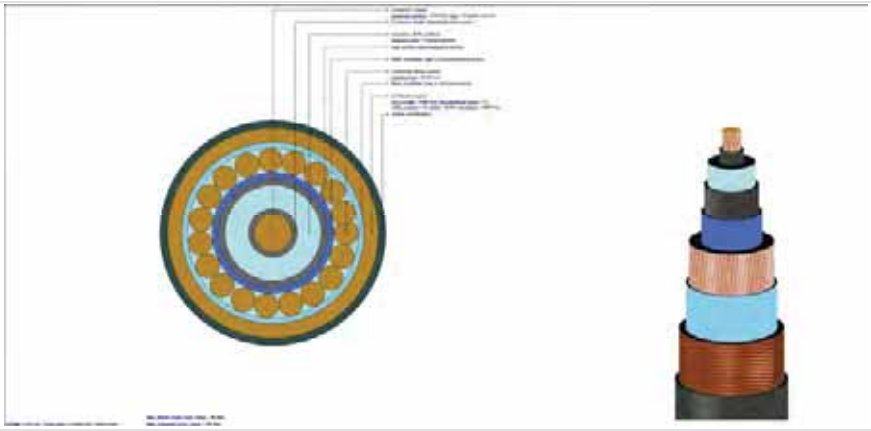
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		PVC Duct in Concrete
71	Duct material thermal resistivity	[K.m/W]	6
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	7.942
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





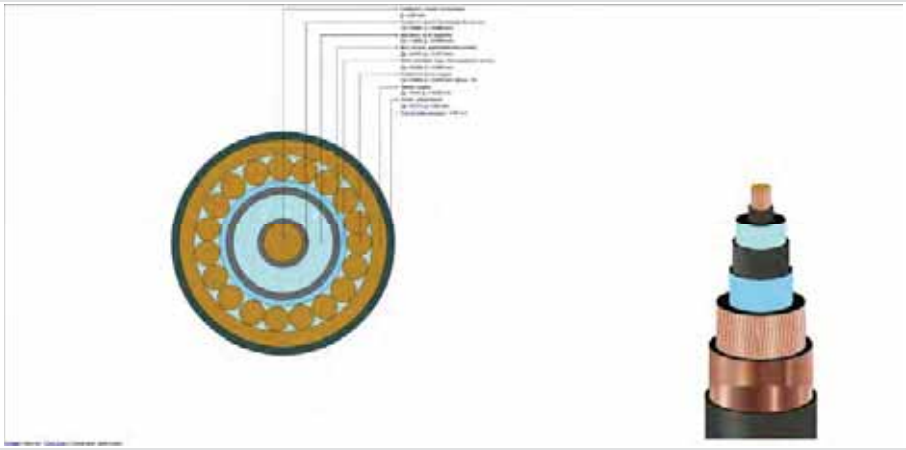
Cables Report

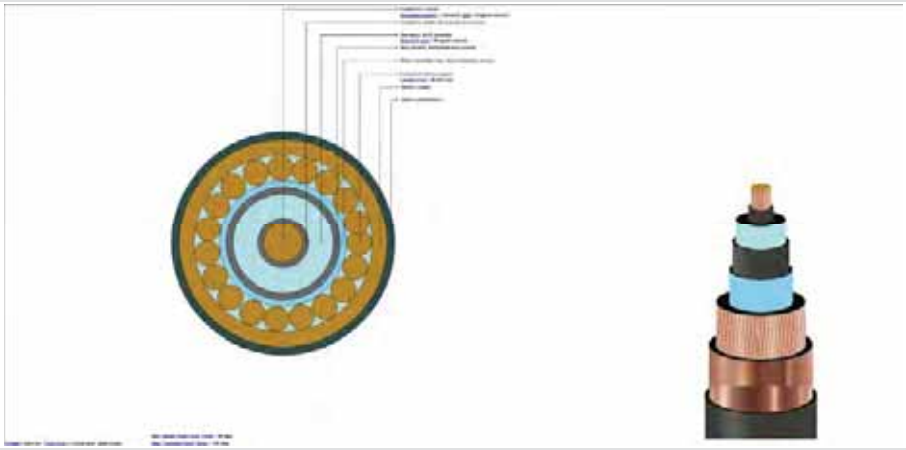
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	I101-230_500kV,30_DOC,85__45_,5000kcmilInCu,@4195_5420A DLF1
Date:	11/3/2024 2:11:08 PM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		PVC Duct in Concrete
66	Duct material thermal resistivity	[K.m/W]	6
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	7.942
69	Outer diameter of the conduit	[in]	8.625

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	I102-230_500kV,30_DOC,65__30_,5000kcmilInCu,@4052_4857A DLF1
Date:	11/3/2024 11:03:17 AM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

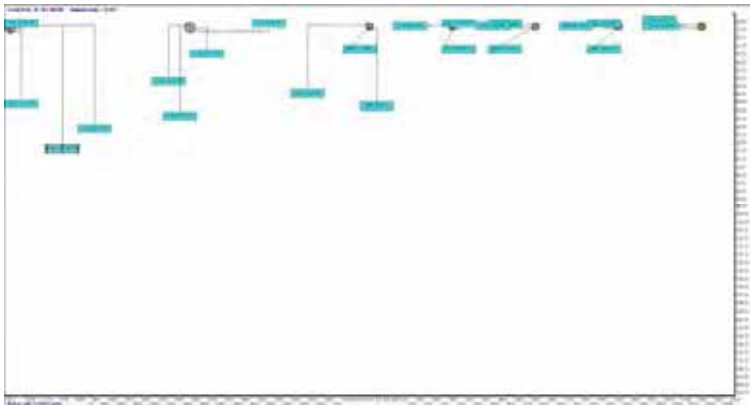
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB1	-65.0	31.933	3.517	3.517	0.8
NSTD DB2	0.0	31.429	2.6	2.6	0.8
NSTD DB3	-130.0	31.933	3.517	3.517	0.8
NSTD DB4	30.0	31.429	2.6	2.6	0.8
NSTD DB5	60.0	31.429	2.6	2.6	0.8
NSTD DB6	90.0	31.429	2.6	2.6	0.8
NSTD DB7	120.0	31.429	2.6	2.6	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	230C5.00X1	1		A	60.0	1.0	-66.08	31.88	90.0	1034.3
2	230C5.00X1	1		B	60.0	1.0	-65.5	31.05	88.3	1034.3
3	230C5.00X1	1		C	60.0	1.0	-64.5	31.05	87.3	1034.3
4	230C5.00X1	2		A	60.0	1.0	-65.0	33.38	89.9	942.1
5	230C5.00X1	2		B	60.0	1.0	-64.22	32.88	88.1	942.1
6	230C5.00X1	2		C	60.0	1.0	-65.78	32.88	90.0	942.1
7	500C5.00X	3		A	60.0	1.0	-0.5	31.93	90.0	998.6
8	500C5.00X	3		B	60.0	1.0	-0.5	30.93	89.0	998.6
9	500C5.00X	3		C	60.0	1.0	0.5	30.93	88.5	998.6
10	230C5.00X1	4		A	60.0	1.0	-131.08	31.88	90.0	1083.0
11	230C5.00X1	4		B	60.0	1.0	-130.5	31.05	88.3	1083.0
12	230C5.00X1	4		C	60.0	1.0	-129.5	31.05	87.4	1083.0
13	230C5.00X1	5		A	60.0	1.0	-130.0	33.38	89.9	993.3
14	230C5.00X1	5		B	60.0	1.0	-129.22	32.88	88.2	993.3
15	230C5.00X1	5		C	60.0	1.0	-130.78	32.88	90.0	993.3
16	500C5.00X	6		A	60.0	1.0	29.5	31.93	90.0	921.6
17	500C5.00X	6		B	60.0	1.0	29.5	30.93	89.0	921.6
18	500C5.00X	6		C	60.0	1.0	30.5	30.93	88.3	921.6
19	500C5.00X	7		A	60.0	1.0	59.5	31.93	90.0	915.2
20	500C5.00X	7		B	60.0	1.0	59.5	30.93	89.0	915.2
21	500C5.00X	7		C	60.0	1.0	60.5	30.93	88.3	915.2
22	500C5.00X	8		A	60.0	1.0	89.5	31.93	90.0	948.1
23	500C5.00X	8		B	60.0	1.0	89.5	30.93	89.1	948.1
24	500C5.00X	8		C	60.0	1.0	90.5	30.93	88.2	948.1
25	500C5.00X	9		A	60.0	1.0	119.5	31.93	90.0	1072.6
26	500C5.00X	9		B	60.0	1.0	119.5	30.93	89.1	1072.6
27	500C5.00X	9		C	60.0	1.0	120.5	30.93	87.8	1072.6

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	I102-230_500kV,30_DOC,65__30_,5000kcmilnCu,@4052_4857A DLF1
Date:	11/3/2024 11:03:17 AM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Cables

Variable	Description	Unit	1	2	3	4	5	6	7	8	9
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9
General Input Data											
Cable ID	Cable Equipment ID		230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-66.08	-65.5	-64.5	-65.0	-64.22	-65.78	-0.5	-0.5	0.5
y	Y coordinate	[ft]	31.88	31.05	31.05	33.38	32.88	32.88	31.93	30.93	30.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	1034.3	1034.3	1034.3	942.1	942.1	942.1	998.6	998.6	998.6
Temperatures											
θc	Conductor temperature	[°C]	90.0	88.3	87.3	89.9	88.1	90.0	90.0	89.0	88.5
θs	Sheath/Shield temperature	[°C]	86.1	84.3	83.4	86.5	84.8	86.7	84.5	83.5	83.0
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	85.6	83.9	82.9	86.2	84.4	86.3	83.5	82.6	82.0
θduct	Duct surface temperature	[°C]	81.8	80.1	79.1	82.9	81.2	83.0	78.9	77.9	77.4
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01666	0.01659	0.01656	0.01668	0.01662	0.01669	0.01663	0.0166	0.01657
ys	Skin Effect Factor		0.16157	0.16309	0.16392	0.16169	0.16319	0.16157	0.16154	0.16239	0.16288
yp	Proximity Effect Factor		0.00918	0.00926	0.0093	0.011	0.01109	0.01099	0.00713	0.00716	0.00718
Losses											
Wc	Conductor Losses	[W/ft]	3.37537	3.36186	3.3545	2.80383	2.79279	2.8047	3.14149	3.13438	3.13034
Wd	Dielectric Losses	[W/ft]	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.18134	0.18229	0.18282	0.18039	0.18132	0.18032	0.28684	0.28764	0.28809
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	4.11111	4.09855	4.09171	3.53861	3.52851	3.53941	5.44165	5.43534	5.43176
λ_1	Screen Loss Factor		0.05373	0.05422	0.0545	0.06434	0.06492	0.06429	0.09131	0.09177	0.09203
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	5.45754	5.3465	5.28587	6.38774	6.25867	6.39707	4.00623	3.95657	3.92831
Others											
Δθint	Temperature rise due to surrounding heat sources	[°C]	57.5	55.9	55.1	60.1	58.6	60.3	50.7	49.6	49.2
	Induced Voltage (standing) on Sheath	[V/mile]	213.38	200.5	242.55	206.13	196.27	177.99	206.79	186.77	197.94
	Induced Voltage (standing) on Concentric Wires	[V/mile]	216.25	203.35	245.22	208.75	198.83	180.03	208.94	188.97	200.09
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	Description	Unit	10	11	12	13	14	15	16	17	18
Cable No.	Cable Index Number		10	11	12	13	14	15	16	17	18
General Input Data											
Cable ID	Cable Equipment ID		230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		4	4	4	5	5	5	6	6	6
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-131.08	-130.5	-129.5	-130.0	-129.22	-130.78	29.5	29.5	30.5
y	Y coordinate	[ft]	31.88	31.05	31.05	33.38	32.88	32.88	31.93	30.93	30.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	1083.0	1083.0	1083.0	993.3	993.3	993.3	921.6	921.6	921.6
Temperatures											
θc	Conductor temperature	[°C]	90.0	88.3	87.4	89.9	88.2	90.0	90.0	89.0	88.3
θs	Sheath/Shield temperature	[°C]	85.7	84.0	83.1	86.2	84.5	86.3	85.1	84.1	83.5
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	85.2	83.5	82.6	85.8	84.1	85.9	84.2	83.3	82.6
θduct	Duct surface temperature	[°C]	81.1	79.4	78.5	82.2	80.5	82.4	80.1	79.1	78.4
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01666	0.0166	0.01656	0.01668	0.01662	0.01669	0.01663	0.01659	0.01657
ys	Skin Effect Factor		0.16157	0.16305	0.16386	0.16166	0.16316	0.16157	0.16154	0.1624	0.163
yp	Proximity Effect Factor		0.00918	0.00925	0.0093	0.011	0.01109	0.01099	0.00713	0.00716	0.00719
Losses											
Wc	Conductor Losses	[W/ft]	3.70081	3.68631	3.67848	3.11713	3.10489	3.11788	2.6755	2.66938	2.66515
Wd	Dielectric Losses	[W/ft]	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.19904	0.20006	0.20062	0.20072	0.20175	0.20066	0.24386	0.24454	0.24502
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	4.45424	4.44076	4.43349	3.87225	3.86104	3.87293	4.93268	4.92725	4.9235
λ_1	Screen Loss Factor		0.05378	0.05427	0.05454	0.06439	0.06498	0.06436	0.09114	0.09161	0.09193
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	5.0106	4.91053	4.85652	5.81046	5.69296	5.81666	4.46345	4.40778	4.36917
Others											
Δθint	Temperature rise due to surrounding heat sources	[°C]	55.7	54.1	53.3	58.3	56.8	58.5	53.3	52.3	51.7
	Induced Voltage (standing) on Sheath	[V/mile]	226.54	205.18	253.69	220.15	202.71	191.7	188.57	169.66	186.6
	Induced Voltage (standing) on Concentric Wires	[V/mile]	229.55	208.16	256.5	222.91	205.4	193.84	190.56	171.69	188.59
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	Description	Unit	19	20	21	22	23	24	25	26	27
Cable No.	Cable Index Number		19	20	21	22	23	24	25	26	27
General Input Data											
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		7	7	7	8	8	8	9	9	9
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	59.5	59.5	60.5	89.5	89.5	90.5	119.5	119.5	120.5
y	Y coordinate	[ft]	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	915.2	915.2	915.2	948.1	948.1	948.1	1072.6	1072.6	1072.6
Temperatures											
θc	Conductor temperature	[°C]	90.0	89.0	88.3	90.0	89.1	88.2	90.0	89.1	87.8
θs	Sheath/Shield temperature	[°C]	85.2	84.2	83.5	84.9	84.0	83.1	83.9	83.0	81.7
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	84.3	83.3	82.6	84.0	83.1	82.2	82.8	81.9	80.7
θduct	Duct surface temperature	[°C]	80.1	79.2	78.4	79.7	78.7	77.9	77.7	76.8	75.5
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.01659	0.01657	0.01663	0.0166	0.01656	0.01663	0.0166	0.01655
ys	Skin Effect Factor		0.16154	0.1624	0.16304	0.16154	0.16236	0.1631	0.16154	0.16229	0.16342
yp	Proximity Effect Factor		0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00716	0.0072
Losses											
Wc	Conductor Losses	[W/ft]	2.63877	2.63275	2.62828	2.8318	2.8256	2.8201	3.62432	3.61704	3.60629
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.24048	0.24115	0.24165	0.25826	0.25895	0.25957	0.33153	0.33235	0.33357
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	4.89257	4.88723	4.88326	5.10338	5.09788	5.09299	5.96917	5.96271	5.95318
λ_1	Screen Loss Factor		0.09113	0.0916	0.09194	0.0912	0.09164	0.09204	0.09147	0.09188	0.0925
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	4.50354	4.44753	4.40578	4.29997	4.24856	4.20278	3.61469	3.57475	3.51555
Others											
Δθint	Temperature rise due to surrounding heat sources	[°C]	53.5	52.5	51.9	52.4	51.4	50.7	47.7	46.8	45.7
	Induced Voltage (standing) on Sheath	[V/mile]	185.9	166.74	187.81	191.1	171.04	197.2	213.37	190.78	227.9
	Induced Voltage (standing) on Concentric Wires	[V/mile]	187.89	168.76	189.79	193.16	173.13	199.25	215.71	193.14	230.22
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cables Report

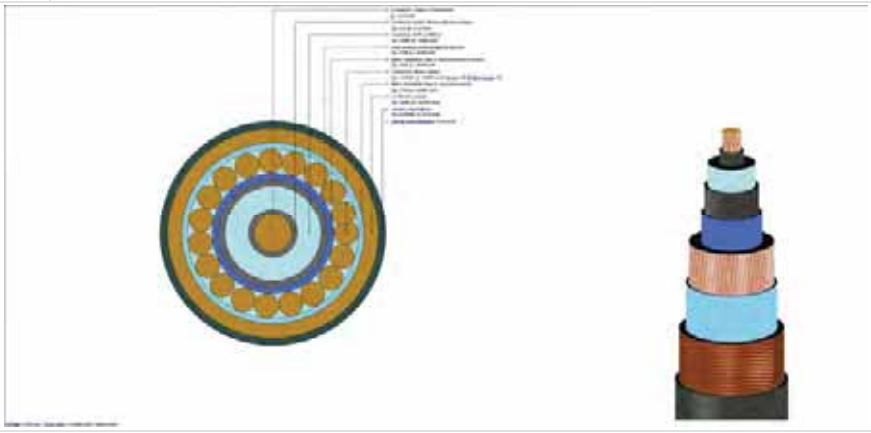
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	I102-230_500kV,30_DOC,65__30_,5000kcmilInCu,@4052_4857A DLF1
Date:	11/3/2024 11:03:17 AM

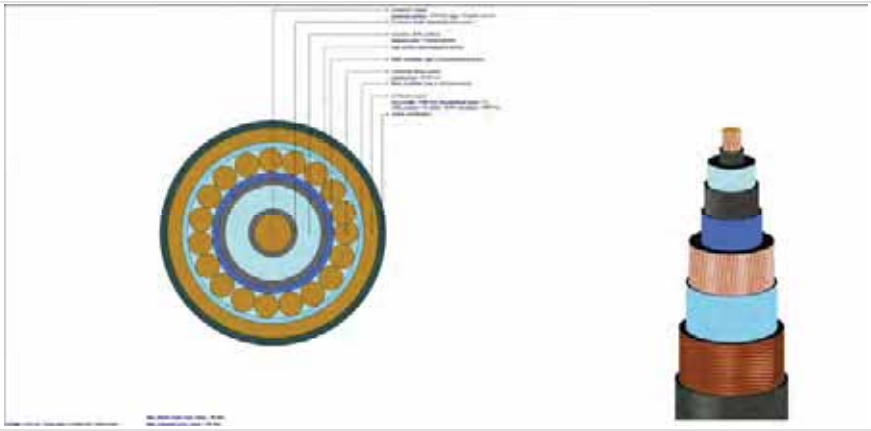
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		PVC Duct in Concrete
71	Duct material thermal resistivity	[K.m/W]	6
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	7.942
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





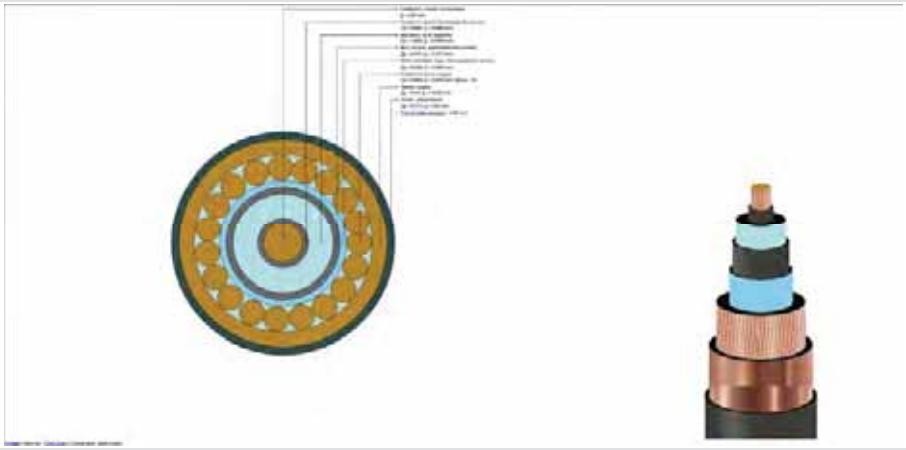
Cables Report

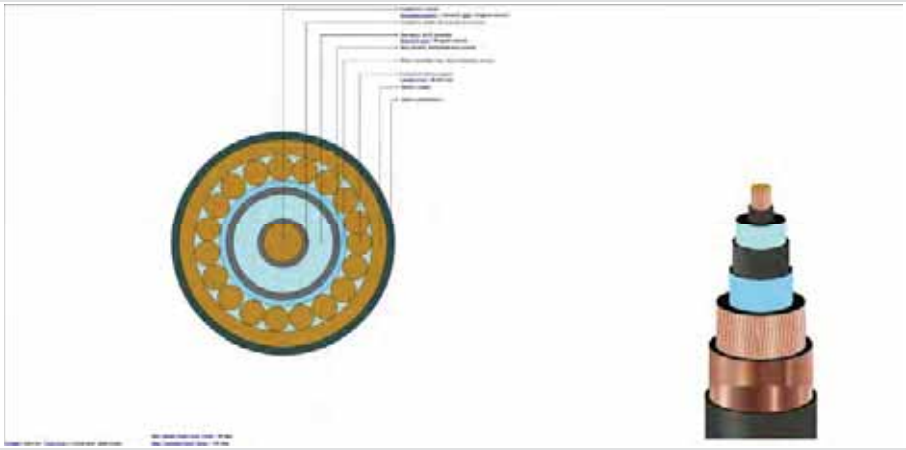
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	I102-230_500kV,30_DOC,65__30_,5000kcmilInCu,@4052_4857A DLF1
Date:	11/3/2024 11:03:17 AM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		PVC Duct in Concrete
66	Duct material thermal resistivity	[K.m/W]	6
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	7.942
69	Outer diameter of the conduit	[in]	8.625

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	I103-230_500kV,30_DOC,60__35_,5000kcmilInCu,@4016_5043A DLF1
Date:	11/3/2024 9:06:24 AM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

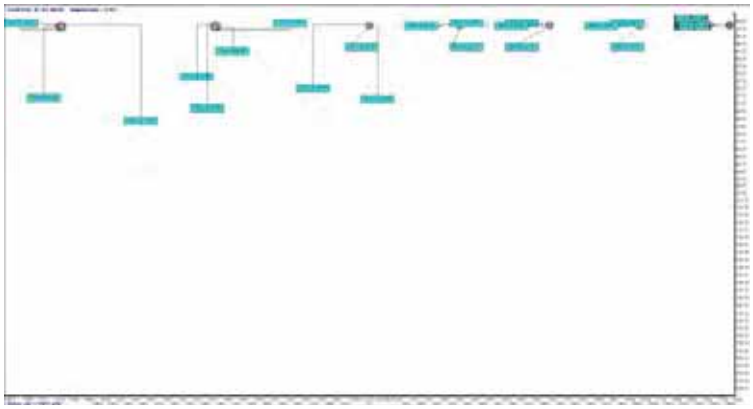
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB1	-60.0	31.933	3.517	3.517	0.8
NSTD DB2	0.0	31.429	2.6	2.6	0.8
NSTD DB3	-120.0	31.933	3.517	3.517	0.8
NSTD DB4	35.0	31.429	2.6	2.6	0.8
NSTD DB5	70.0	31.429	2.6	2.6	0.8
NSTD DB6	105.0	31.429	2.6	2.6	0.8
NSTD DB7	140.0	31.429	2.6	2.6	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	230C5.00X1	1		A	60.0	1.0	-61.08	31.88	90.0	1024.2
2	230C5.00X1	1		B	60.0	1.0	-60.5	31.05	88.3	1024.2
3	230C5.00X1	1		C	60.0	1.0	-59.5	31.05	87.3	1024.2
4	230C5.00X1	2		A	60.0	1.0	-60.0	33.38	89.9	931.5
5	230C5.00X1	2		B	60.0	1.0	-59.22	32.88	88.2	931.5
6	230C5.00X1	2		C	60.0	1.0	-60.78	32.88	90.0	931.5
7	500C5.00X	3		A	60.0	1.0	-0.5	31.93	90.0	1016.5
8	500C5.00X	3		B	60.0	1.0	-0.5	30.93	89.0	1016.5
9	500C5.00X	3		C	60.0	1.0	0.5	30.93	88.4	1016.5
10	230C5.00X1	4		A	60.0	1.0	-121.08	31.88	90.0	1075.6
11	230C5.00X1	4		B	60.0	1.0	-120.5	31.05	88.3	1075.6
12	230C5.00X1	4		C	60.0	1.0	-119.5	31.05	87.4	1075.6
13	230C5.00X1	5		A	60.0	1.0	-120.0	33.38	89.9	985.1
14	230C5.00X1	5		B	60.0	1.0	-119.22	32.88	88.2	985.1
15	230C5.00X1	5		C	60.0	1.0	-120.78	32.88	90.0	985.1
16	500C5.00X	6		A	60.0	1.0	34.5	31.93	90.0	965.4
17	500C5.00X	6		B	60.0	1.0	34.5	30.93	89.0	965.4
18	500C5.00X	6		C	60.0	1.0	35.5	30.93	88.3	965.4
19	500C5.00X	7		A	60.0	1.0	69.5	31.93	90.0	964.4
20	500C5.00X	7		B	60.0	1.0	69.5	30.93	89.0	964.4
21	500C5.00X	7		C	60.0	1.0	70.5	30.93	88.2	964.4
22	500C5.00X	8		A	60.0	1.0	104.5	31.93	90.0	993.7
23	500C5.00X	8		B	60.0	1.0	104.5	30.93	89.1	993.7
24	500C5.00X	8		C	60.0	1.0	105.5	30.93	88.2	993.7
25	500C5.00X	9		A	60.0	1.0	139.5	31.93	90.0	1103.4
26	500C5.00X	9		B	60.0	1.0	139.5	30.93	89.1	1103.4
27	500C5.00X	9		C	60.0	1.0	140.5	30.93	87.9	1103.4

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	I103-230_500kV,30_DOC,60__35_5000kcmilInCu,@4016_5043A DLF1
Date:	11/3/2024 9:06:24 AM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Variable	Description	Unit	Cables																										
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
General Input Data																													
Cable ID	Cable Equipment ID		230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	500C5.00X	500C5.00X	500C5.00X	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9
Phase	Cable Phase		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-61.08	-60.5	-59.5	-60.0	-59.22	-60.78	-0.5	-0.5	0.5	-121.08	-120.5	-119.5	-120.0	-119.22	-120.78	34.5	34.5	35.5	69.5	69.5	70.5	104.5	104.5	105.5	139.5	139.5	140.5
y	Y coordinate	[ft]	31.88	31.05	31.05	33.38	32.88	32.88	31.93	30.93	30.93	31.88	31.05	31.05	33.38	32.88	32.88	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity																													
I	Steady State Ampacity	[A]	1024.2	1024.2	1024.2	931.5	931.5	931.5	1016.5	1016.5	1016.5	1075.6	1075.6	1075.6	985.1	985.1	985.1	965.4	965.4	965.4	964.4	964.4	964.4	993.7	993.7	993.7	1103.4	1103.4	1103.4
Temperatures																													
θc	Conductor temperature	[°C]	90.0	88.3	87.3	89.9	88.2	90.0	90.0	89.0	88.4	90.0	88.3	87.4	89.9	88.2	90.0	90.0	89.0	88.3	90.0	89.0	88.2	90.0	89.1	88.2	90.0	89.1	87.9
θs	Sheath/Shield temperature	[°C]	86.1	84.4	83.5	86.6	84.9	86.7	84.3	83.4	82.7	85.8	84.1	83.2	86.3	84.7	86.4	84.8	83.8	83.0	84.8	83.8	83.0	84.5	83.6	82.7	83.6	82.7	81.5
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	85.7	84.0	83.0	86.2	84.5	86.4	83.4	82.4	81.7	85.3	83.6	82.7	85.9	84.2	86.0	83.8	82.9	82.1	83.8	82.9	82.1	83.6	82.6	81.8	82.5	81.6	80.4
θduct	Duct surface temperature	[°C]	82.0	80.2	79.3	83.1	81.4	83.2	78.6	77.6	77.0	81.2	79.5	78.7	82.4	80.7	82.5	79.4	78.4	77.7	79.4	78.4	77.7	79.0	78.0	77.2	77.2	76.3	75.1
Resistances																													
R_o	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01666	0.01659	0.01656	0.01668	0.01662	0.01669	0.01663	0.0166	0.01657	0.01666	0.0166	0.01656	0.01668	0.01662	0.01669	0.01663	0.01659	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01656	0.01663	0.0166	0.01655
ys	Skin Effect Factor		0.16157	0.16308	0.1639	0.16168	0.16316	0.16157	0.16154	0.16239	0.16297	0.16157	0.16304	0.16382	0.16165	0.16311	0.16157	0.16154	0.16239	0.16305	0.16154	0.16239	0.16308	0.16154	0.16235	0.16312	0.16154	0.16228	0.16338
yp	Proximity Effect Factor		0.00918	0.00925	0.0093	0.011	0.01109	0.01099	0.00713	0.00716	0.00719	0.00918	0.00925	0.00929	0.011	0.01109	0.01099	0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00716	0.0072
Losses																													
Wc	Conductor Losses	[W/ft]	3.31002	3.29686	3.28974	2.74122	2.73052	2.742	3.25522	3.2479	3.24291	3.65052	3.63637	3.62894	3.06636	3.05459	3.06696	2.93582	2.92916	2.92409	2.92989	2.92328	2.91798	3.11069	3.10395	3.09768	3.83545	3.82788	3.81679
Wd	Dielectric Losses	[W/ft]	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	2.01332	2.01332	2.01332	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.17779	0.17872	0.17923	0.17632	0.17722	0.17625	0.29735	0.29817	0.29874	0.1963	0.1973	0.19783	0.1974	0.19839	0.19735	0.26785	0.2686	0.26917	0.2673	0.26804	0.26864	0.28399	0.28475	0.28546	0.35112	0.35198	0.35323
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	4.04221	4.02997	4.02336	3.47193	3.46214	3.47265	5.56589	5.55939	5.55497	4.40122	4.38806	4.38116	3.81815	3.80737	3.8187	5.217	5.21108	5.20659	5.21052	5.20465	5.19994	5.40801	5.40202	5.39646	6.1999	6.19318	6.18335
λ_1	Screen Loss Factor		0.05371	0.05421	0.05448	0.06432	0.0649	0.06428	0.09135	0.0918	0.09212	0.05377	0.05426	0.05451	0.06438	0.06495	0.06435	0.09123	0.0917	0.09205	0.09123	0.09169	0.09206	0.0913	0.09174	0.09215	0.09155	0.09195	0.09255
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances																													
T1	Thermal resistance of insulation	[K.m/W]	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.4049	0.4049	0.4049	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.05408	0.05408	0.05408	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	5.55644	5.44416	5.38334	6.51797	6.38744	6.52664	3.90733	3.85914	3.82624	5.07513	4.97493	4.92235	5.89921	5.78265	5.90413	4.19705	4.14496	4.10523	4.2028	4.15093	4.10925	4.03383	3.98595	3.94133	3.46437	3.42668	3.37128
Others																													
Δθint	Temperature rise due to surrounding heat sources	[°C]	57.9	56.3	55.5	60.4	58.9	60.7	50.0	49.0	48.5	55.9	54.4	53.6	58.6	57.1	58.8	51.8	50.8	50.2	51.9	50.8	50.2	50.8	49.8	49.1	46.5	45.6	44.5
	Induced Voltage (standing) on Sheath	[V/mile]	211.27	198.83	240.05	203.84	194.34	175.68	209.68	189.76	202.52	225.29	203.74	251.67	218.68	201.06	190.04	197.37	177.46	195.79	196.0	175.56	197.88	200.63	179.3	206.31	220.27	196.64	233.37
	Induced Voltage (standing) on Concentric Wires	[V/mile]	214.11	201.65	242.69	206.43	196.87	177.7	211.87	192.0	204.71	228.28	206.7	254.46	221.42	203.73	192.15	199.46	179.59	197.87	198.09	177.69	199.96	202.78	181.49	208.46	222.67	199.07	235.76
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cables Report

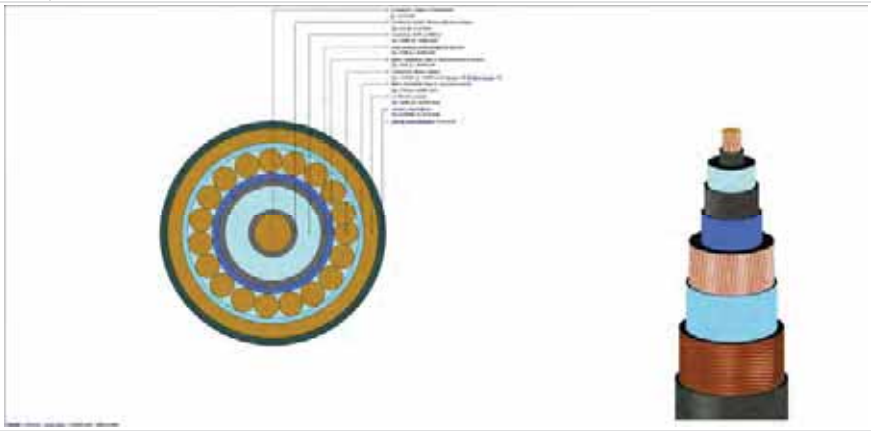
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	I103-230_500kV,30_DOC,60__35_,5000kcmilInCu,@4016_5043A DLF1
Date:	11/3/2024 9:06:24 AM

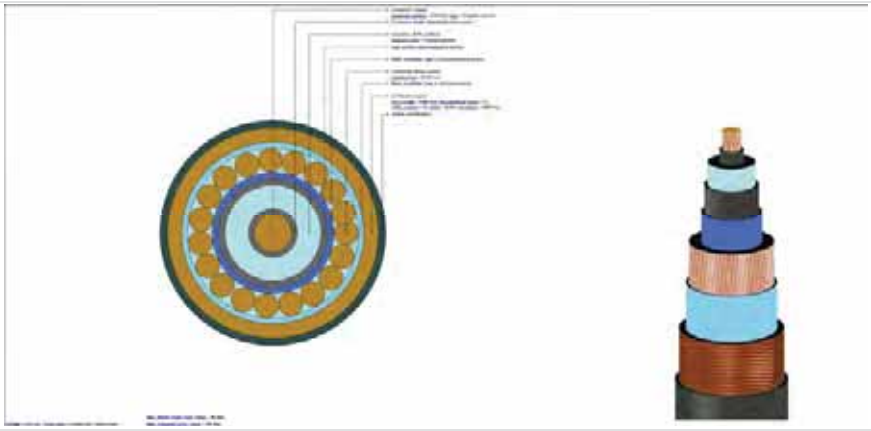
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		PVC Duct in Concrete
71	Duct material thermal resistivity	[K.m/W]	6
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	7.942
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





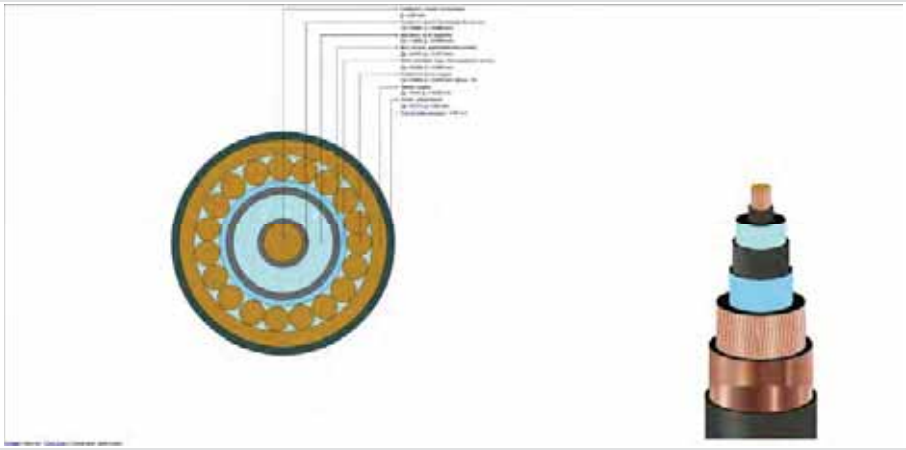
Cables Report

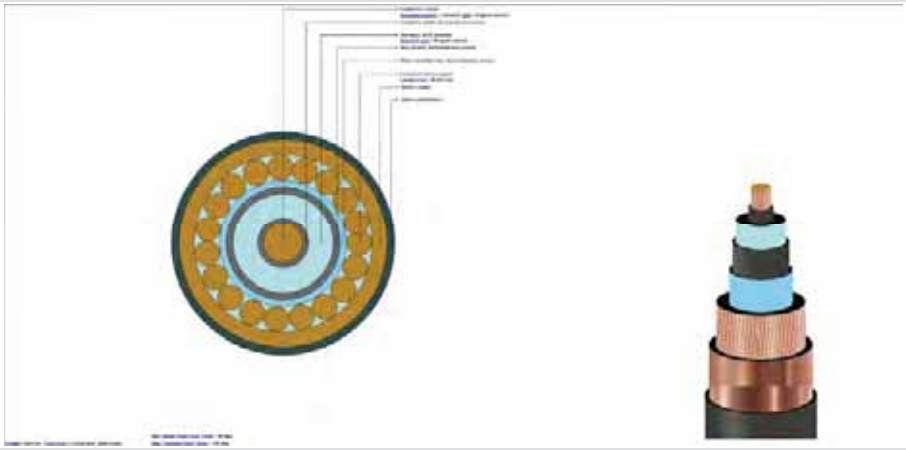
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	I103-230_500kV,30_DOC,60__35_,5000kcmilInCu,@4016_5043A DLF1
Date:	11/3/2024 9:06:24 AM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		PVC Duct in Concrete
66	Duct material thermal resistivity	[K.m/W]	6
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	7.942
69	Outer diameter of the conduit	[in]	8.625

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	J100-230_500kV,30_DOC,15__60_,5000kcmillnCu,@4307_5650A DLF1
Date:	11/3/2024 2:09:47 AM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB2	0.0	31.429	2.6	2.6	0.8
NSTD DB4	60.0	31.429	2.6	2.6	0.8
NSTD DB5	120.0	31.429	2.6	2.6	0.8
NSTD DB6	180.001	31.429	2.6	2.6	0.8
NSTD DB7	240.001	31.429	2.6	2.6	0.8
NSTD DB6	-60.0	31.429	2.6	2.6	0.8
NSTD DB7	-75.0	31.429	2.6	2.6	0.8
NSTD DB8	-90.0	31.429	2.6	2.6	0.8
NSTD DB9	-105.0	31.429	2.6	2.6	0.8

Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	500C5.00X	1		A	60.0	1.0	-0.5	31.93	90.0	1089.8
2	500C5.00X	1		B	60.0	1.0	-0.5	30.93	89.1	1089.8
3	500C5.00X	1		C	60.0	1.0	0.5	30.93	88.1	1089.8
4	500C5.00X	2		A	60.0	1.0	59.5	31.93	90.0	1112.1
5	500C5.00X	2		B	60.0	1.0	59.5	30.93	89.1	1112.1
6	500C5.00X	2		C	60.0	1.0	60.5	30.93	88.2	1112.1
7	500C5.00X	3		A	60.0	1.0	119.5	31.93	90.0	1120.1
8	500C5.00X	3		B	60.0	1.0	119.5	30.93	89.1	1120.1
9	500C5.00X	3		C	60.0	1.0	120.5	30.93	88.2	1120.1
10	500C5.00X	4		A	60.0	1.0	179.5	31.93	90.0	1134.2
11	500C5.00X	4		B	60.0	1.0	179.5	30.93	89.1	1134.2
12	500C5.00X	4		C	60.0	1.0	180.5	30.93	88.2	1134.2
13	500C5.00X	5		A	60.0	1.0	239.5	31.93	90.0	1193.4
14	500C5.00X	5		B	60.0	1.0	239.5	30.93	89.2	1193.4
15	500C5.00X	5		C	60.0	1.0	240.5	30.93	88.0	1193.4
16	230C5.00X1	6		A	60.0	1.0	-60.5	31.93	90.0	1113.5
17	230C5.00X1	6		B	60.0	1.0	-60.5	30.93	88.9	1113.5
18	230C5.00X1	6		C	60.0	1.0	-59.5	30.93	87.6	1113.5
19	230C5.00X1	7		A	60.0	1.0	-75.5	31.93	90.0	1004.0
20	230C5.00X1	7		B	60.0	1.0	-75.5	30.93	88.9	1004.0
21	230C5.00X1	7		C	60.0	1.0	-74.5	30.93	88.3	1004.0
22	230C5.00X1	8		A	60.0	1.0	-90.5	31.93	90.0	1018.6
23	230C5.00X1	8		B	60.0	1.0	-90.5	30.93	88.9	1018.6
24	230C5.00X1	8		C	60.0	1.0	-89.5	30.93	88.5	1018.6
25	230C5.00X1	9		A	60.0	1.0	-105.5	31.93	90.0	1170.9
26	230C5.00X1	9		B	60.0	1.0	-105.5	30.93	88.9	1170.9
27	230C5.00X1	9		C	60.0	1.0	-104.5	30.93	89.0	1170.9

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_GIZM_New 3 Routes
Execution :	J100-230_500kV_3Q_DOC_1.5__60__5000kcmilinCu@4307_5650A DLF1
Date:	11/3/2024 2:09:47 AM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Uniqually Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical Interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Variable	Description	Unit	Cables																												
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
General Input Data																															
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9
Phase	Cable Phase		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Frq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-0.5	-0.5	0.5	59.5	59.5	60.5	119.5	119.5	120.5	179.5	179.5	180.5	239.5	239.5	240.5	-60.5	-60.5	-59.5	-75.5	-75.5	-74.5	-90.5	-90.5	-89.5	-105.5	-105.5	-104.5
y	Y coordinate	[ft]	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity																															
I	Steady State Ampacity	[A]	1089.8	1089.8	1089.8	1112.1	1112.1	1112.1	1120.1	1120.1	1120.1	1134.2	1134.2	1134.2	1193.4	1193.4	1193.4	1113.5	1113.5	1113.5	1004.0	1004.0	1004.0	1018.6	1018.6	1018.6	1170.9	1170.9	1170.9
Temperatures																															
θc	Conductor temperature	[°C]	90.0	89.1	88.1	90.0	89.1	88.2	90.0	89.1	88.2	90.0	89.1	88.2	90.0	89.2	88.0	90.0	88.9	87.6	90.0	88.9	88.3	90.0	88.9	88.5	90.0	88.9	89.0
θs	Sheath/Shield temperature	[°C]	83.7	82.8	81.8	83.5	82.6	81.7	83.4	82.5	81.6	83.3	82.4	81.5	82.7	81.9	80.8	85.5	84.4	83.1	86.3	85.2	84.6	86.2	85.1	84.7	85.1	83.9	84.0
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	82.6	81.7	80.8	82.4	81.5	80.6	82.3	81.4	80.5	82.2	81.3	80.3	81.5	80.7	79.5	84.9	83.9	82.6	85.8	84.8	84.2	85.7	84.7	84.3	84.5	83.4	83.5
θduct	Duct surface temperature	[°C]	77.4	76.5	75.5	77.0	76.1	75.2	76.9	76.0	75.0	76.6	75.8	74.8	75.6	74.8	73.6	80.7	79.6	78.3	82.3	81.2	80.6	82.1	81.0	80.6	79.8	78.7	78.8
Resistances																															
R_c	DC Resistance of the conductor at 20°C	(Ω/mile)	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	(Ω/mile)	0.01663	0.0166	0.01656	0.01663	0.0166	0.01656	0.01663	0.0166	0.01656	0.01663	0.0166	0.01656	0.01663	0.0166	0.01656	0.01663	0.01659	0.01654	0.01663	0.01659	0.01657	0.01664	0.01659	0.01658	0.01664	0.01659	0.0166
ys	Skin Effect Factor		0.16164	0.16235	0.16318	0.16153	0.16232	0.16315	0.16153	0.1623	0.16314	0.16183	0.16228	0.16315	0.16153	0.16222	0.16326	0.1616	0.16256	0.16369	0.16198	0.16251	0.16306	0.16157	0.16249	0.16285	0.16157	0.16254	0.16247
yp	Proximity Effect Factor		0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00716	0.0072	0.00742	0.00746	0.00751	0.00742	0.00746	0.00748	0.00742	0.00746	0.00747	0.00742	0.00746	0.00746
Losses																															
Wc	Conductor Losses	[W/ft]	3.74147	3.73343	3.72522	3.89628	3.88815	3.8796	3.95238	3.94423	3.93549	4.05215	4.04402	4.03472	4.4865	4.47824	4.46996	3.90585	3.89593	3.8843	3.17581	3.16799	3.16341	3.26902	3.26102	3.25298	4.31972	4.30855	4.30934
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439
Ws	Metallic Screen Losses	[W/ft]	0.34341	0.34331	0.34424	0.35676	0.35768	0.35865	0.36197	0.36289	0.36388	0.37134	0.37216	0.37321	0.41172	0.41265	0.41405	0.1698	0.17096	0.17103	0.13772	0.13816	0.13842	0.1418	0.14225	0.14242	0.18801	0.18864	0.18896
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	6.0972	6.09007	6.08279	6.26936	6.25915	6.25157	6.32767	6.32044	6.31269	6.43672	6.42951	6.42126	6.91154	6.90422	6.89333	4.63004	4.62068	4.60972	3.86793	3.86055	3.85622	3.96521	3.95766	3.9548	5.06213	5.05159	5.05233
$λ_s$	Screen Loss Factor		0.09152	0.09196	0.09241	0.09157	0.09199	0.09244	0.09158	0.092	0.09246	0.09162	0.09203	0.0925	0.09177	0.09215	0.09271	0.04347	0.04373	0.04403	0.04337	0.04361	0.04376	0.04338	0.04362	0.04371	0.04352	0.04378	0.04377
$λ_a$	Armour Loss Factor r + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances																															
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843
T2	Thermal resistance of bedding/medium inside pipe type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387
T4	External thermal resistance	[K.m/W]	3.52853	3.48779	3.44506	3.4231	3.38385	3.34244	3.38592	3.34758	3.30628	3.32142	3.2848	3.24273	3.06412	3.03298	2.98641	4.80302	4.74059	4.6671	5.81874	5.74627	5.70354	5.66787	5.59784	5.57119	4.36444	4.30692	4.31112
Others																															
ΔθInt	Temperature rise due to surrounding heat sources	[°C]	47.2	46.2	45.4	46.3	45.3	44.6	46.0	45.0	44.2	45.4	44.4	43.6	42.7	41.8	40.8	54.8	53.7	52.5	58.7	57.6	57.1	58.2	57.1	56.8	52.5	51.4	51.6		
	Induced Voltage (standing) on Sheath	(V/mile)	221.96	195.73	224.93	226.62	199.83	229.35	227.77	200.91	231.72	229.84	202.82	235.84	240.29	212.24	250.57	236.19	210.68	252.4	219.15	194.65	217.88	226.61	200.86	214.54	267.48	236.7	256.23		
	Induced Voltage (standing) on Concentric Wires	(V/mile)	224.33	198.14	227.29	229.03	202.28	231.76	230.2	203.37	234.14	232.31	205.32	238.3	242.88	214.87	253.16	239.25	213.77	255.45	221.9	197.44	220.63	229.39	203.68	217.32	270.65	239.94	259.42		
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

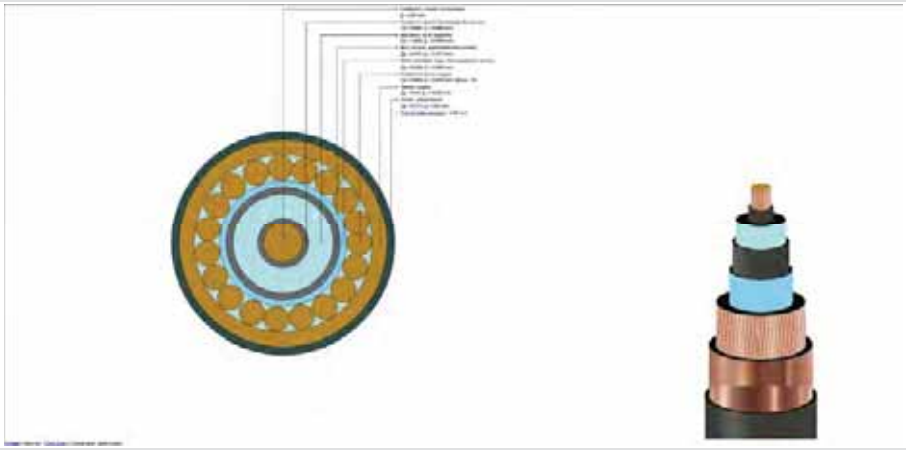
Cables Report

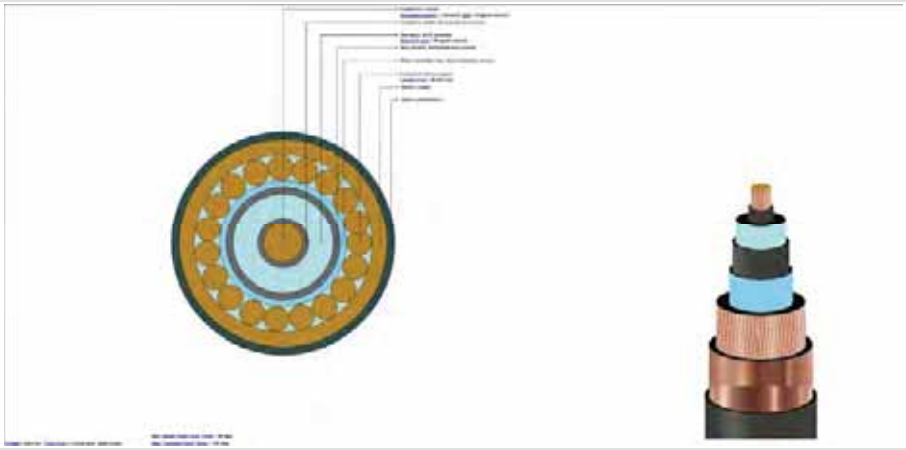
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	J100-230_500kV,30_DOC,15__60_,5000kcmilInCu,@4307_5650A DLF1
Date:	11/3/2024 2:09:47 AM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		PVC Duct in Concrete
66	Duct material thermal resistivity	[K.m/W]	6
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	7.942
69	Outer diameter of the conduit	[in]	8.625

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Cables Report

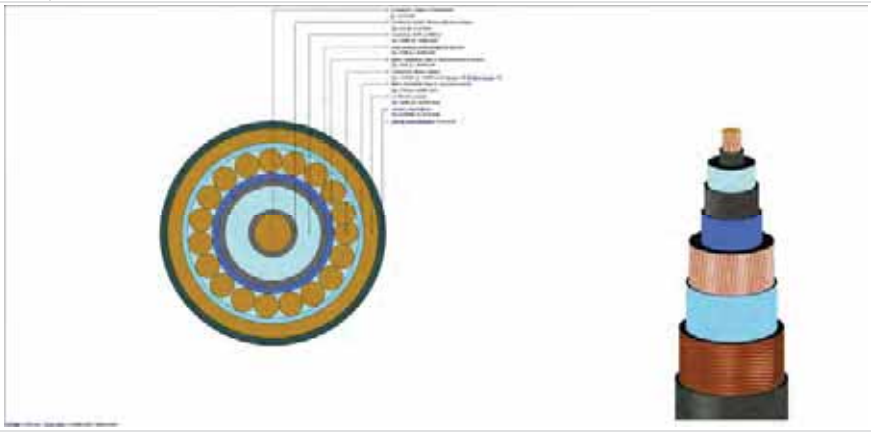
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	J100-230_500kV,30_DOC,15__60_,5000kcmilInCu,@4307_5650A DLF1
Date:	11/3/2024 2:09:47 AM

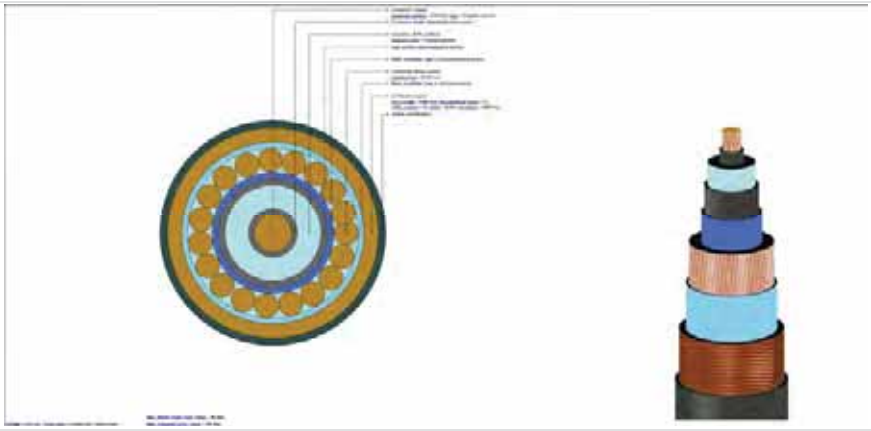
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		PVC Duct in Concrete
71	Duct material thermal resistivity	[K.m/W]	6
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	7.942
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	J101-230_500kV,30_DOC,15__35_,5000kcmillnCu,@4162_4888A DLF1
Date:	11/3/2024 1:28:03 AM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

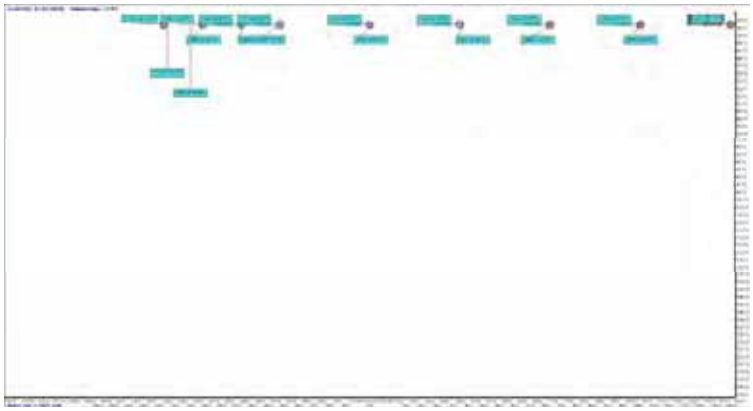
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB2	0.0	31.429	2.6	2.6	0.8
NSTD DB4	35.0	31.429	2.6	2.6	0.8
NSTD DB5	70.0	31.429	2.6	2.6	0.8
NSTD DB6	105.0	31.429	2.6	2.6	0.8
NSTD DB7	140.0	31.429	2.6	2.6	0.8
NSTD DB6	-35.0	31.429	2.6	2.6	0.8
NSTD DB7	-50.0	31.429	2.6	2.6	0.8
NSTD DB8	-65.0	31.429	2.6	2.6	0.8
NSTD DB9	-80.0	31.429	2.6	2.6	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	500C5.00X	1		A	60.0	1.0	-0.5	31.93	90.0	913.2
2	500C5.00X	1		B	60.0	1.0	-0.5	30.93	89.0	913.2
3	500C5.00X	1		C	60.0	1.0	0.5	30.93	88.2	913.2
4	500C5.00X	2		A	60.0	1.0	34.5	31.93	90.0	934.4
5	500C5.00X	2		B	60.0	1.0	34.5	30.93	89.0	934.4
6	500C5.00X	2		C	60.0	1.0	35.5	30.93	88.2	934.4
7	500C5.00X	3		A	60.0	1.0	69.5	31.93	90.0	951.8
8	500C5.00X	3		B	60.0	1.0	69.5	30.93	89.0	951.8
9	500C5.00X	3		C	60.0	1.0	70.5	30.93	88.2	951.8
10	500C5.00X	4		A	60.0	1.0	104.5	31.93	90.0	987.8
11	500C5.00X	4		B	60.0	1.0	104.5	30.93	89.1	987.8
12	500C5.00X	4		C	60.0	1.0	105.5	30.93	88.2	987.8
13	500C5.00X	5		A	60.0	1.0	139.5	31.93	90.0	1100.6
14	500C5.00X	5		B	60.0	1.0	139.5	30.93	89.1	1100.6
15	500C5.00X	5		C	60.0	1.0	140.5	30.93	87.9	1100.6
16	230C5.00X1	6		A	60.0	1.0	-35.5	31.93	90.0	1036.7
17	230C5.00X1	6		B	60.0	1.0	-35.5	30.93	88.8	1036.7
18	230C5.00X1	6		C	60.0	1.0	-34.5	30.93	87.8	1036.7
19	230C5.00X1	7		A	60.0	1.0	-50.5	31.93	90.0	967.6
20	230C5.00X1	7		B	60.0	1.0	-50.5	30.93	88.9	967.6
21	230C5.00X1	7		C	60.0	1.0	-49.5	30.93	88.4	967.6
22	230C5.00X1	8		A	60.0	1.0	-65.5	31.93	90.0	999.0
23	230C5.00X1	8		B	60.0	1.0	-65.5	30.93	88.9	999.0
24	230C5.00X1	8		C	60.0	1.0	-64.5	30.93	88.5	999.0
25	230C5.00X1	9		A	60.0	1.0	-80.5	31.93	90.0	1158.9
26	230C5.00X1	9		B	60.0	1.0	-80.5	30.93	88.9	1158.9
27	230C5.00X1	9		C	60.0	1.0	-79.5	30.93	89.0	1158.9

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	J101-230_500kV_3Q_DOC,1/5__35__5000kcmilinCu@4162_4888A DLF1
Date:	11/3/2024 1:28:03 AM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Uniqually Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Variable	Description	Unit	Cables																												
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27		
General Input Data																															
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1		
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9		
Phase	Cable Phase		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C		
Frq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0		
x	X coordinate	[ft]	-0.5	-0.5	0.5	34.5	34.5	35.5	69.5	69.5	70.5	104.5	104.5	105.5	139.5	139.5	140.5	-35.5	-35.5	-34.5	-50.5	-50.5	-49.5	-65.5	-65.5	-64.5	-80.5	-80.5	-79.5		
y	Y coordinate	[ft]	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93		
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular		
Ampacity																															
I	Steady State Ampacity	[A]	913.2	913.2	913.2	934.4	934.4	934.4	951.8	951.8	951.8	987.8	987.8	987.8	1100.6	1100.6	1100.6	1036.7	1036.7	1036.7	967.6	967.6	967.6	999.0	999.0	999.0	1158.9	1158.9	1158.9		
Temperatures																															
θc	Conductor temperature	[°C]	90.0	89.0	88.2	90.0	89.0	88.2	90.0	89.0	88.2	90.0	89.1	88.2	90.0	89.1	87.9	90.0	88.8	87.8	90.0	88.9	88.4	90.0	88.9	88.5	90.0	88.9	89.0		
θs	Sheath/Shield temperature	[°C]	85.2	84.1	83.4	85.0	84.0	83.2	84.9	83.9	83.1	84.6	83.6	82.8	83.6	82.7	81.5	86.0	84.9	83.9	86.5	85.4	84.9	86.3	85.2	84.9	85.1	84.0	84.1		
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
θsurf	Cable surface temperature	[°C]	84.3	83.3	82.5	84.1	83.1	82.4	84.0	83.0	82.2	83.6	82.7	81.8	82.5	81.7	80.4	85.6	84.4	83.5	86.1	85.0	84.5	85.9	84.8	84.4	84.6	83.5	83.6		
θduct	Duct surface temperature	[°C]	80.2	79.1	78.4	79.9	78.8	78.1	79.6	78.6	77.8	79.1	78.1	77.2	77.2	76.4	75.1	81.8	80.7	79.7	82.8	81.7	81.1	82.4	81.3	80.9	80.0	78.9	79.0		
Resistances																															
R_c	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116		
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.01659	0.01656	0.01663	0.01659	0.01656	0.01663	0.01659	0.01656	0.01663	0.0166	0.01656	0.01663	0.0166	0.01655	0.01663	0.01659	0.01655	0.01664	0.01659	0.01657	0.01664	0.01659	0.01658	0.01664	0.01659	0.0166		
ys	Skin Effect Factor		0.16154	0.16245	0.16311	0.16153	0.16243	0.16309	0.16153	0.1624	0.16309	0.16153	0.16236	0.16313	0.16153	0.16229	0.16339	0.16159	0.16259	0.16347	0.16138	0.16255	0.16301	0.16157	0.16252	0.16284	0.16157	0.16256	0.16248		
yp	Proximity Effect Factor		0.00713	0.00717	0.00719	0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00716	0.0072	0.00742	0.00746	0.0075	0.00742	0.00746	0.00748	0.00742	0.00746	0.00747	0.00742	0.00746	0.00746		
Losses																															
Wc	Conductor Losses	[W/ft]	2.62697	2.62066	2.61606	2.75042	2.74389	2.73909	2.85393	2.84733	2.84214	3.07383	3.06705	3.06084	3.8157	3.80804	3.79899	3.38597	3.37897	3.36918	2.94989	2.94231	2.93871	3.14445	3.13651	3.1339	4.23118	4.22001	4.22096		
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439		
Ws	Metallic Screen Losses	[W/ft]	0.23184	0.24011	0.24062	0.25075	0.25148	0.25203	0.26029	0.26103	0.26161	0.28057	0.28133	0.28203	0.34827	0.35013	0.35159	0.14694	0.14765	0.14789	0.12785	0.12825	0.12846	0.13634	0.13679	0.13693	0.1841	0.18474	0.18468		
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Wt	Total Losses	[W/ft]	4.87969	4.87409	4.87001	5.0145	5.0087	5.00444	5.12754	5.12168	5.11708	5.36773	5.36171	5.3562	6.1783	6.1715	6.1617	4.0873	4.07881	4.07146	3.63211	3.62496	3.62156	3.83518	3.82769	3.82523	4.96968	4.95914	4.96003		
λ_1	Screen Loss Factor		0.09113	0.09162	0.09198	0.09117	0.09165	0.09201	0.0912	0.09167	0.09205	0.09128	0.09173	0.09214	0.09154	0.09195	0.09254	0.0434	0.04366	0.0439	0.04333	0.04359	0.04371	0.04336	0.04361	0.04369	0.04351	0.04378	0.04375		
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Thermal resistances																															
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843		
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387		
T4	External thermal resistance	[K.m/W]	4.51602	4.45679	4.41359	4.38355	4.33683	4.28504	4.27771	4.22376	4.18132	4.0674	4.01847	3.97359	3.47811	3.4398	3.38425	5.46742	5.41341	5.34899	6.21932	6.13875	6.10025	5.87192	5.7971	5.77257	4.45213	4.39228	4.39751		
Others																															
Δθint	Temperature rise due to surrounding heat sources	[°C]	53.6	52.5	51.9	52.9	51.8	51.2	52.3	51.2	50.6	51.0	50.0	49.2	46.6	45.6	44.6	57.6	56.4	55.5	59.9	58.7	58.3	58.8	57.7	57.5	53.0	51.8	52.0		
	Induced Voltage (standing) on Sheath	[V/mile]	185.37	163.51	189.45	189.75	167.38	193.71	192.68	170.03	198.27	198.91	175.86	207.4	219.33	194.01	234.67	221.19	197.12	232.94	211.94	188.17	208.87	222.72	197.37	209.7	265.06	234.54	233.31		
	Induced Voltage (standing) on Concentric Wires	[V/mile]	187.35	165.52	191.43	191.78	169.44	195.74	194.74	172.13	200.34	201.06	177.84	209.55	221.73	196.44	237.06	224.04	200.0	235.78	214.59	190.85	211.51	225.44	200.14	212.43	268.2	237.74	236.47		
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

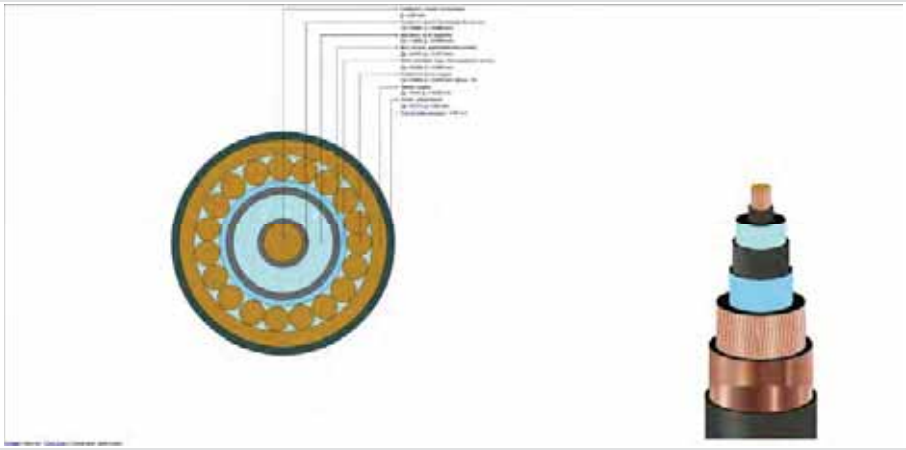
Cables Report

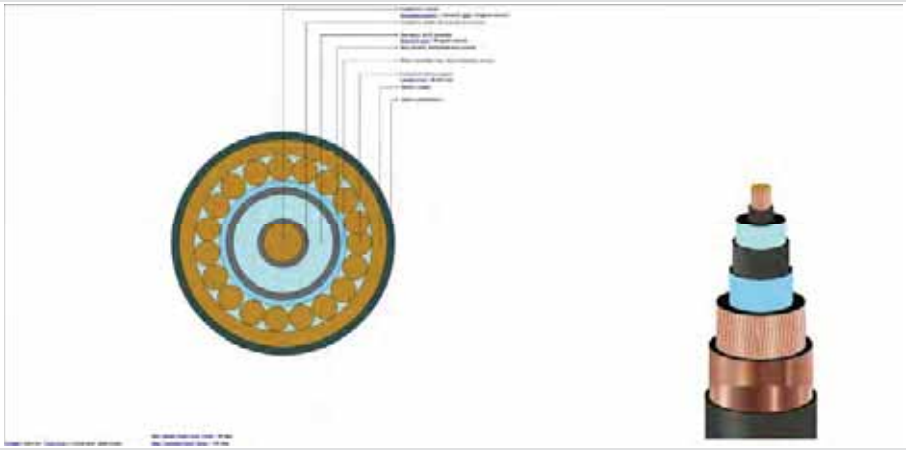
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	J101-230_500kV,30_DOC,15__35_,5000kcmilInCu,@4162_4888A DLF1
Date:	11/3/2024 1:28:03 AM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		PVC Duct in Concrete
66	Duct material thermal resistivity	[K.m/W]	6
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	7.942
69	Outer diameter of the conduit	[in]	8.625

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Cables Report

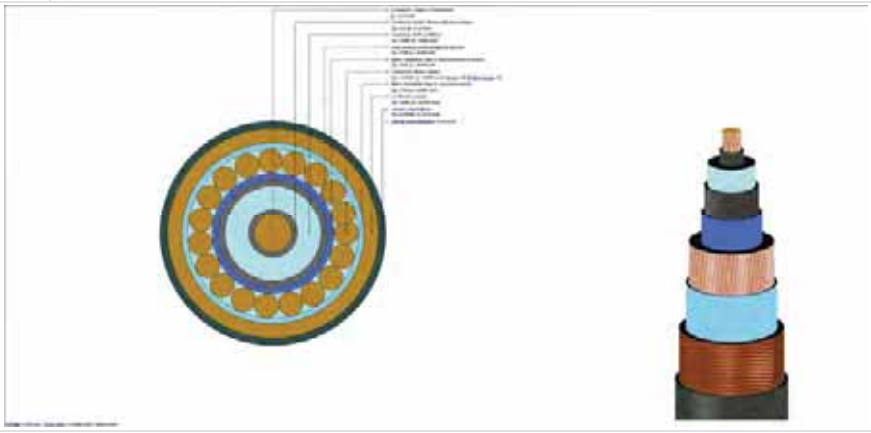
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	J101-230_500kV,30_DOC,15__35_,5000kcmilInCu,@4162_4888A DLF1
Date:	11/3/2024 1:28:03 AM

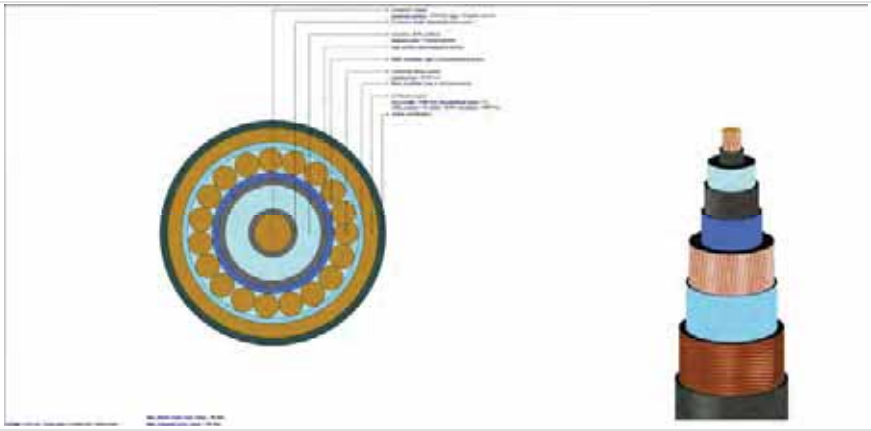
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		PVC Duct in Concrete
71	Duct material thermal resistivity	[K.m/W]	6
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	7.942
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	J102-230_500kV,30_DOC,15__45_,5000kcmillnCu,@4156_5184A DLF1
Date:	11/3/2024 12:40:13 AM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

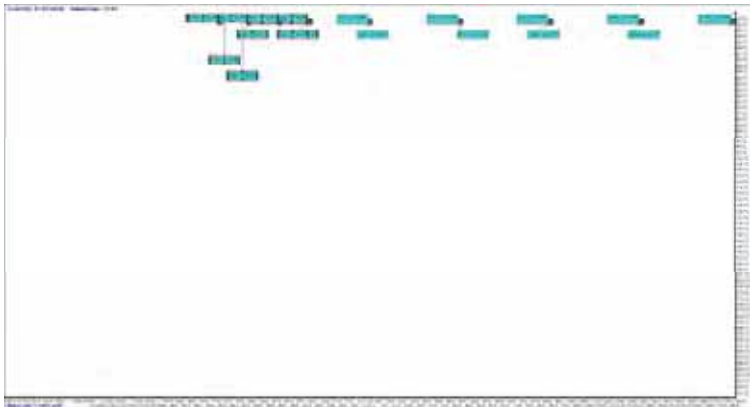
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB2	0.0	31.429	2.6	2.6	0.8
NSTD DB4	45.0	31.429	2.6	2.6	0.8
NSTD DB5	90.0	31.429	2.6	2.6	0.8
NSTD DB6	135.0	31.429	2.6	2.6	0.8
NSTD DB7	180.001	31.429	2.6	2.6	0.8
NSTD DB6	-30.0	31.429	2.6	2.6	0.8
NSTD DB7	-45.0	31.429	2.6	2.6	0.8
NSTD DB8	-60.0	31.429	2.6	2.6	0.8
NSTD DB9	-75.0	31.429	2.6	2.6	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	500C5.00X	1		A	60.0	1.0	-0.5	31.93	90.0	932.0
2	500C5.00X	1		B	60.0	1.0	-0.5	30.93	89.0	932.0
3	500C5.00X	1		C	60.0	1.0	0.5	30.93	88.0	932.0
4	500C5.00X	2		A	60.0	1.0	44.5	31.93	90.0	1011.1
5	500C5.00X	2		B	60.0	1.0	44.5	30.93	89.0	1011.1
6	500C5.00X	2		C	60.0	1.0	45.5	30.93	88.2	1011.1
7	500C5.00X	3		A	60.0	1.0	89.5	31.93	90.0	1033.0
8	500C5.00X	3		B	60.0	1.0	89.5	30.93	89.0	1033.0
9	500C5.00X	3		C	60.0	1.0	90.5	30.93	88.2	1033.0
10	500C5.00X	4		A	60.0	1.0	134.5	31.93	90.0	1060.5
11	500C5.00X	4		B	60.0	1.0	134.5	30.93	89.1	1060.5
12	500C5.00X	4		C	60.0	1.0	135.5	30.93	88.2	1060.5
13	500C5.00X	5		A	60.0	1.0	179.5	31.93	90.0	1147.9
14	500C5.00X	5		B	60.0	1.0	179.5	30.93	89.2	1147.9
15	500C5.00X	5		C	60.0	1.0	180.5	30.93	88.0	1147.9
16	230C5.00X1	6		A	60.0	1.0	-30.5	31.93	90.0	1029.9
17	230C5.00X1	6		B	60.0	1.0	-30.5	30.93	88.8	1029.9
18	230C5.00X1	6		C	60.0	1.0	-29.5	30.93	87.9	1029.9
19	230C5.00X1	7		A	60.0	1.0	-45.5	31.93	90.0	966.8
20	230C5.00X1	7		B	60.0	1.0	-45.5	30.93	88.9	966.8
21	230C5.00X1	7		C	60.0	1.0	-44.5	30.93	88.4	966.8
22	230C5.00X1	8		A	60.0	1.0	-60.5	31.93	90.0	999.4
23	230C5.00X1	8		B	60.0	1.0	-60.5	30.93	88.9	999.4
24	230C5.00X1	8		C	60.0	1.0	-59.5	30.93	88.6	999.4
25	230C5.00X1	9		A	60.0	1.0	-75.5	31.93	90.0	1159.4
26	230C5.00X1	9		B	60.0	1.0	-75.5	30.93	88.9	1159.4
27	230C5.00X1	9		C	60.0	1.0	-74.5	30.93	89.0	1159.4

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	J102-230_500kV,30_DOC,15__45_,5000kcmilInCu,@4156_5184A DLF1
Date:	11/3/2024 12:40:13 AM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Cables 1–9

Variable	Description	Unit	1	2	3	4	5	6	7	8	9
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9
General Input Data											
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-0.5	-0.5	0.5	44.5	44.5	45.5	89.5	89.5	90.5
y	Y coordinate	[ft]	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	932.0	932.0	932.0	1011.1	1011.1	1011.1	1033.0	1033.0	1033.0
Temperatures											
θc	Conductor temperature	[°C]	90.0	89.0	88.0	90.0	89.0	88.2	90.0	89.0	88.2
θs	Sheath/Shield temperature	[°C]	85.0	84.0	83.1	84.4	83.4	82.6	84.2	83.3	82.4
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	84.1	83.1	82.2	83.4	82.4	81.6	83.2	82.2	81.4
θduct	Duct surface temperature	[°C]	79.9	78.9	77.9	78.7	77.7	76.9	78.4	77.4	76.5
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.01659	0.01656	0.01663	0.01659	0.01656	0.01663	0.0166	0.01656
ys	Skin Effect Factor		0.16155	0.16243	0.16325	0.16153	0.1624	0.16315	0.16153	0.16237	0.16313
yp	Proximity Effect Factor		0.00713	0.00716	0.0072	0.00713	0.00716	0.00719	0.00713	0.00716	0.00719
Losses											
Wc	Conductor Losses	[W/ft]	2.73621	2.72979	2.72388	3.22043	3.21306	3.2067	3.36163	3.35415	3.34742
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.24946	0.25018	0.25084	0.29413	0.29495	0.29567	0.30718	0.30802	0.30878
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	4.99899	4.9933	4.98805	5.52788	5.52134	5.5157	5.68213	5.6755	5.66952
λ_1	Screen Loss Factor		0.09117	0.09165	0.09209	0.09133	0.0918	0.0922	0.09138	0.09183	0.09224
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	4.39803	4.34174	4.2897	3.937	3.88776	3.84511	3.81876	3.77232	3.73039
Others											
Δθint	Temperature rise due to surrounding heat sources	[°C]	52.9	51.9	51.1	50.2	49.1	48.4	49.4	48.3	47.6
	Induced Voltage (standing) on Sheath	[V/mile]	187.8	165.82	195.5	205.4	181.18	209.5	209.51	184.85	214.56
	Induced Voltage (standing) on Concentric Wires	[V/mile]	189.82	167.87	197.52	207.59	183.41	211.69	211.75	187.13	216.8
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cables 10–18

Variable	Description	Unit	10	11	12	13	14	15	16	17	18
Cable No.	Cable Index Number		10	11	12	13	14	15	16	17	18
General Input Data											
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	230C5.00X1	230C5.00X1	230C5.00X1
Circuit No.	Circuit No.		4	4	4	5	5	5	6	6	6
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	134.5	134.5	135.5	179.5	179.5	180.5	-30.5	-30.5	-29.5
y	Y coordinate	[ft]	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	1060.5	1060.5	1060.5	1147.9	1147.9	1147.9	1029.9	1029.9	1029.9
Temperatures											
θc	Conductor temperature	[°C]	90.0	89.1	88.2	90.0	89.2	88.0	90.0	88.8	87.9
θs	Sheath/Shield temperature	[°C]	84.0	83.1	82.1	83.2	82.3	81.1	86.1	85.0	84.0
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	82.9	82.0	81.1	82.0	81.2	80.0	85.6	84.5	83.6
θduct	Duct surface temperature	[°C]	77.9	77.0	76.1	76.4	75.6	74.3	81.9	80.8	79.8
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.0166	0.01656	0.01663	0.0166	0.01655	0.01663	0.01659	0.01655
ys	Skin Effect Factor		0.16153	0.16233	0.16315	0.16153	0.16226	0.16332	0.16159	0.16258	0.16342
yp	Proximity Effect Factor		0.00713	0.00716	0.00719	0.00713	0.00716	0.0072	0.00742	0.00746	0.0075
Losses											
Wc	Conductor Losses	[W/ft]	3.54259	3.53503	3.52742	4.15112	4.1431	4.13148	3.34156	3.33277	3.32539
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	0.55439	0.55439	0.55439
Ws	Metallic Screen Losses	[W/ft]	0.32393	0.32478	0.32564	0.38046	0.38136	0.38268	0.14499	0.14549	0.14591
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	5.87985	5.87314	5.86639	6.54491	6.53779	6.52748	4.04095	4.03266	4.0257
λ_1	Screen Loss Factor		0.09144	0.09188	0.09232	0.09165	0.09205	0.09263	0.04339	0.04365	0.04388
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.32843	0.32843	0.32843
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.03387	0.03387	0.03387
T4	External thermal resistance	[K.m/W]	3.67617	3.63324	3.5899	3.25953	3.22487	3.17434	5.55437	5.48028	5.41773
Others											
Δθint	Temperature rise due to surrounding heat sources	[°C]	48.3	47.3	46.6	44.6	43.7	42.7	57.8	56.6	55.8
	Induced Voltage (standing) on Sheath	[V/mile]	214.2	189.1	221.6	229.98	203.27	242.84	219.96	195.99	231.07
	Induced Voltage (standing) on Concentric Wires	[V/mile]	216.51	191.44	223.91	232.48	205.8	245.34	222.79	198.84	233.89
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cables 19–27

Variable	Description	Unit	19	20	21	22	23	24	25	26	27
Cable No.	Cable Index Number		19	20	21	22	23	24	25	26	27
General Input Data											
Cable ID	Cable Equipment ID		230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1
Circuit No.	Circuit No.		7	7	7	8	8	8	9	9	9
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-45.5	-45.5	-44.5	-60.5	-60.5	-59.5	-75.5	-75.5	-74.5
y	Y coordinate	[ft]	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	966.8	966.8	966.8	999.4	999.4	999.4	1159.4	1159.4	1159.4
Temperatures											
θc	Conductor temperature	[°C]	90.0	88.9	88.4	90.0	88.9	88.6	90.0	88.9	89.0
θs	Sheath/Shield temperature	[°C]	86.5	85.4	84.9	86.3	85.2	84.9	85.1	84.0	84.1
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	86.1	85.0	84.5	85.9	84.8	84.4	84.6	83.5	83.6
θduct	Duct surface temperature	[°C]	82.8	81.7	81.2	82.4	81.3	80.9	80.0	78.9	78.9
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01664	0.01659	0.01657	0.01664	0.01659	0.01658	0.01664	0.01659	0.0166
ys	Skin Effect Factor		0.16158	0.16254	0.163	0.16157	0.16252	0.16283	0.16157	0.16256	0.16247
yp	Proximity Effect Factor		0.00742	0.00746	0.00748	0.00742	0.00746	0.00747	0.00742	0.00746	0.00746
Losses											
Wc	Conductor Losses	[W/ft]	2.94501	2.93749	2.93394	3.14694	3.13901	3.1364	4.2352	4.22406	4.225
Wd	Dielectric Losses	[W/ft]	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439
Ws	Metallic Screen Losses	[W/ft]	0.12761	0.12804	0.12824	0.13645	0.13689	0.13704	0.18428	0.18491	0.18486
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	3.62702	3.61992	3.61657	3.83778	3.83029	3.82784	4.97388	4.96337	4.96425
λ_1	Screen Loss Factor		0.04333	0.04359	0.04371	0.04336	0.04361	0.04369	0.04351	0.04378	0.04375
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387
T4	External thermal resistance	[K.m/W]	6.22853	6.14823	6.11022	5.86771	5.79316	5.76863	4.44808	4.38847	4.39368
Others											
Δθint	Temperature rise due to surrounding heat sources	[°C]	59.9	58.8	58.4	58.8	57.7	57.4	53.0	51.8	52.0
	Induced Voltage (standing) on Sheath	[V/mile]	211.82	188.06	208.6	222.83	197.46	209.75	265.2	234.66	233.39
	Induced Voltage (standing) on Concentric Wires	[V/mile]	214.47	190.74	211.25	225.56	200.24	212.48	268.34	237.87	236.56
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

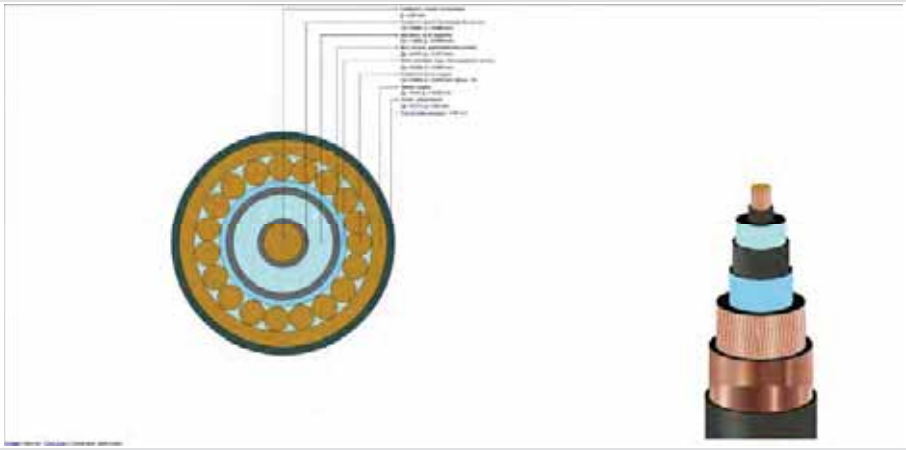
Cables Report

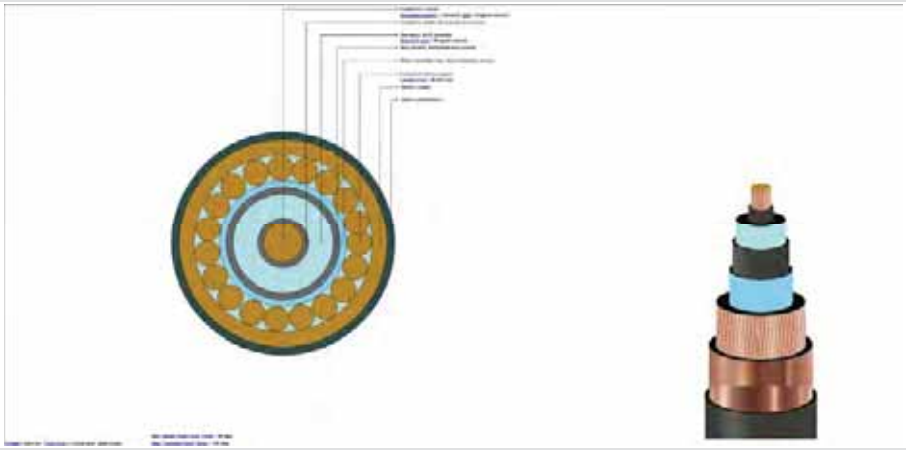
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	J102-230_500kV,30_DOC,15__45_,5000kcmilInCu,@4156_5184A DLF1
Date:	11/3/2024 12:40:13 AM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		PVC Duct in Concrete
66	Duct material thermal resistivity	[K.m/W]	6
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	7.942
69	Outer diameter of the conduit	[in]	8.625

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Cables Report

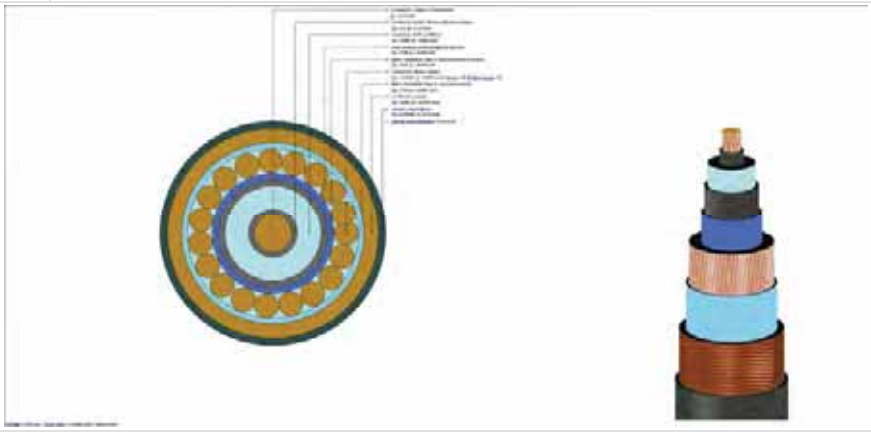
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	J102-230_500kV,30_DOC,15__45_,5000kcmilInCu,@4156_5184A DLF1
Date:	11/3/2024 12:40:13 AM

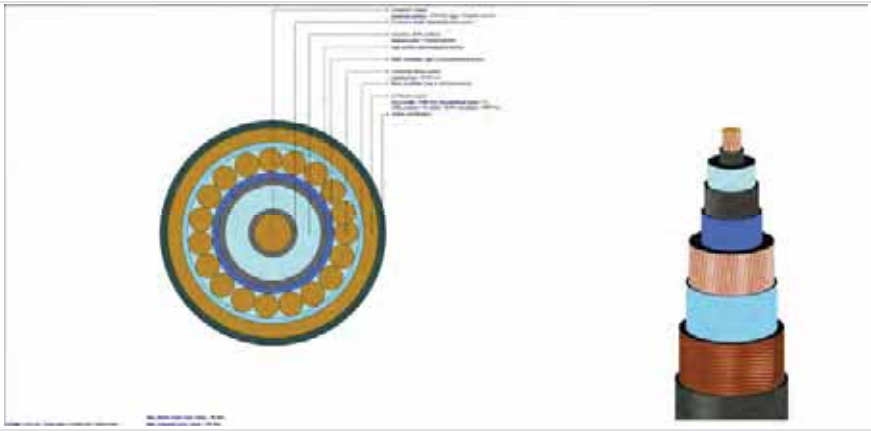
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		PVC Duct in Concrete
71	Duct material thermal resistivity	[K.m/W]	6
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	7.942
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	J103-230_500kV,30_DOC,15__45_,5000kcmillnCu,@4047_5043A DLF1
Date:	11/3/2024 12:00:14 AM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

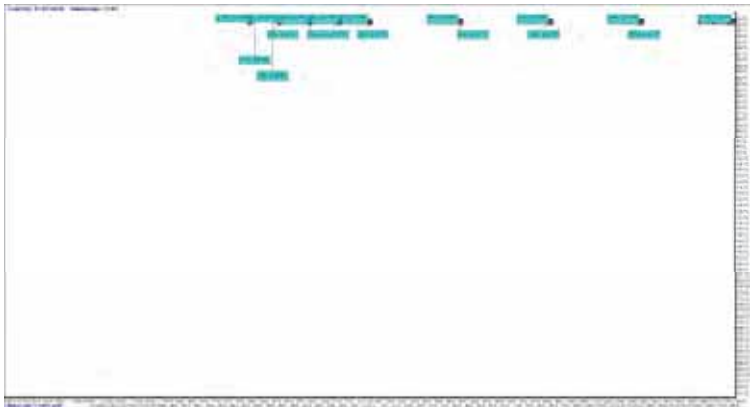
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB2	0.0	31.429	2.6	2.6	0.8
NSTD DB4	45.0	31.429	2.6	2.6	0.8
NSTD DB5	90.0	31.429	2.6	2.6	0.8
NSTD DB6	135.0	31.429	2.6	2.6	0.8
NSTD DB7	180.001	31.429	2.6	2.6	0.8
NSTD DB6	-15.0	31.429	2.6	2.6	0.8
NSTD DB7	-30.0	31.429	2.6	2.6	0.8
NSTD DB8	-45.0	31.429	2.6	2.6	0.8
NSTD DB9	-60.0	31.429	2.6	2.6	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	500C5.00X	1		A	60.0	1.0	-0.5	31.93	90.0	809.5
2	500C5.00X	1		B	60.0	1.0	-0.5	30.93	89.0	809.5
3	500C5.00X	1		C	60.0	1.0	0.5	30.93	87.8	809.5
4	500C5.00X	2		A	60.0	1.0	44.5	31.93	90.0	997.3
5	500C5.00X	2		B	60.0	1.0	44.5	30.93	89.0	997.3
6	500C5.00X	2		C	60.0	1.0	45.5	30.93	88.1	997.3
7	500C5.00X	3		A	60.0	1.0	89.5	31.93	90.0	1029.4
8	500C5.00X	3		B	60.0	1.0	89.5	30.93	89.0	1029.4
9	500C5.00X	3		C	60.0	1.0	90.5	30.93	88.2	1029.4
10	500C5.00X	4		A	60.0	1.0	134.5	31.93	90.0	1059.3
11	500C5.00X	4		B	60.0	1.0	134.5	30.93	89.1	1059.3
12	500C5.00X	4		C	60.0	1.0	135.5	30.93	88.2	1059.3
13	500C5.00X	5		A	60.0	1.0	179.5	31.93	90.0	1147.5
14	500C5.00X	5		B	60.0	1.0	179.5	30.93	89.2	1147.5
15	500C5.00X	5		C	60.0	1.0	180.5	30.93	88.0	1147.5
16	230C5.00X1	6		A	60.0	1.0	-15.5	31.93	90.0	955.6
17	230C5.00X1	6		B	60.0	1.0	-15.5	30.93	88.9	955.6
18	230C5.00X1	6		C	60.0	1.0	-14.5	30.93	88.3	955.6
19	230C5.00X1	7		A	60.0	1.0	-30.5	31.93	90.0	945.4
20	230C5.00X1	7		B	60.0	1.0	-30.5	30.93	88.9	945.4
21	230C5.00X1	7		C	60.0	1.0	-29.5	30.93	88.4	945.4
22	230C5.00X1	8		A	60.0	1.0	-45.5	31.93	90.0	991.0
23	230C5.00X1	8		B	60.0	1.0	-45.5	30.93	88.9	991.0
24	230C5.00X1	8		C	60.0	1.0	-44.5	30.93	88.6	991.0
25	230C5.00X1	9		A	60.0	1.0	-60.5	31.93	90.0	1155.3
26	230C5.00X1	9		B	60.0	1.0	-60.5	30.93	88.9	1155.3
27	230C5.00X1	9		C	60.0	1.0	-59.5	30.93	89.0	1155.3

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	J103-230_500kV_30_DOC_15__45_5000kcmilInCu@4047_5043A DLF1
Date:	11/3/2024 12:00:14 AM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-isothermal Earth Suiface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Variable	Description	Unit	Cables																												
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
General Input Data																															
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9
Phase	Cable Phase		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-0.5	-0.5	0.5	44.5	44.5	45.5	89.5	89.5	90.5	134.5	134.5	135.5	179.5	179.5	180.5	-15.5	-15.5	-14.5	-30.5	-30.5	-29.5	-45.5	-45.5	-44.5	-60.5	-60.5	-59.5
y	Y coordinate	[ft]	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93	31.93	30.93	30.93
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity																															
I	Steady State Ampacity	[A]	809.5	809.5	809.5	997.3	997.3	997.3	1029.4	1029.4	1029.4	1059.3	1059.3	1059.3	1147.5	1147.5	1147.5	955.6	955.6	955.6	945.4	945.4	945.4	991.0	991.0	991.0	1155.3	1155.3	1155.3
Temperatures																															
θc	Conductor temperature	[°C]	90.0	89.0	87.8	90.0	89.0	88.1	90.0	89.0	88.2	90.0	89.1	88.2	90.0	89.2	88.0	90.0	88.9	88.3	90.0	88.9	88.4	90.0	88.9	88.6	90.0	88.9	89.0
θs	Sheath/Shield temperature	[°C]	85.9	84.9	83.8	84.5	83.5	82.7	84.2	83.3	82.4	84.0	83.1	82.1	83.2	82.3	81.1	86.6	85.5	84.9	86.7	85.6	85.1	86.4	85.3	84.9	85.2	84.0	84.1
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	85.2	84.2	83.0	83.5	82.5	81.7	83.2	82.3	81.4	82.9	82.0	81.1	82.0	81.2	80.0	86.2	85.1	84.5	86.3	85.2	84.7	86.0	84.9	84.5	84.6	83.5	83.6
θduct	Duct surface temperature	[°C]	81.6	80.6	79.4	78.9	77.9	77.1	78.4	77.4	76.6	77.9	77.0	76.1	76.4	75.6	74.3	82.9	81.8	81.2	83.1	82.0	81.5	82.5	81.4	81.0	80.1	78.9	79.0
Resistances																															
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.01659	0.01655	0.01663	0.01659	0.01656	0.01663	0.0166	0.01656	0.01663	0.0166	0.01656	0.01663	0.0166	0.01655	0.01663	0.01659	0.01657	0.01664	0.01659	0.01658	0.01664	0.01659	0.01658	0.01664	0.01659	0.0166
ys	Skin Effect Factor		0.16155	0.16241	0.16343	0.16154	0.16241	0.16316	0.16153	0.16237	0.16313	0.16153	0.16233	0.16315	0.16153	0.16226	0.16332	0.16158	0.16256	0.16308	0.16157	0.16254	0.16294	0.16157	0.16252	0.16282	0.16157	0.16256	0.16247
yp	Proximity Effect Factor		0.00713	0.00716	0.0072	0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00716	0.0072	0.00742	0.00746	0.00748	0.00742	0.00746	0.00748	0.00742	0.00746	0.00747	0.00742	0.00746	0.00746
Losses																															
Wc	Conductor Losses	[W/ft]	2.06437	2.05961	2.05408	3.13326	3.1126	3.11976	3.33785	3.33039	3.3237	3.53492	3.52738	3.51979	4.14829	4.14027	4.12865	2.87711	2.86963	2.86573	2.81586	2.80863	2.80571	3.09422	3.08638	3.08399	4.20507	4.19395	4.19497
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439
Ws	Metallic Screen Losses	[W/ft]	0.18773	0.18826	0.18888	0.28607	0.28689	0.28759	0.30498	0.30582	0.30657	0.32322	0.32407	0.32493	0.38019	0.3811	0.38242	0.12465	0.12507	0.12529	0.12196	0.12237	0.12254	0.13414	0.13458	0.13472	0.18295	0.18358	0.18352
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	4.26542	4.2612	4.25629	5.43266	5.42621	5.42068	5.65615	5.64953	5.6436	5.87147	5.86477	5.85804	6.54181	6.5347	6.52439	3.55615	3.54909	3.54541	3.49221	3.48539	3.48264	3.78275	3.77536	3.7731	4.94242	4.93193	4.93289
λ_1	Screen Loss Factor		0.09094	0.09141	0.09196	0.0913	0.09177	0.09218	0.09137	0.09183	0.09224	0.09144	0.09187	0.09231	0.09165	0.09205	0.09263	0.04332	0.04358	0.04372	0.04331	0.04357	0.04367	0.04335	0.0436	0.04368	0.04351	0.04377	0.04375
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances																															
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387
T4	External thermal resistance	[K.m/W]	5.22744	5.16179	5.08529	4.01342	3.96257	3.91883	3.83824	3.79135	3.74915	3.68201	3.63902	3.59564	3.26127	3.22659	3.17601	6.35935	6.27595	6.23222	6.48251	6.39866	6.36476	5.95817	5.88208	5.85884	4.47863	4.41832	4.42406
Others																															
Δθint	Temperature rise due to surrounding heat sources	[°C]	56.8	55.7	54.7	50.7	49.6	48.9	49.5	48.5	47.8	48.3	47.4	46.6	44.6	43.7	42.7	60.3	59.1	58.6	60.6	59.5	59.1	59.1	58.0	57.7	53.1	51.9	52.2
	Induced Voltage (standing) on Sheath	[V/mile]	159.18	141.05	176.19	202.25	178.44	207.18	208.69	184.13	213.93	213.96	188.89	221.39	229.91	203.21	242.75	206.11	183.36	211.25	207.62	184.26	203.23	221.15	195.95	207.71	264.34	233.9	232.44
	Induced Voltage (standing) on Concentric Wires	[V/mile]	160.95	142.83	177.94	204.41	180.64	209.35	210.92	186.4	216.16	216.26	191.22	223.68	232.41	205.74	245.24	208.73	186.01	213.87	210.2	186.89	205.81	223.85	198.7	210.41	267.47	237.09	235.59
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

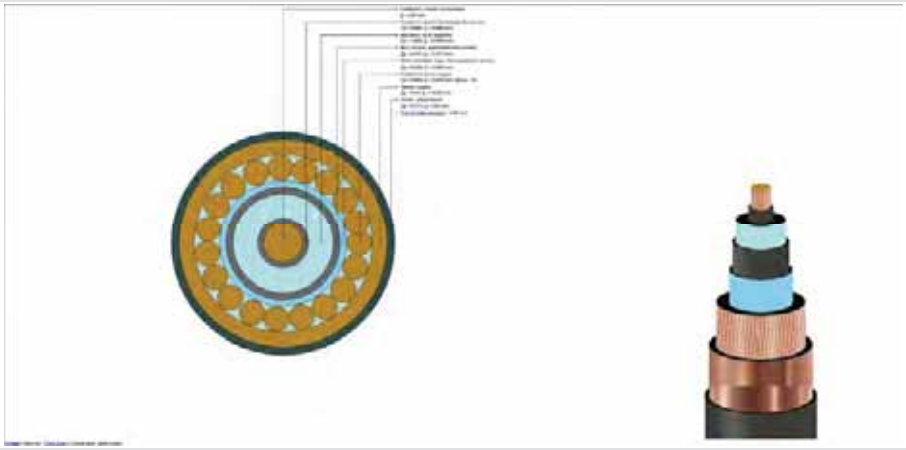
Cables Report

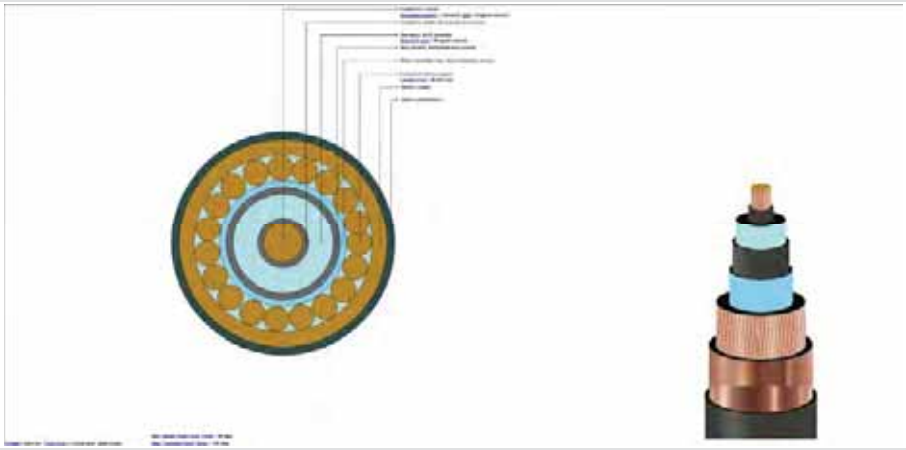
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	J103-230_500kV,30_DOC,15__45_,5000kcmilInCu,@4047_5043A DLF1
Date:	11/3/2024 12:00:14 AM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		PVC Duct in Concrete
66	Duct material thermal resistivity	[K.m/W]	6
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	7.942
69	Outer diameter of the conduit	[in]	8.625

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Cables Report

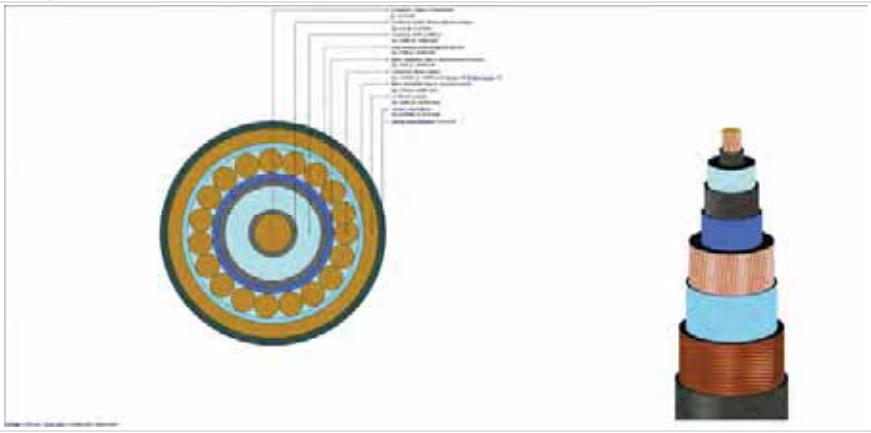
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	J103-230_500kV,30_DOC,15__45_,5000kcmilInCu,@4047_5043A DLF1
Date:	11/3/2024 12:00:14 AM

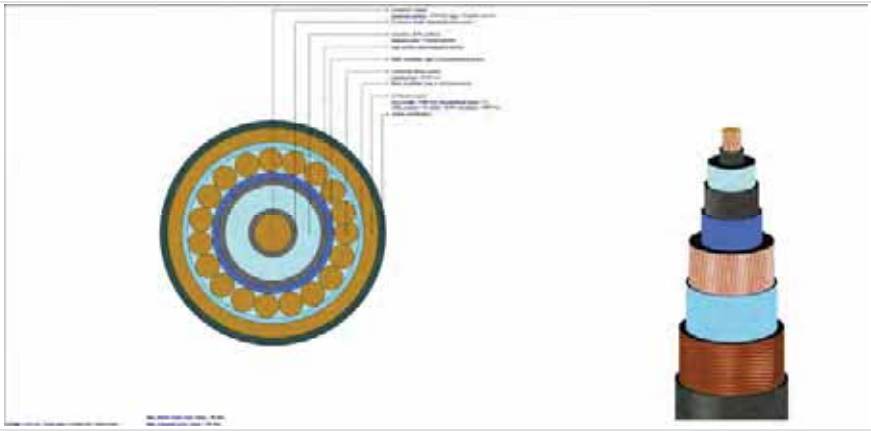
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		PVC Duct in Concrete
71	Duct material thermal resistivity	[K.m/W]	6
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	7.942
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K100-230_500kV,45_DOC,15__60_,5000kcmillnCu,@3825_4878A DLF1
Date:	11/2/2024 9:43:17 PM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

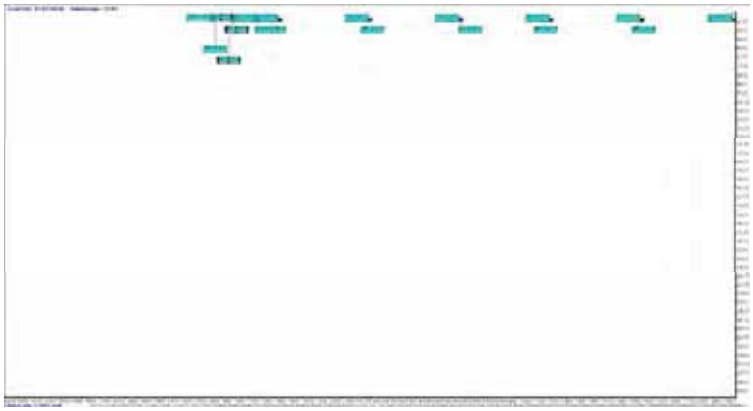
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB2	0.0	46.265	2.3	2.3	0.8
NSTD DB4	60.0	46.265	2.3	2.3	0.8
NSTD DB5	120.0	46.265	2.3	2.3	0.8
NSTD DB6	180.001	46.265	2.3	2.3	0.8
NSTD DB7	240.001	46.265	2.3	2.3	0.8
NSTD DB6	-60.0	46.265	2.3	2.3	0.8
NSTD DB7	-75.0	46.265	2.3	2.3	0.8
NSTD DB8	-90.0	46.265	2.3	2.3	0.8
NSTD DB9	-105.0	46.265	2.3	2.3	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	500C5.00X	1		A	60.0	1.0	-0.5	46.76	90.0	918.5
2	500C5.00X	1		B	60.0	1.0	-0.5	45.76	89.1	918.5
3	500C5.00X	1		C	60.0	1.0	0.5	45.76	88.3	918.5
4	500C5.00X	2		A	60.0	1.0	59.5	46.76	90.0	943.4
5	500C5.00X	2		B	60.0	1.0	59.5	45.76	89.2	943.4
6	500C5.00X	2		C	60.0	1.0	60.5	45.76	88.3	943.4
7	500C5.00X	3		A	60.0	1.0	119.5	46.76	90.0	957.9
8	500C5.00X	3		B	60.0	1.0	119.5	45.76	89.2	957.9
9	500C5.00X	3		C	60.0	1.0	120.5	45.76	88.3	957.9
10	500C5.00X	4		A	60.0	1.0	179.5	46.76	90.0	985.2
11	500C5.00X	4		B	60.0	1.0	179.5	45.76	89.2	985.2
12	500C5.00X	4		C	60.0	1.0	180.5	45.76	88.2	985.2
13	500C5.00X	5		A	60.0	1.0	239.5	46.76	90.0	1072.8
14	500C5.00X	5		B	60.0	1.0	239.5	45.76	89.2	1072.8
15	500C5.00X	5		C	60.0	1.0	240.5	45.76	88.0	1072.8
16	230C5.00X1	6		A	60.0	1.0	-60.5	46.76	90.0	978.7
17	230C5.00X1	6		B	60.0	1.0	-60.5	45.76	89.3	978.7
18	230C5.00X1	6		C	60.0	1.0	-59.5	45.76	88.3	978.7
19	230C5.00X1	7		A	60.0	1.0	-75.5	46.76	90.0	882.6
20	230C5.00X1	7		B	60.0	1.0	-75.5	45.76	89.4	882.6
21	230C5.00X1	7		C	60.0	1.0	-74.5	45.76	88.8	882.6
22	230C5.00X1	8		A	60.0	1.0	-90.5	46.76	90.0	904.5
23	230C5.00X1	8		B	60.0	1.0	-90.5	45.76	89.4	904.5
24	230C5.00X1	8		C	60.0	1.0	-89.5	45.76	89.0	904.5
25	230C5.00X1	9		A	60.0	1.0	-105.5	46.76	90.0	1058.9
26	230C5.00X1	9		B	60.0	1.0	-105.5	45.76	89.4	1058.9
27	230C5.00X1	9		C	60.0	1.0	-104.5	45.76	89.4	1058.9

	Steady State Summary
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K100-230_500kV,45_DOC,15__60_,5000kcmilInCu,@3825_4878A DLF1
Date:	11/2/2024 9:43:17 PM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Variable	Description	Unit	Cables																										
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
General Input Data																													
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9
Phase	Cable Phase		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-0.5	-0.5	0.5	59.5	59.5	60.5	119.5	119.5	120.5	179.5	179.5	180.5	239.5	239.5	240.5	-60.5	-60.5	-59.5	-75.5	-75.5	-74.5	-90.5	-90.5	-89.5	-105.5	-105.5	-104.5
y	Y coordinate	[ft]	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity																													
I	Steady State Ampacity	[A]	918.5	918.5	918.5	943.4	943.4	943.4	957.9	957.9	957.9	985.2	985.2	985.2	1072.8	1072.8	1072.8	978.7	978.7	978.7	882.6	882.6	882.6	904.5	904.5	904.5	1058.9	1058.9	1058.9
Temperatures																													
θc	Conductor temperature	[°C]	90.0	89.1	88.3	90.0	89.2	88.3	90.0	89.2	88.3	90.0	89.2	88.2	90.0	89.2	88.0	90.0	89.3	88.3	90.0	89.4	88.8	90.0	89.4	89.0	90.0	89.4	89.4
θs	Sheath/Shield temperature	[°C]	85.1	84.3	83.4	84.9	84.1	83.2	84.8	84.0	83.1	84.6	83.8	82.9	83.9	83.1	81.9	86.4	85.8	84.7	87.1	86.4	85.9	86.9	86.3	86.0	85.9	85.3	85.3
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	84.3	83.4	82.5	84.0	83.2	82.3	83.9	83.1	82.2	83.7	82.9	81.9	82.8	82.0	80.8	86.0	85.4	84.3	86.7	86.1	85.6	86.6	85.9	85.6	85.4	84.8	84.9
θduct	Duct surface temperature	[°C]	79.4	78.6	77.7	79.1	78.2	77.3	78.8	78.0	77.1	78.4	77.6	76.6	76.9	76.1	74.9	82.1	81.5	80.4	83.4	82.8	82.3	83.2	82.5	82.2	81.0	80.3	80.4
Resistances																													
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01656	0.01663	0.0166	0.01656	0.01663	0.01661	0.01657	0.01664	0.01661	0.01659	0.01664	0.01661	0.0166	0.01664	0.01661	0.01661
ys	Skin Effect Factor		0.16154	0.16229	0.16305	0.16153	0.16227	0.16304	0.16153	0.16226	0.16304	0.16153	0.16224	0.16308	0.16153	0.1622	0.16326	0.16159	0.16214	0.16309	0.16157	0.16212	0.16258	0.16157	0.16211	0.1624	0.16157	0.16214	0.16206
yp	Proximity Effect Factor		0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00715	0.00719	0.00713	0.00715	0.0072	0.00742	0.00744	0.00748	0.00742	0.00744	0.00746	0.00742	0.00744	0.00745	0.00742	0.00744	0.00744
Losses																													
Wc	Conductor Losses	[W/ft]	2.65751	2.65223	2.64688	2.80341	2.79791	2.79224	2.89054	2.88493	2.87895	3.05738	3.05163	3.04485	3.62538	3.61896	3.60877	3.01772	3.01324	3.00574	2.45419	2.45062	2.44762	2.57735	2.57363	2.57164	3.5328	3.5275	3.5282
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439
Ws	Metallic Screen Losses	[W/ft]	0.24212	0.24271	0.24332	0.25555	0.25616	0.2568	0.26357	0.2642	0.26487	0.27896	0.2796	0.28037	0.3315	0.33222	0.33337	0.13076	0.13101	0.13144	0.10614	0.10634	0.10651	0.1115	0.11171	0.11183	0.15332	0.15362	0.15358
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	4.91295	4.90827	4.90352	5.07228	5.06739	5.06236	5.16744	5.16246	5.15715	5.34966	5.34456	5.33855	5.97021	5.9645	5.95547	3.70287	3.69864	3.69157	3.11472	3.11135	3.10852	3.24325	3.23973	3.23786	4.24051	4.23551	4.23618
λ_1	Screen Loss Factor		0.09111	0.09151	0.09193	0.09116	0.09156	0.09197	0.09118	0.09158	0.092	0.09124	0.09162	0.09208	0.09144	0.0918	0.09238	0.04333	0.04348	0.04373	0.04325	0.04339	0.04351	0.04326	0.04341	0.04348	0.0434	0.04355	0.04353
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances																													
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387
T4	External thermal resistance	[K.m/W]	4.48272	4.43423	4.38498	4.32886	4.28258	4.2348	4.24147	4.19669	4.1488	4.0826	4.0408	3.99139	3.61416	3.57913	3.5233	6.09338	6.04752	5.97066	7.31064	7.25744	7.21253	7.00752	6.9569	6.92995	5.27754	5.23749	5.24283
Others																													
Δθint	Temperature rise due to surrounding heat sources	[°C]	51.8	50.7	50.1	50.9	49.8	49.2	50.4	49.3	48.6	49.3	48.2	47.6	45.7	44.6	43.7	58.1	57.4	56.4	61.3	60.6	60.2	60.5	59.9	59.6	55.0	54.3	54.5
	Induced Voltage (standing) on Sheath	[V/mile]	186.96	164.88	189.78	192.22	169.5	194.61	194.83	171.85	198.14	199.74	176.25	204.76	216.16	190.91	225.06	207.48	185.09	222.11	192.48	170.98	191.84	200.98	178.16	190.89	241.59	213.81	214.12
	Induced Voltage (standing) on Concentric Wires	[V/mile]	188.95	166.9	191.77	194.27	171.58	196.65	196.91	173.96	200.22	201.88	178.42	206.9	218.49	193.27	227.38	210.17	187.81	224.79	194.9	173.43	194.26	203.45	180.67	193.37	244.46	216.74	217.02
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

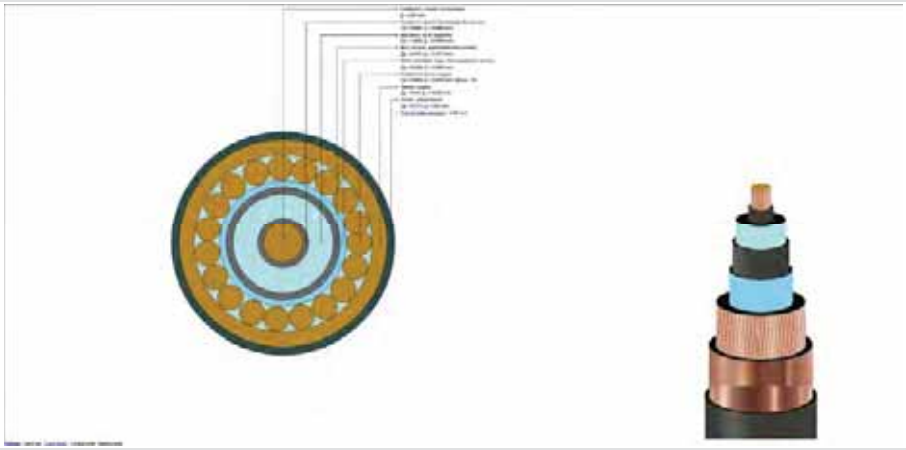
Cables Report

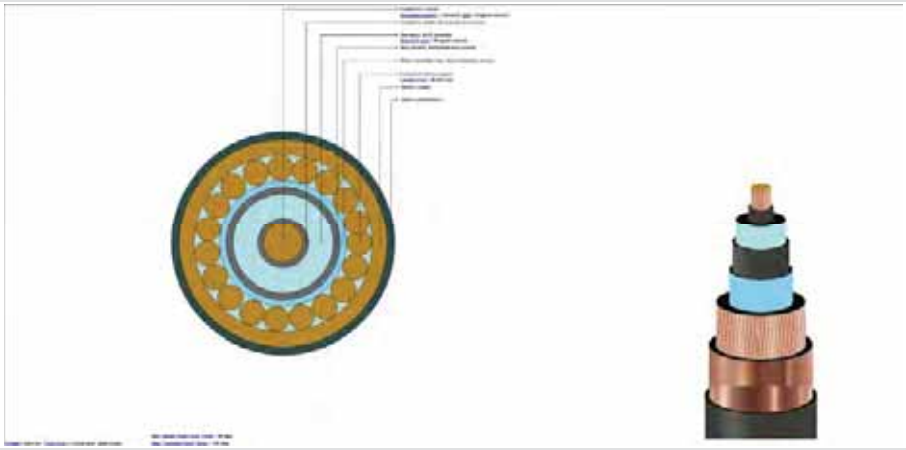
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K100-230_500kV,45_DOC,15__60_,5000kcmilInCu,@3825_4878A DLF1
Date:	11/2/2024 9:43:17 PM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		Polyethylene in Concrete
66	Duct material thermal resistivity	[K.m/W]	3.5
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	8.678
69	Outer diameter of the conduit	[in]	10.75

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Cables Report

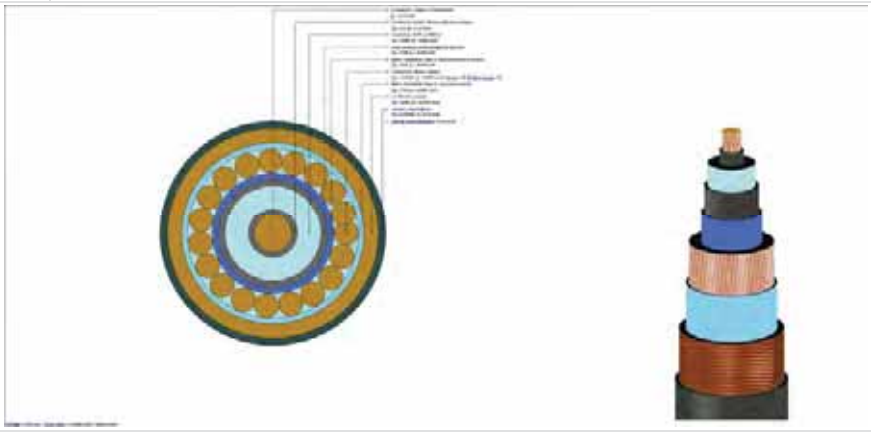
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K100-230_500kV,45_DOC,15__60_,5000kcmilInCu,@3825_4878A DLF1
Date:	11/2/2024 9:43:17 PM

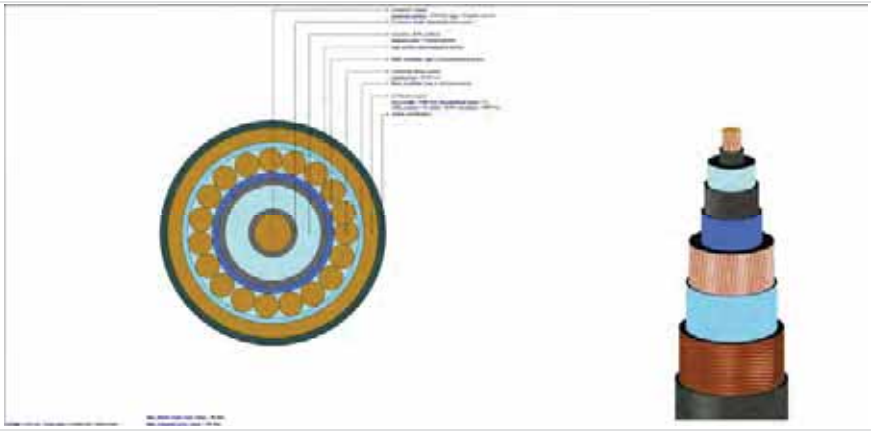
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		Polyethylene in Concrete
71	Duct material thermal resistivity	[K.m/W]	3.5
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	6.963
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K101-230_500kV,45_DOC,25__70__5000kcmilInCu,@4229_5092A DLF1
Date:	11/2/2024 7:22:55 PM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

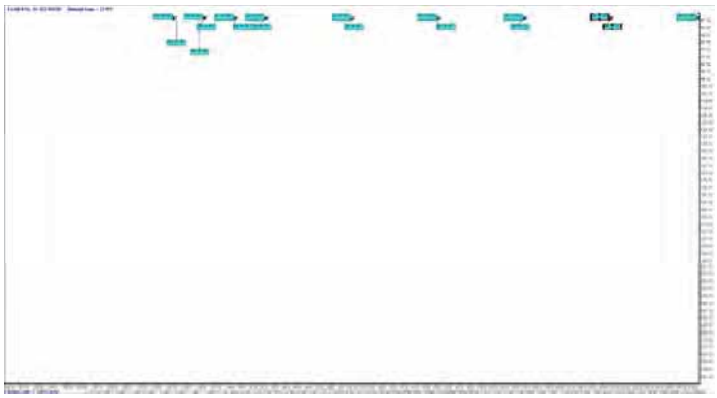
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB2	0.0	46.265	2.3	2.3	0.8
NSTD DB4	70.0	46.265	2.3	2.3	0.8
NSTD DB5	140.0	46.265	2.3	2.3	0.8
NSTD DB6	210.001	46.265	2.3	2.3	0.8
NSTD DB7	280.001	46.265	2.3	2.3	0.8
NSTD DB6	-70.0	46.265	2.3	2.3	0.8
NSTD DB7	-95.0	46.265	2.3	2.3	0.8
NSTD DB8	-120.0	46.265	2.3	2.3	0.8
NSTD DB9	-145.0	46.265	2.3	2.3	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	500C5.00X	1		A	60.0	1.0	-0.5	46.76	90.0	971.5
2	500C5.00X	1		B	60.0	1.0	-0.5	45.76	89.1	971.5
3	500C5.00X	1		C	60.0	1.0	0.5	45.76	88.2	971.5
4	500C5.00X	2		A	60.0	1.0	69.5	46.76	90.0	993.0
5	500C5.00X	2		B	60.0	1.0	69.5	45.76	89.2	993.0
6	500C5.00X	2		C	60.0	1.0	70.5	45.76	88.2	993.0
7	500C5.00X	3		A	60.0	1.0	139.5	46.76	90.0	1004.2
8	500C5.00X	3		B	60.0	1.0	139.5	45.76	89.2	1004.2
9	500C5.00X	3		C	60.0	1.0	140.5	45.76	88.2	1004.2
10	500C5.00X	4		A	60.0	1.0	209.5	46.76	90.0	1025.1
11	500C5.00X	4		B	60.0	1.0	209.5	45.76	89.2	1025.1
12	500C5.00X	4		C	60.0	1.0	210.5	45.76	88.2	1025.1
13	500C5.00X	5		A	60.0	1.0	279.5	46.76	90.0	1098.3
14	500C5.00X	5		B	60.0	1.0	279.5	45.76	89.3	1098.3
15	500C5.00X	5		C	60.0	1.0	280.5	45.76	88.0	1098.3
16	230C5.00X1	6		A	60.0	1.0	-70.5	46.76	90.0	1072.5
17	230C5.00X1	6		B	60.0	1.0	-70.5	45.76	89.3	1072.5
18	230C5.00X1	6		C	60.0	1.0	-69.5	45.76	88.3	1072.5
19	230C5.00X1	7		A	60.0	1.0	-95.5	46.76	90.0	996.0
20	230C5.00X1	7		B	60.0	1.0	-95.5	45.76	89.3	996.0
21	230C5.00X1	7		C	60.0	1.0	-94.5	45.76	88.7	996.0
22	230C5.00X1	8		A	60.0	1.0	-120.5	46.76	90.0	1015.4
23	230C5.00X1	8		B	60.0	1.0	-120.5	45.76	89.4	1015.4
24	230C5.00X1	8		C	60.0	1.0	-119.5	45.76	88.9	1015.4
25	230C5.00X1	9		A	60.0	1.0	-145.5	46.76	90.0	1145.3
26	230C5.00X1	9		B	60.0	1.0	-145.5	45.76	89.4	1145.3
27	230C5.00X1	9		C	60.0	1.0	-144.5	45.76	89.1	1145.3

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K101-230_500kV,45_DOC,25__70_,5000kcmilInCu,@4229_5092A DLF1
Date:	11/2/2024 7:22:55 PM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Cables 1–14

Variable	Description	Unit	Cables													
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14
General Input Data																
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3	4	4	4	5	5
Phase	Cable Phase		A	B	C	A	B	C	A	B	C	A	B	C	A	B
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-0.5	-0.5	0.5	69.5	69.5	70.5	139.5	139.5	140.5	209.5	209.5	210.5	279.5	279.5
y	Y coordinate	[ft]	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded
Ampacity																
I	Steady State Ampacity	[A]	971.5	971.5	971.5	993.0	993.0	993.0	1004.2	1004.2	1004.2	1025.1	1025.1	1025.1	1098.3	1098.3
Temperatures																
θc	Conductor temperature	[°C]	90.0	89.1	88.2	90.0	89.2	88.2	90.0	89.2	88.2	90.0	89.2	88.2	90.0	89.3
θs	Sheath/Shield temperature	[°C]	84.7	83.9	83.0	84.5	83.7	82.8	84.5	83.6	82.7	84.3	83.5	82.5	83.6	82.9
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	83.8	82.9	82.0	83.6	82.8	81.8	83.5	82.7	81.7	83.3	82.5	81.5	82.5	81.8
θduct	Duct surface temperature	[°C]	78.6	77.8	76.8	78.3	77.4	76.5	78.1	77.3	76.3	77.7	76.9	75.9	76.5	75.7
Resistances																
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.0166	0.01656	0.01663	0.0166	0.01657	0.01663	0.0166	0.01656	0.01663	0.0166	0.01656	0.01663	0.0166
ys	Skin Effect Factor		0.16154	0.16228	0.16309	0.16153	0.16226	0.16307	0.16153	0.16224	0.16308	0.16153	0.16222	0.1631	0.16153	0.16218
yp	Proximity Effect Factor		0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00715	0.00719	0.00713	0.00715	0.00719	0.00713	0.00715
Losses																
Wc	Conductor Losses	[W/ft]	2.97312	2.9673	2.96095	3.10593	3.09996	3.09327	3.17672	3.17069	3.16372	3.31031	3.30418	3.29654	3.79974	3.7931
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.27121	0.27186	0.27258	0.28345	0.28412	0.28487	0.28998	0.29066	0.29144	0.30232	0.30301	0.30388	0.34767	0.34842
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	5.25765	5.25249	5.24685	5.4027	5.3974	5.39147	5.48002	5.47467	5.46848	5.62596	5.62052	5.61374	6.16074	6.15484
λ_1	Screen Loss Factor		0.09122	0.09162	0.09206	0.09126	0.09165	0.09209	0.09128	0.09167	0.09212	0.09133	0.09171	0.09218	0.0915	0.09186
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances																
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	4.16093	4.11645	4.06774	4.03815	3.99579	3.94826	3.97532	3.93418	3.88647	3.86125	3.82223	3.77346	3.48926	3.45588
Others																
Δθint	Temperature rise due to surrounding heat sources	[°C]	49.9	48.8	48.1	49.1	48.0	47.3	48.6	47.5	46.9	47.8	46.7	46.0	44.6	43.6
	Induced Voltage (standing) on Sheath	[V/mile]	198.01	174.6	200.33	202.45	178.51	204.65	204.39	180.27	207.5	208.06	183.57	212.72	221.71	195.76
	Induced Voltage (standing) on Concentric Wires	[V/mile]	200.11	176.74	202.44	204.6	180.7	206.8	206.57	182.48	209.67	210.29	185.83	214.94	224.1	198.18
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cables 15–27

Variable	Description	Unit	Cables												
Cable No.	Cable Index Number		15	16	17	18	19	20	21	22	23	24	25	26	27
General Input Data															
Cable ID	Cable Equipment ID		500C5.00X	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1
Circuit No.	Circuit No.		5	6	6	6	7	7	7	8	8	8	9	9	9
Phase	Cable Phase		C	A	B	C	A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	280.5	-70.5	-70.5	-69.5	-95.5	-95.5	-94.5	-120.5	-120.5	-119.5	-145.5	-145.5	-144.5
y	Y coordinate	[ft]	45.76	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded	1 Conductor 1 Point Bonded
Ampacity															
I	Steady State Ampacity	[A]	1098.3	1072.5	1072.5	1072.5	996.0	996.0	996.0	1015.4	1015.4	1015.4	1145.3	1145.3	1145.3
Temperatures															
θc	Conductor temperature	[°C]	88.0	90.0	89.3	88.3	90.0	89.3	88.7	90.0	89.4	88.9	90.0	89.4	89.1
θs	Sheath/Shield temperature	[°C]	81.7	85.8	85.1	84.1	86.3	85.7	85.1	86.2	85.6	85.1	85.3	84.6	84.3
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	80.6	85.3	84.6	83.7	85.9	85.2	84.6	85.8	85.1	84.6	84.7	84.1	83.8
θduct	Duct surface temperature	[°C]	74.5	80.7	80.1	79.1	81.9	81.2	80.6	81.6	81.0	80.5	79.6	78.9	78.6
Resistances															
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01656	0.01663	0.01661	0.01657	0.01663	0.01661	0.01659	0.01664	0.01661	0.01659	0.01664	0.01661	0.0166
ys	Skin Effect Factor		0.16325	0.1616	0.16217	0.16303	0.16158	0.16215	0.16269	0.16157	0.16213	0.16257	0.16157	0.16213	0.16238
yp	Proximity Effect Factor		0.00719	0.00742	0.00744	0.00748	0.00742	0.00744	0.00746	0.00742	0.00744	0.00746	0.00742	0.00744	0.00745
Losses															
Wc	Conductor Losses	[W/ft]	3.78248	3.62353	3.61798	3.60983	3.12559	3.12085	3.11641	3.24839	3.24353	3.23981	4.13286	4.12667	4.12399
Wd	Dielectric Losses	[W/ft]	2.01332	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439
Ws	Metallic Screen Losses	[W/ft]	0.34962	0.15733	0.15764	0.1581	0.13547	0.13574	0.13599	0.14085	0.14112	0.14133	0.17971	0.18006	0.18021
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	6.14542	4.33525	4.33002	4.32233	3.81546	3.81099	3.8068	3.94364	3.93905	3.93554	4.86696	4.86113	4.8586
λ_1	Screen Loss Factor		0.09243	0.04342	0.04357	0.0438	0.04334	0.04349	0.04364	0.04336	0.04351	0.04362	0.04348	0.04363	0.0437
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances															
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387
T4	External thermal resistance	[K.m/W]	3.40219	5.1534	5.11302	5.05366	5.90358	5.8584	5.81583	5.70078	5.65777	5.62479	4.55341	4.51884	4.50389
Others															
Δθint	Temperature rise due to surrounding heat sources	[°C]	42.7	54.6	53.9	53.0	57.5	56.7	56.2	56.7	56.0	55.6	51.6	50.9	50.7
	Induced Voltage (standing) on Sheath	[V/mile]	229.76	230.31	205.14	238.59	217.45	193.26	216.05	224.2	199.0	216.4	256.95	227.77	237.96
	Induced Voltage (standing) on Concentric Wires	[V/mile]	232.14	233.25	208.11	241.53	220.18	196.02	218.78	226.97	201.82	219.18	260.07	230.95	241.09
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

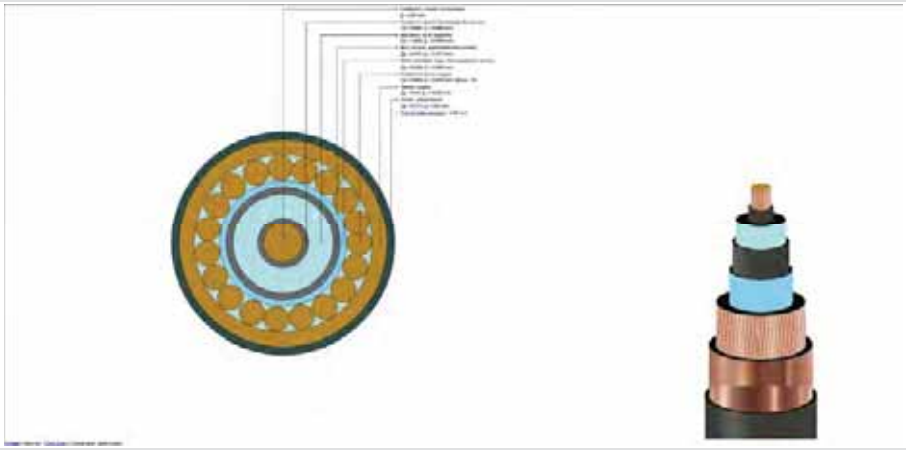
Cables Report

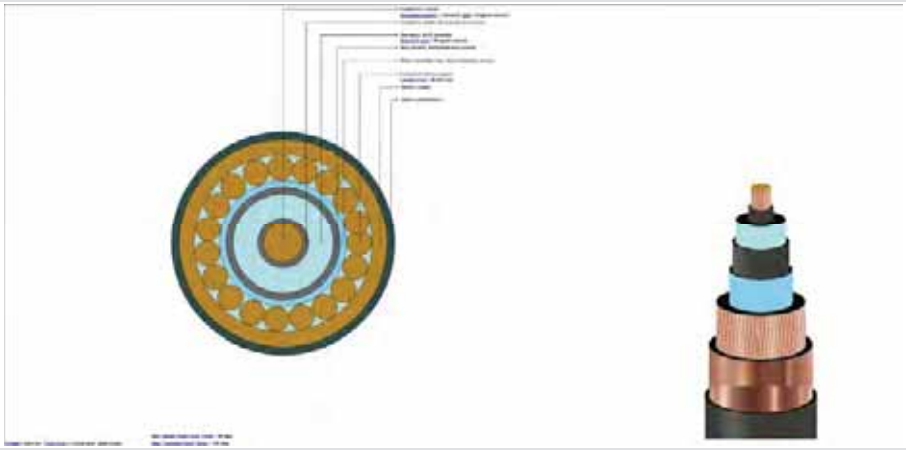
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K101-230_500kV,45_DOC,25__70_,5000kcmilInCu,@4229_5092A DLF1
Date:	11/2/2024 7:22:55 PM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		Polyethylene in Concrete
66	Duct material thermal resistivity	[K.m/W]	3.5
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	8.678
69	Outer diameter of the conduit	[in]	10.75

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Cables Report

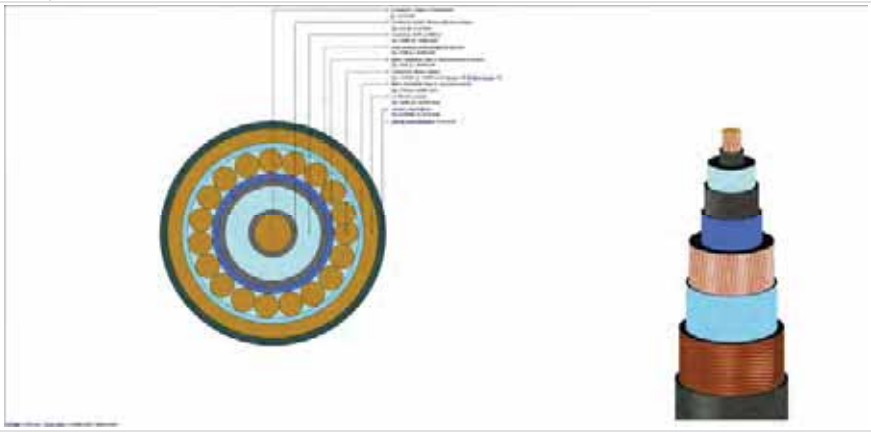
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K101-230_500kV,45_DOC,25__70_,5000kcmilInCu,@4229_5092A DLF1
Date:	11/2/2024 7:22:55 PM

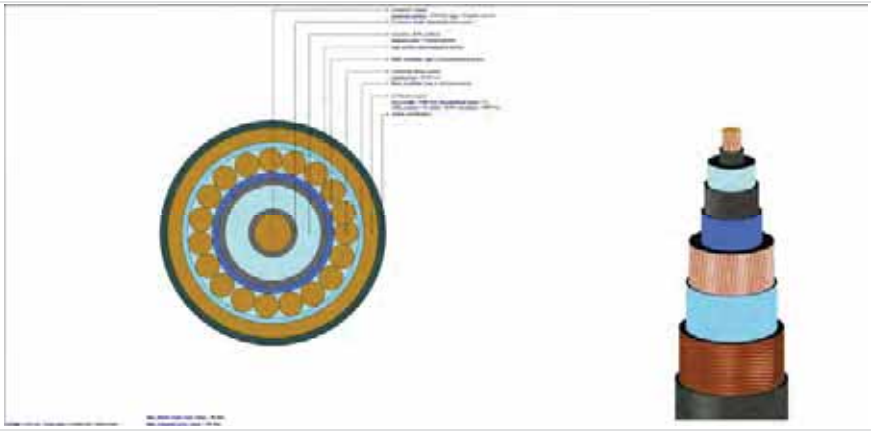
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		Polyethylene in Concrete
71	Duct material thermal resistivity	[K.m/W]	3.5
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	6.963
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K102-230_500kV,45_DOC,20__65_.5000kcmilInCu,@4032_4974A DLF1
Date:	11/2/2024 5:01:41 PM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

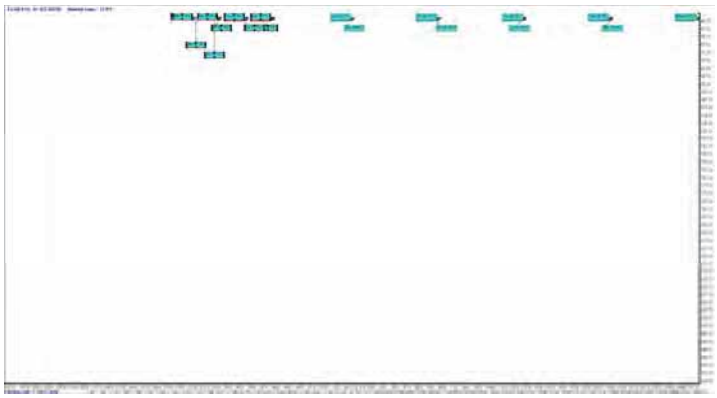
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB2	0.0	46.265	2.3	2.3	0.8
NSTD DB4	65.0	46.265	2.3	2.3	0.8
NSTD DB5	130.0	46.265	2.3	2.3	0.8
NSTD DB6	195.001	46.265	2.3	2.3	0.8
NSTD DB7	260.001	46.265	2.3	2.3	0.8
NSTD DB6	-60.0	46.265	2.3	2.3	0.8
NSTD DB7	-80.0	46.265	2.3	2.3	0.8
NSTD DB8	-100.0	46.265	2.3	2.3	0.8
NSTD DB9	-120.0	46.265	2.3	2.3	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	500C5.00X	1		A	60.0	1.0	-0.5	46.76	90.0	933.4
2	500C5.00X	1		B	60.0	1.0	-0.5	45.76	89.1	933.4
3	500C5.00X	1		C	60.0	1.0	0.5	45.76	88.2	933.4
4	500C5.00X	2		A	60.0	1.0	64.5	46.76	90.0	966.7
5	500C5.00X	2		B	60.0	1.0	64.5	45.76	89.2	966.7
6	500C5.00X	2		C	60.0	1.0	65.5	45.76	88.3	966.7
7	500C5.00X	3		A	60.0	1.0	129.5	46.76	90.0	981.5
8	500C5.00X	3		B	60.0	1.0	129.5	45.76	89.2	981.5
9	500C5.00X	3		C	60.0	1.0	130.5	45.76	88.3	981.5
10	500C5.00X	4		A	60.0	1.0	194.5	46.76	90.0	1006.0
11	500C5.00X	4		B	60.0	1.0	194.5	45.76	89.2	1006.0
12	500C5.00X	4		C	60.0	1.0	195.5	45.76	88.2	1006.0
13	500C5.00X	5		A	60.0	1.0	259.5	46.76	90.0	1086.3
14	500C5.00X	5		B	60.0	1.0	259.5	45.76	89.3	1086.3
15	500C5.00X	5		C	60.0	1.0	260.5	45.76	88.0	1086.3
16	230C5.00X1	6		A	60.0	1.0	-60.5	46.76	90.0	1021.8
17	230C5.00X1	6		B	60.0	1.0	-60.5	45.76	89.3	1021.8
18	230C5.00X1	6		C	60.0	1.0	-59.5	45.76	88.3	1021.8
19	230C5.00X1	7		A	60.0	1.0	-80.5	46.76	90.0	940.8
20	230C5.00X1	7		B	60.0	1.0	-80.5	45.76	89.3	940.8
21	230C5.00X1	7		C	60.0	1.0	-79.5	45.76	88.8	940.8
22	230C5.00X1	8		A	60.0	1.0	-100.5	46.76	90.0	963.4
23	230C5.00X1	8		B	60.0	1.0	-100.5	45.76	89.4	963.4
24	230C5.00X1	8		C	60.0	1.0	-99.5	45.76	88.9	963.4
25	230C5.00X1	9		A	60.0	1.0	-120.5	46.76	90.0	1105.7
26	230C5.00X1	9		B	60.0	1.0	-120.5	45.76	89.3	1105.7
27	230C5.00X1	9		C	60.0	1.0	-119.5	45.76	89.2	1105.7

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K102-230_500kV,45_DOC,20__65_,5000kcmilInCu,@4032_4974A DLF1
Date:	11/2/2024 5:01:41 PM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Variable	Description	Unit	Cables																										
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
General Input Data																													
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9
Phase	Cable Phase		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-0.5	-0.5	0.5	64.5	64.5	65.5	129.5	129.5	130.5	194.5	194.5	195.5	259.5	259.5	260.5	-60.5	-60.5	-59.5	-80.5	-80.5	-79.5	-100.5	-100.5	-99.5	-120.5	-120.5	-119.5
y	Y coordinate	[ft]	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity																													
I	Steady State Ampacity	[A]	933.4	933.4	933.4	966.7	966.7	966.7	981.5	981.5	981.5	1006.0	1006.0	1006.0	1086.3	1086.3	1086.3	1021.8	1021.8	1021.8	940.8	940.8	940.8	963.4	963.4	963.4	1105.7	1105.7	1105.7
Temperatures																													
θc	Conductor temperature	[°C]	90.0	89.1	88.2	90.0	89.2	88.3	90.0	89.2	88.3	90.0	89.2	88.2	90.0	89.3	88.0	90.0	89.3	88.3	90.0	89.3	88.8	90.0	89.4	88.9	90.0	89.3	89.2
θs	Sheath/Shield temperature	[°C]	85.0	84.2	83.3	84.8	83.9	83.0	84.6	83.8	82.9	84.4	83.6	82.7	83.7	83.0	81.8	86.1	85.5	84.5	86.7	86.0	85.5	86.6	85.9	85.5	85.6	84.9	84.8
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	84.1	83.3	82.4	83.8	83.0	82.1	83.7	82.9	82.0	83.5	82.7	81.7	82.7	81.9	80.7	85.7	85.0	84.1	86.3	85.7	85.1	86.2	85.5	85.1	85.0	84.4	84.3
θduct	Duct surface temperature	[°C]	79.2	78.4	77.4	78.7	77.9	77.0	78.5	77.6	76.7	78.1	77.3	76.3	76.7	75.9	74.7	81.5	80.8	79.9	82.7	82.0	81.5	82.4	81.7	81.3	80.2	79.6	79.4
Resistances																													
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.0166	0.01656	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01656	0.01663	0.0166	0.01656	0.01663	0.01661	0.01657	0.01664	0.01661	0.01659	0.01664	0.01661	0.01659	0.01664	0.01661	0.01661
ys	Skin Effect Factor		0.16154	0.16229	0.16308	0.16153	0.16227	0.16306	0.16153	0.16225	0.16306	0.16153	0.16223	0.16309	0.16153	0.16219	0.16325	0.16159	0.16217	0.16303	0.16158	0.16214	0.16263	0.16157	0.16213	0.16249	0.16157	0.16214	0.16225
yp	Proximity Effect Factor		0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00715	0.00719	0.00713	0.00715	0.00719	0.00742	0.00744	0.00748	0.00742	0.00744	0.00746	0.00742	0.00744	0.00746	0.00742	0.00744	0.00745
Losses																													
Wc	Conductor Losses	[W/ft]	2.74429	2.73887	2.73312	2.94381	2.93805	2.93193	3.03455	3.0287	3.02224	3.18833	3.18236	3.17518	3.71717	3.71064	3.70022	3.28906	3.28403	3.27658	2.78851	2.78433	2.7807	2.92447	2.92015	2.91731	3.85174	3.84592	3.84481
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439
Ws	Metallic Screen Losses	[W/ft]	0.25011	0.25072	0.25137	0.26849	0.26913	0.26982	0.27685	0.27751	0.27824	0.29105	0.29172	0.29253	0.34001	0.34074	0.34192	0.14265	0.14293	0.14335	0.12073	0.12096	0.12117	0.12667	0.12691	0.12707	0.16733	0.16766	0.16772
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	5.00772	5.00292	4.99782	5.22562	5.22051	5.21508	5.32472	5.31953	5.3138	5.49271	5.48741	5.48103	6.07051	6.06471	6.05547	3.9861	3.98136	3.97433	3.46364	3.45969	3.45627	3.60553	3.60145	3.59877	4.57347	4.56798	4.56692
$λ_1$	Screen Loss Factor		0.09114	0.09154	0.09197	0.0912	0.0916	0.09203	0.09123	0.09163	0.09206	0.09129	0.09167	0.09213	0.09147	0.09183	0.09241	0.04337	0.04352	0.04375	0.04329	0.04344	0.04358	0.04331	0.04346	0.04356	0.04344	0.04359	0.04362
$λ_2$	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances																													
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387
T4	External thermal resistance	[K.m/W]	4.38978	4.34253	4.29227	4.18936	4.14472	4.09709	4.10363	4.06057	4.01285	3.96522	3.92478	3.87595	3.54743	3.51332	3.45861	5.63547	5.5916	5.52659	6.53882	6.48942	6.44655	6.26819	6.22166	6.19105	4.86798	4.83074	4.82368
Others																													
Δθint	Temperature rise due to surrounding heat sources	[°C]	51.3	50.2	49.5	50.1	48.9	48.3	49.5	48.4	47.7	48.5	47.4	46.8	45.1	44.1	43.2	56.5	55.8	54.9	59.4	58.7	58.2	58.6	57.9	57.6	53.2	52.5	52.5
	Induced Voltage (standing) on Sheath	[V/mile]	189.9	167.49	192.98	196.99	173.7	199.4	199.68	176.12	202.93	204.08	180.07	208.94	219.09	193.47	227.56	218.48	194.7	228.83	205.38	182.5	204.11	213.29	189.23	204.49	249.68	221.19	227.33
	Induced Voltage (standing) on Concentric Wires	[V/mile]	191.93	169.54	195.01	199.08	175.83	201.5	201.81	178.28	205.06	206.26	182.28	211.12	221.45	195.86	229.91	221.29	197.53	231.63	207.96	185.11	206.68	215.92	191.91	207.13	252.69	224.25	230.35
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

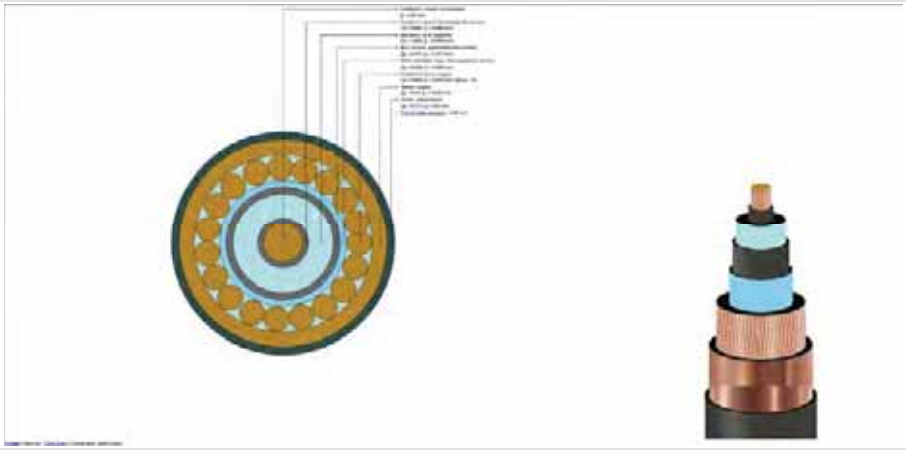
Cables Report

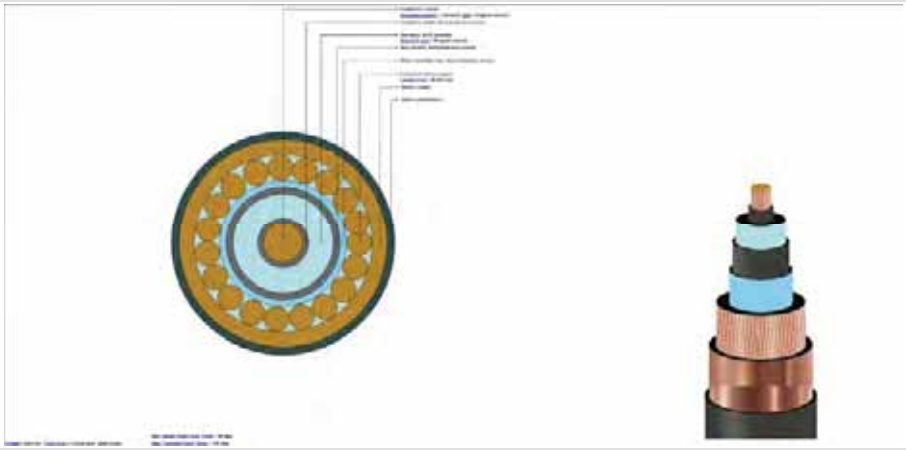
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K102-230_500kV,45_DOC,20__65_,5000kcmilInCu,@4032_4974A DLF1
Date:	11/2/2024 5:01:41 PM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		Polyethylene in Concrete
66	Duct material thermal resistivity	[K.m/W]	3.5
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	8.678
69	Outer diameter of the conduit	[in]	10.75

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Cables Report

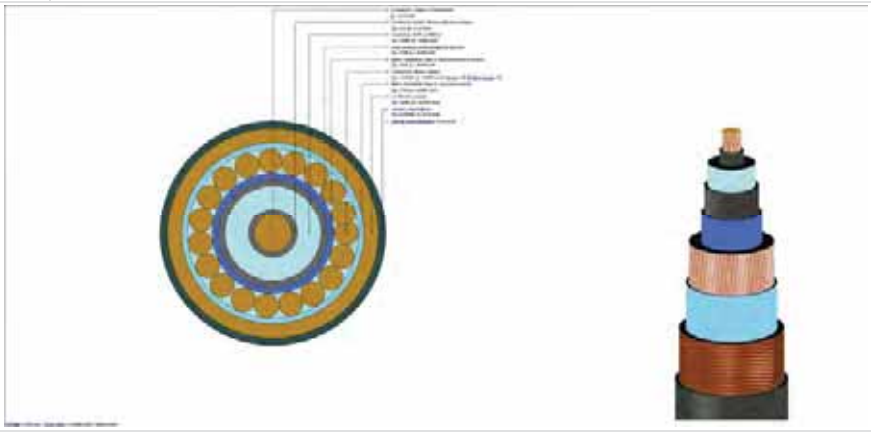
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K102-230_500kV,45_DOC,20__65_,5000kcmilInCu,@4032_4974A DLF1
Date:	11/2/2024 5:01:41 PM

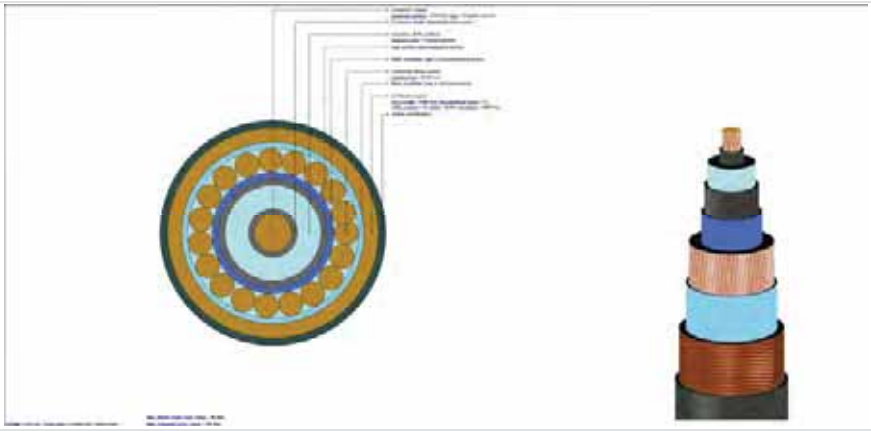
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		Polyethylene in Concrete
71	Duct material thermal resistivity	[K.m/W]	3.5
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	6.963
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K103-230_500kV,45_DOC,20__65_,5000kcmillnCu,@4047_4990A DLF1
Date:	11/2/2024 12:58:32 PM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

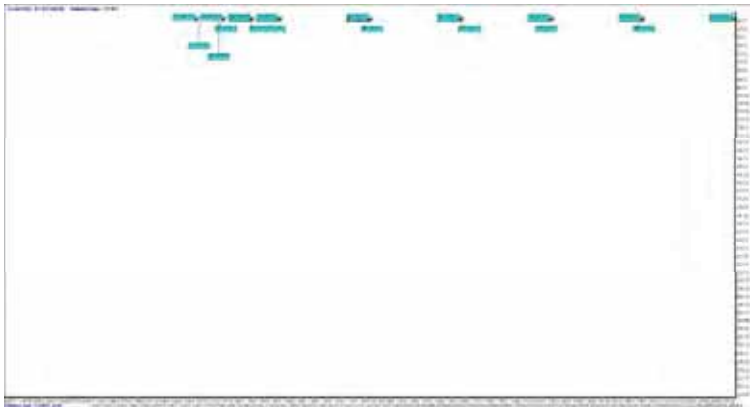
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
$\lambda_2$pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB2	0.0	46.265	2.3	2.3	0.8
NSTD DB4	65.0	46.265	2.3	2.3	0.8
NSTD DB5	130.0	46.265	2.3	2.3	0.8
NSTD DB6	195.001	46.265	2.3	2.3	0.8
NSTD DB7	260.001	46.265	2.3	2.3	0.8
NSTD DB6	-65.0	46.265	2.3	2.3	0.8
NSTD DB7	-85.0	46.265	2.3	2.3	0.8
NSTD DB8	-105.0	46.265	2.3	2.3	0.8
NSTD DB9	-125.0	46.265	2.3	2.3	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	500C5.00X	1		A	60.0	1.0	-0.5	46.76	90.0	946.0
2	500C5.00X	1		B	60.0	1.0	-0.5	45.76	89.1	946.0
3	500C5.00X	1		C	60.0	1.0	0.5	45.76	88.2	946.0
4	500C5.00X	2		A	60.0	1.0	64.5	46.76	90.0	969.4
5	500C5.00X	2		B	60.0	1.0	64.5	45.76	89.2	969.4
6	500C5.00X	2		C	60.0	1.0	65.5	45.76	88.3	969.4
7	500C5.00X	3		A	60.0	1.0	129.5	46.76	90.0	982.3
8	500C5.00X	3		B	60.0	1.0	129.5	45.76	89.2	982.3
9	500C5.00X	3		C	60.0	1.0	130.5	45.76	88.3	982.3
10	500C5.00X	4		A	60.0	1.0	194.5	46.76	90.0	1006.3
11	500C5.00X	4		B	60.0	1.0	194.5	45.76	89.2	1006.3
12	500C5.00X	4		C	60.0	1.0	195.5	45.76	88.2	1006.3
13	500C5.00X	5		A	60.0	1.0	259.5	46.76	90.0	1086.4
14	500C5.00X	5		B	60.0	1.0	259.5	45.76	89.3	1086.4
15	500C5.00X	5		C	60.0	1.0	260.5	45.76	88.0	1086.4
16	230C5.00X1	6		A	60.0	1.0	-65.5	46.76	90.0	1029.9
17	230C5.00X1	6		B	60.0	1.0	-65.5	45.76	89.3	1029.9
18	230C5.00X1	6		C	60.0	1.0	-64.5	45.76	88.3	1029.9
19	230C5.00X1	7		A	60.0	1.0	-85.5	46.76	90.0	944.7
20	230C5.00X1	7		B	60.0	1.0	-85.5	45.76	89.4	944.7
21	230C5.00X1	7		C	60.0	1.0	-84.5	45.76	88.8	944.7
22	230C5.00X1	8		A	60.0	1.0	-105.5	46.76	90.0	965.5
23	230C5.00X1	8		B	60.0	1.0	-105.5	45.76	89.4	965.5
24	230C5.00X1	8		C	60.0	1.0	-104.5	45.76	88.9	965.5
25	230C5.00X1	9		A	60.0	1.0	-125.5	46.76	90.0	1106.9
26	230C5.00X1	9		B	60.0	1.0	-125.5	45.76	89.4	1106.9
27	230C5.00X1	9		C	60.0	1.0	-124.5	45.76	89.2	1106.9

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K103-230_500kV_45_DOC_20__65_5000kcmilInCu@4047_4990A DLF1
Date:	11/2/2024 12:58:32 PM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Variable	Description	Unit	1	2	3	4	5	6	7	8	9
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9
General Input Data											
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-0.5	-0.5	0.5	64.5	64.5	65.5	129.5	129.5	130.5
y	Y coordinate	[ft]	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	946.0	946.0	946.0	969.4	969.4	969.4	982.3	982.3	982.3
Temperatures											
θ_c	Conductor temperature	[°C]	90.0	89.1	88.2	90.0	89.2	88.3	90.0	89.2	88.3
θ_s	Sheath/Shield temperature	[°C]	84.9	84.1	83.2	84.7	83.9	83.0	84.6	83.8	82.9
θ_a	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θ_{surf}	Cable surface temperature	[°C]	84.0	83.2	82.3	83.8	83.0	82.1	83.7	82.9	82.0
θ_{duct}	Duct surface temperature	[°C]	79.0	78.2	77.3	78.7	77.8	76.9	78.5	77.6	76.7
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657
ys	Skin Effect Factor		0.16154	0.16228	0.16307	0.16153	0.16227	0.16306	0.16153	0.16225	0.16306
yp	Proximity Effect Factor		0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00716	0.00719
Losses											
Wc	Conductor Losses	[W/ft]	2.81889	2.81334	2.80749	2.96059	2.95482	2.94864	3.03991	3.03406	3.02759
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.25699	0.2561	0.25827	0.27004	0.27068	0.27138	0.27735	0.278	0.27873
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	5.0892	5.08427	5.07908	5.24395	5.23883	5.23335	5.33058	5.32539	5.31965
λ_1	Screen Loss Factor		0.09117	0.09157	0.09199	0.09121	0.09161	0.09204	0.09124	0.09163	0.09206
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	4.31272	4.26637	4.21741	4.17324	4.12895	4.08133	4.09866	4.05578	4.00811
Others											
$\Delta\theta int$	Temperature rise due to surrounding heat sources	[°C]	50.8	49.7	49.0	50.0	48.8	48.2	49.5	48.4	47.7
	Induced Voltage (standing) on Sheath	[V/mile]	192.69	169.92	195.24	197.59	174.24	199.89	199.87	176.29	203.09
	Induced Voltage (standing) on Concentric Wires	[V/mile]	194.74	172.0	197.3	199.7	176.37	202.0	202.01	178.45	205.22
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	Description	Unit	10	11	12	13	14	15	16	17	18
Cable No.	Cable Index Number		10	11	12	13	14	15	16	17	18
General Input Data											
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	230C5.00XI	230C5.00XI	230C5.00XI
Circuit No.	Circuit No.		4	4	4	5	5	5	6	6	6
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	194.5	194.5	195.5	259.5	259.5	260.5	-65.5	-65.5	-64.5
y	Y coordinate	[ft]	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	1006.3	1006.3	1006.3	1086.4	1086.4	1086.4	1029.9	1029.9	1029.9
Temperatures											
θ_c	Conductor temperature	[°C]	90.0	89.2	88.2	90.0	89.3	88.0	90.0	89.3	88.3
θ_s	Sheath/Shield temperature	[°C]	84.4	83.6	82.7	83.7	83.0	81.8	86.1	85.4	84.4
θ_a	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θ_{surf}	Cable surface temperature	[°C]	83.5	82.7	81.7	82.7	81.9	80.7	85.6	85.0	84.0
θ_{duct}	Duct surface temperature	[°C]	78.1	77.2	76.3	76.7	75.9	74.7	81.4	80.7	79.7
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.0166	0.01656	0.01663	0.0166	0.01656	0.01663	0.01661	0.01657
ys	Skin Effect Factor		0.16153	0.16223	0.16309	0.16153	0.16219	0.16325	0.16159	0.16216	0.16305
yp	Proximity Effect Factor		0.00713	0.00715	0.00719	0.00713	0.00715	0.00719	0.00742	0.00744	0.00748
Losses											
Wc	Conductor Losses	[W/ft]	3.19014	3.18418	3.17697	3.71787	3.71132	3.70092	3.3415	3.33644	3.32865
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	0.55439	0.55439	0.55439
Ws	Metallic Screen Losses	[W/ft]	0.29122	0.29189	0.2927	0.34007	0.34081	0.34199	0.14495	0.14523	0.14567
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	5.49468	5.48939	5.48299	6.07126	6.06545	6.05623	4.04084	4.03606	4.02871
λ_1	Screen Loss Factor		0.09129	0.09167	0.09213	0.09147	0.09183	0.09241	0.04338	0.04353	0.04376
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.32843	0.32843	0.32843
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.03387	0.03387	0.03387
T4	External thermal resistance	[K.m/W]	3.96364	3.92328	3.87431	3.54694	3.51275	3.45819	5.55436	5.5115	5.44546
Others											
$\Delta\theta int$	Temperature rise due to surrounding heat sources	[°C]	48.5	47.4	46.7	45.1	44.1	43.2	56.2	55.5	54.6
	Induced Voltage (standing) on Sheath	[V/mile]	204.14	180.12	208.98	219.12	193.49	227.57	220.11	196.16	230.81
	Induced Voltage (standing) on Concentric Wires	[V/mile]	206.33	182.34	211.17	221.48	195.88	229.93	222.94	199.02	233.63
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	Description	Unit	19	20	21	22	23	24	25	26	27
Cable No.	Cable Index Number		19	20	21	22	23	24	25	26	27
General Input Data											
Cable ID	Cable Equipment ID		230C5.00XI	230C5.00XI	230C5.00XI	230C5.00XI	230C5.00XI	230C5.00XI	230C5.00XI	230C5.00XI	230C5.00XI
Circuit No.	Circuit No.		7	7	7	8	8	8	9	9	9
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-85.5	-85.5	-84.5	-105.5	-105.5	-104.5	-125.5	-125.5	-124.5
y	Y coordinate	[ft]	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	944.7	944.7	944.7	965.5	965.5	965.5	1106.9	1106.9	1106.9
Temperatures											
θ_c	Conductor temperature	[°C]	90.0	89.4	88.8	90.0	89.4	88.9	90.0	89.4	89.2
θ_s	Sheath/Shield temperature	[°C]	86.7	86.0	85.5	86.5	85.9	85.5	85.5	84.9	84.8
θ_a	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θ_{surf}	Cable surface temperature	[°C]	86.3	85.6	85.1	86.1	85.5	85.1	85.0	84.4	84.3
θ_{duct}	Duct surface temperature	[°C]	82.6	82.0	81.4	82.3	81.7	81.3	80.2	79.5	79.4
Resistances											
R_0	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01664	0.01661	0.01659	0.01664	0.01661	0.01659	0.01664	0.01661	0.01661
ys	Skin Effect Factor		0.16158	0.16214	0.16264	0.16157	0.16212	0.1625	0.16157	0.16214	0.16225
yp	Proximity Effect Factor		0.00742	0.00744	0.00746	0.00742	0.00744	0.00746	0.00742	0.00744	0.00745
Losses											
Wc	Conductor Losses	[W/ft]	2.81149	2.80732	2.80359	2.93673	2.9324	2.92952	3.86038	3.85456	3.85342
Wd	Dielectric Losses	[W/ft]	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439
Ws	Metallic Screen Losses	[W/ft]	0.12173	0.12197	0.12218	0.1272	0.12745	0.1276	0.16771	0.16804	0.16811
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	3.48762	3.48368	3.48016	3.61833	3.61424	3.61152	4.58249	4.577	4.57592
λ_1	Screen Loss Factor		0.0433	0.04345	0.04358	0.04331	0.04346	0.04356	0.04344	0.0436	0.04363
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387
T4	External thermal resistance	[K.m/W]	6.49144	6.44289	6.39942	6.24478	6.19852	6.16776	4.85771	4.82065	4.81342
Others											
$\Delta\theta int$	Temperature rise due to surrounding heat sources	[°C]	59.2	58.5	58.1	58.5	57.8	57.5	53.1	52.4	52.4
	Induced Voltage (standing) on Sheath	[V/mile]	206.17	183.2	205.03	213.71	189.6	204.97	249.94	221.42	227.62
	Induced Voltage (standing) on Concentric Wires	[V/mile]	208.76	185.83	207.62	216.34	192.28	207.61	252.95	224.49	230.65
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

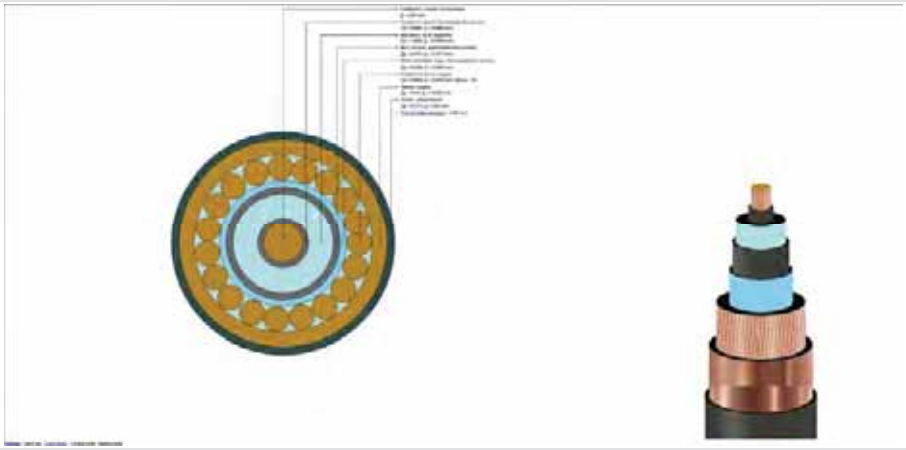
Cables Report

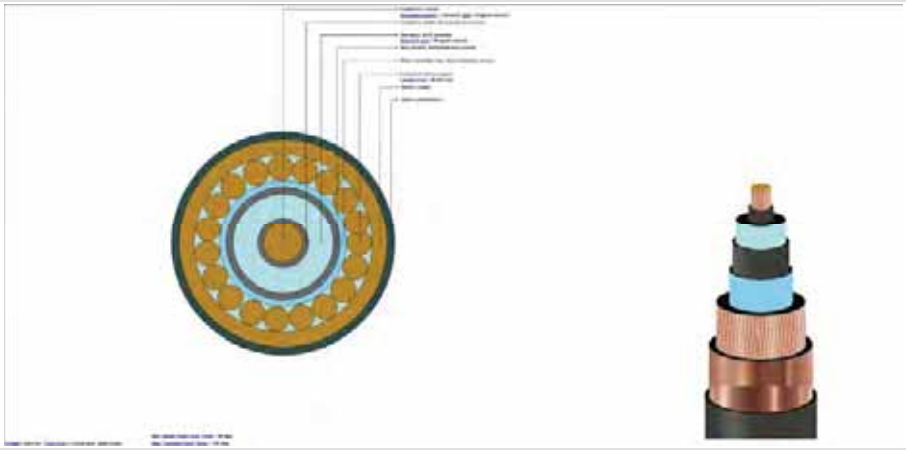
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K103-230_500kV,45_DOC,20__65_,5000kcmilInCu,@4047_4990A DLF1
Date:	11/2/2024 12:58:32 PM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		Polyethylene in Concrete
66	Duct material thermal resistivity	[K.m/W]	3.5
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	8.678
69	Outer diameter of the conduit	[in]	10.75

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Cables Report

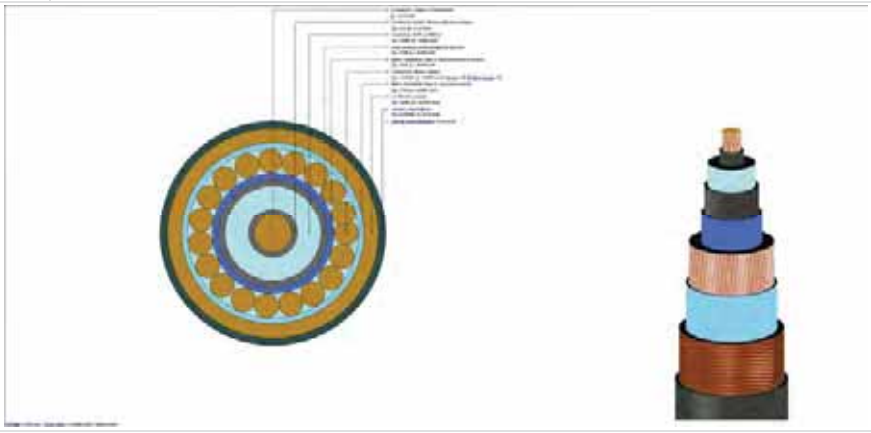
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K103-230_500kV,45_DOC,20__65_,5000kcmilInCu,@4047_4990A DLF1
Date:	11/2/2024 12:58:32 PM

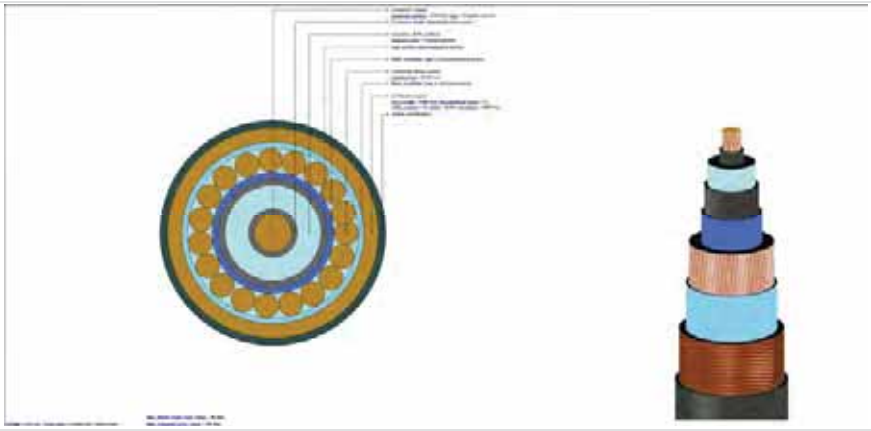
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		Polyethylene in Concrete
71	Duct material thermal resistivity	[K.m/W]	3.5
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	6.963
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





Study Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K104-230_500kV,45_DOC,20__65_5000kcmilInCu,@4061_5006A DLF1
Date:	11/2/2024 10:42:47 AM

General Simulation Data

Steady State Option	Unequally Loaded
Consider Electrical interaction between circuits	No
Induced currents in metallic layers as a fraction of conductor current (applied to all single phase circuits) :	0.0
Conductor Resistances Computation Option:	IEC-228

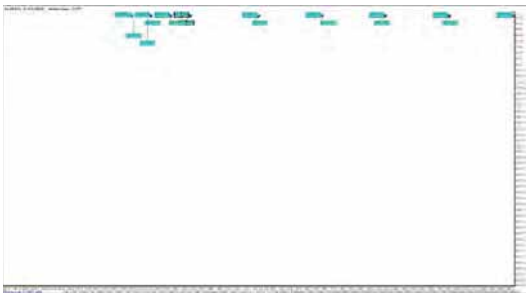
Standard Settings Options

General guidance	Custom
Factor on RAC due to magnetic armour	CIGREGuidance
Factor on RAC due to magnetic duct	CIGREGuidance
Factor on λ_1 due to magnetic armour	CYMCAPGuidance
Factor on λ_1 due to magnetic duct	CIGREGuidance
Factor on λ_2 due to λ'_1	CYMCAPGuidance
λ''_1 computation	CIGREGuidance
λ_2-pipe computation	CYMCAPGuidance
Wd computation	CIGREGuidance
T_2 computation	CIGREGuidance
T_4 computation	CYMCAPGuidance

Installation Type:Multiple Ductbanks/Backfills

Ambient Soil Temperature at Installation Depth	[°C]	12.0
Native Soil Thermal Resistivity	[K.m/W]	1.15
Consider Non-Isothermal Earth Surface		No

Layer Name	X [ft]	Y [ft]	Width [ft]	Height [ft]	Thermal Resistivity [K.m/W]
NSTD DB2	0.0	46.265	2.3	2.3	0.8
NSTD DB4	65.0	46.265	2.3	2.3	0.8
NSTD DB5	130.0	46.265	2.3	2.3	0.8
NSTD DB6	195.001	46.265	2.3	2.3	0.8
NSTD DB7	260.001	46.265	2.3	2.3	0.8
NSTD DB6	-70.0	46.265	2.3	2.3	0.8
NSTD DB7	-90.0	46.265	2.3	2.3	0.8
NSTD DB8	-110.0	46.265	2.3	2.3	0.8
NSTD DB9	-130.0	46.265	2.3	2.3	0.8



Results Summary

Cable No.	Cable ID	Circuit No.	Feeder ID	Cable Phase	Cable Frequency	Daily Load Factor	X coordinate [ft]	Y coordinate [ft]	Conductor temperature [°C]	Ampacity [A]
1	500C5.00X	1		A	60.0	1.0	-0.5	46.76	90.0	957.4
2	500C5.00X	1		B	60.0	1.0	-0.5	45.76	89.1	957.4
3	500C5.00X	1		C	60.0	1.0	0.5	45.76	88.3	957.4
4	500C5.00X	2		A	60.0	1.0	64.5	46.76	90.0	972.0
5	500C5.00X	2		B	60.0	1.0	64.5	45.76	89.2	972.0
6	500C5.00X	2		C	60.0	1.0	65.5	45.76	88.3	972.0
7	500C5.00X	3		A	60.0	1.0	129.5	46.76	90.0	983.2
8	500C5.00X	3		B	60.0	1.0	129.5	45.76	89.2	983.2
9	500C5.00X	3		C	60.0	1.0	130.5	45.76	88.3	983.2
10	500C5.00X	4		A	60.0	1.0	194.5	46.76	90.0	1006.6
11	500C5.00X	4		B	60.0	1.0	194.5	45.76	89.2	1006.6
12	500C5.00X	4		C	60.0	1.0	195.5	45.76	88.2	1006.6
13	500C5.00X	5		A	60.0	1.0	259.5	46.76	90.0	1086.5
14	500C5.00X	5		B	60.0	1.0	259.5	45.76	89.3	1086.5
15	500C5.00X	5		C	60.0	1.0	260.5	45.76	88.0	1086.5
16	230C5.00X1	6		A	60.0	1.0	-70.5	46.76	90.0	1037.3
17	230C5.00X1	6		B	60.0	1.0	-70.5	45.76	89.3	1037.3
18	230C5.00X1	6		C	60.0	1.0	-69.5	45.76	88.3	1037.3
19	230C5.00X1	7		A	60.0	1.0	-90.5	46.76	90.0	948.2
20	230C5.00X1	7		B	60.0	1.0	-90.5	45.76	89.4	948.2
21	230C5.00X1	7		C	60.0	1.0	-89.5	45.76	88.8	948.2
22	230C5.00X1	8		A	60.0	1.0	-110.5	46.76	90.0	967.4
23	230C5.00X1	8		B	60.0	1.0	-110.5	45.76	89.4	967.4
24	230C5.00X1	8		C	60.0	1.0	-109.5	45.76	88.9	967.4
25	230C5.00X1	9		A	60.0	1.0	-130.5	46.76	90.0	1108.2
26	230C5.00X1	9		B	60.0	1.0	-130.5	45.76	89.4	1108.2
27	230C5.00X1	9		C	60.0	1.0	-129.5	45.76	89.2	1108.2

Steady State Summary

CYMCAP Version	8.1 Revision 2
Study:	Golden to Mass_G2M_New 3 Routes
Execution:	K104-230_500kV_45_DOC_20__65__5000kcmilInCu@4061_5006A DLF1
Date:	11/2/2024 10:42:47 AM

Simulation Data

Installation type:	Multiple Ductbanks
Steady State Option	Unequally Loaded
Ambient temperature [°C]	12
Native Soil Thermal Resistivity [K.m/W]	1.15
Consider Non-Isothermal Earth Surface	No
Consider effect of soil dry out	No
Consider Electrical interaction between circuits	No
Induced current in metallic layers as a fraction of conductor current (applied to all single phase circuits)	0

Cables (1–9)

Variable	Description	Unit	1	2	3	4	5	6	7	8	9
Cable No.	Cable Index Number		1	2	3	4	5	6	7	8	9
General Input Data											
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X
Circuit No.	Circuit No.		1	1	1	2	2	2	3	3	3
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-0.5	-0.5	0.5	64.5	64.5	65.5	129.5	129.5	130.5
y	Y coordinate	[ft]	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	957.4	957.4	957.4	972.0	972.0	972.0	983.2	983.2	983.2
Temperatures											
θc	Conductor temperature	[°C]	90.0	89.1	88.3	90.0	89.2	88.3	90.0	89.2	88.3
θs	Sheath/Shield temperature	[°C]	84.8	84.0	83.1	84.7	83.9	83.0	84.6	83.8	82.9
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	83.9	83.1	82.2	83.8	83.0	82.1	83.7	82.9	81.9
θduct	Duct surface temperature	[°C]	78.8	78.0	77.1	78.6	77.8	76.9	78.4	77.6	76.7
Resistances											
R_o	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657	0.01663	0.0166	0.01657
ys	Skin Effect Factor		0.16154	0.16228	0.16307	0.16153	0.16226	0.16306	0.16153	0.16225	0.16306
yp	Proximity Effect Factor		0.00713	0.00716	0.00719	0.00713	0.00716	0.00719	0.00713	0.00716	0.00719
Losses											
Wc	Conductor Losses	[W/ft]	2.88766	2.88195	2.876	2.97632	2.97054	2.96431	3.04499	3.03914	3.03265
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332
Ws	Metallic Screen Losses	[W/ft]	0.26332	0.26396	0.26463	0.27149	0.27213	0.27284	0.27782	0.27847	0.2792
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	5.16431	5.15924	5.15396	5.26113	5.256	5.25047	5.33613	5.33094	5.32518
λ_1	Screen Loss Factor		0.09119	0.09159	0.09201	0.09122	0.09161	0.09204	0.09124	0.09163	0.09207
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408
T4	External thermal resistance	[K.m/W]	4.24384	4.1981	4.15024	4.15824	4.11425	4.06667	4.09396	4.05112	4.0035
Others											
Δθint	Temperature rise due to surrounding heat sources	[°C]	50.4	49.3	48.6	49.9	48.7	48.1	49.4	48.3	47.7
	Induced Voltage (standing) on Sheath	[V/mile]	195.22	172.13	197.31	198.16	174.73	200.35	200.06	176.45	203.23
	Induced Voltage (standing) on Concentric Wires	[V/mile]	197.3	174.24	199.39	200.27	176.87	202.46	202.19	178.61	205.36
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cables (10–18)

Variable	Description	Unit	10	11	12	13	14	15	16	17	18
Cable No.	Cable Index Number		10	11	12	13	14	15	16	17	18
General Input Data											
Cable ID	Cable Equipment ID		500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	500C5.00X	230C5.00X1	230C5.00X1	230C5.00X1
Circuit No.	Circuit No.		4	4	4	5	5	5	6	6	6
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	194.5	194.5	195.5	259.5	259.5	260.5	-70.5	-70.5	-69.5
y	Y coordinate	[ft]	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	1006.6	1006.6	1006.6	1086.5	1086.5	1086.5	1037.3	1037.3	1037.3
Temperatures											
θc	Conductor temperature	[°C]	90.0	89.2	88.2	90.0	89.3	88.0	90.0	89.3	88.3
θs	Sheath/Shield temperature	[°C]	84.4	83.6	82.7	83.7	83.0	81.8	86.0	85.4	84.4
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	83.5	82.7	81.7	82.7	81.9	80.7	85.6	84.9	83.9
θduct	Duct surface temperature	[°C]	78.1	77.2	76.3	76.7	75.9	74.7	81.3	80.6	79.6
Resistances											
R_o	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01663	0.0166	0.01656	0.01663	0.0166	0.01656	0.01663	0.01661	0.01657
ys	Skin Effect Factor		0.16153	0.16223	0.16308	0.16153	0.16219	0.16325	0.16159	0.16216	0.16306
yp	Proximity Effect Factor		0.00713	0.00715	0.00719	0.00713	0.00715	0.00719	0.00742	0.00744	0.00748
Losses											
Wc	Conductor Losses	[W/ft]	3.19191	3.18593	3.17876	3.71845	3.71192	3.70151	3.38968	3.38458	3.3765
Wd	Dielectric Losses	[W/ft]	2.01332	2.01332	2.01332	2.01332	2.01332	2.01332	0.55439	0.55439	0.55439
Ws	Metallic Screen Losses	[W/ft]	0.29138	0.29205	0.29286	0.34013	0.34086	0.34204	0.14706	0.14735	0.14781
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	5.49662	5.49131	5.48495	6.0719	6.0661	6.05687	4.09114	4.08632	4.0787
λ_1	Screen Loss Factor		0.09129	0.09167	0.09213	0.09147	0.09183	0.09241	0.04338	0.04354	0.04378
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.4049	0.4049	0.4049	0.4049	0.4049	0.4049	0.32843	0.32843	0.32843
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.05408	0.05408	0.05408	0.05408	0.05408	0.05408	0.03387	0.03387	0.03387
T4	External thermal resistance	[K.m/W]	3.9621	3.92167	3.87301	3.54652	3.51246	3.45783	5.48175	5.43963	5.37293
Others											
Δθint	Temperature rise due to surrounding heat sources	[°C]	48.5	47.4	46.7	45.1	44.1	43.2	55.9	55.2	54.3
	Induced Voltage (standing) on Sheath	[V/mile]	204.21	180.18	209.03	219.14	193.51	227.58	221.6	197.5	232.62
	Induced Voltage (standing) on Concentric Wires	[V/mile]	206.4	182.4	211.21	221.5	195.9	229.94	224.45	200.38	235.46
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cables (19–27)

Variable	Description	Unit	19	20	21	22	23	24	25	26	27
Cable No.	Cable Index Number		19	20	21	22	23	24	25	26	27
General Input Data											
Cable ID	Cable Equipment ID		230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1	230C5.00X1
Circuit No.	Circuit No.		7	7	7	8	8	8	9	9	9
Phase	Cable Phase		A	B	C	A	B	C	A	B	C
Fq	Operating Frequency	[Hz]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
x	X coordinate	[ft]	-90.5	-90.5	-89.5	-110.5	-110.5	-109.5	-130.5	-130.5	-129.5
y	Y coordinate	[ft]	46.76	45.76	45.76	46.76	45.76	45.76	46.76	45.76	45.76
DLF	Daily Load Factor	[p.u.]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Bonding Type		1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular	1 Conductor 1 Point Bonded Triangular
Ampacity											
I	Steady State Ampacity	[A]	948.2	948.2	948.2	967.4	967.4	967.4	1108.2	1108.2	1108.2
Temperatures											
θc	Conductor temperature	[°C]	90.0	89.4	88.8	90.0	89.4	88.9	90.0	89.4	89.2
θs	Sheath/Shield temperature	[°C]	86.6	86.0	85.4	86.5	85.9	85.5	85.5	84.9	84.8
θa	Armour temperature	[°C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
θsurf	Cable surface temperature	[°C]	86.3	85.6	85.0	86.1	85.5	85.1	85.0	84.4	84.3
θduct	Duct surface temperature	[°C]	82.6	81.9	81.3	82.3	81.7	81.2	80.2	79.5	79.4
Resistances											
R_o	DC Resistance of the conductor at 20°C	[Ω/mile]	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116	0.01116
R	AC Resistance of the Conductor at Operating Temperature	[Ω/mile]	0.01664	0.01661	0.01659	0.01664	0.01661	0.01659	0.01664	0.01661	0.01661
ys	Skin Effect Factor		0.16158	0.16213	0.16264	0.16157	0.16212	0.16249	0.16157	0.16213	0.16225
yp	Proximity Effect Factor		0.00742	0.00744	0.00746	0.00742	0.00744	0.00746	0.00742	0.00744	0.00745
Losses											
Wc	Conductor Losses	[W/ft]	2.8329	2.82871	2.8249	2.94879	2.94446	2.94156	3.86902	3.86323	3.86207
Wd	Dielectric Losses	[W/ft]	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439	0.55439
Ws	Metallic Screen Losses	[W/ft]	0.12267	0.1229	0.12312	0.12773	0.12797	0.12814	0.16809	0.16842	0.16849
Wa	Armor/Pipe Losses	[W/ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wt	Total Losses	[W/ft]	3.50997	3.50601	3.50241	3.63092	3.62682	3.62409	4.59151	4.58605	4.58495
λ_1	Screen Loss Factor		0.0433	0.04345	0.04358	0.04332	0.04346	0.04356	0.04345	0.0436	0.04363
λ_2	Armour Loss Factor + Pipe Loss Factor		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thermal resistances											
T1	Thermal resistance of insulation	[K.m/W]	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843	0.32843
T2	Thermal resistance of bedding/medium inside pipe-type	[K.m/W]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3	Thermal resistance of outer covering	[K.m/W]	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387	0.03387
T4	External thermal resistance	[K.m/W]	6.44789	6.39983	6.35602	6.22191	6.17596	6.14526	4.84747	4.81073	4.80341
Others											
Δθint	Temperature rise due to surrounding heat sources	[°C]	59.1	58.4	57.9	58.4	57.7	57.4	53.1	52.4	52.4
	Induced Voltage (standing) on Sheath	[V/mile]	206.9	183.86	205.89	214.11	189.96	205.44	250.2	221.65	227.91
	Induced Voltage (standing) on Concentric Wires	[V/mile]	209.5	186.49	208.49	216.75	192.65	208.09	253.21	224.72	230.94
	Induced current on Metallic Screen	[A]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

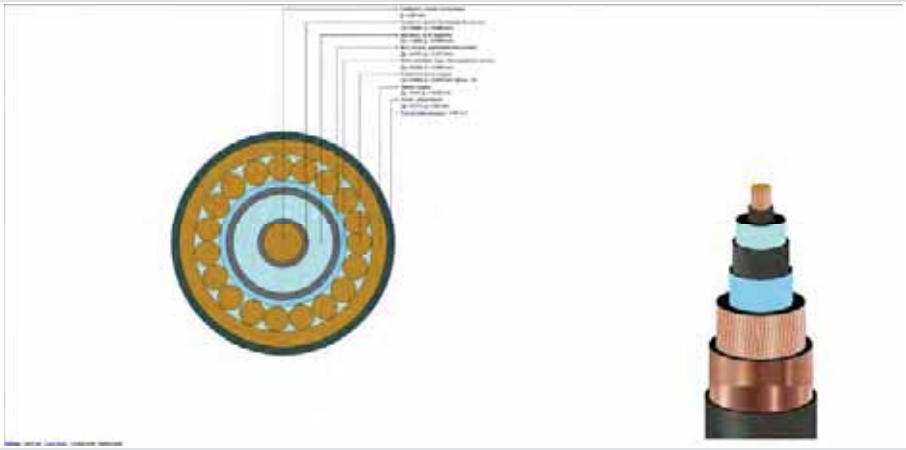
Cables Report

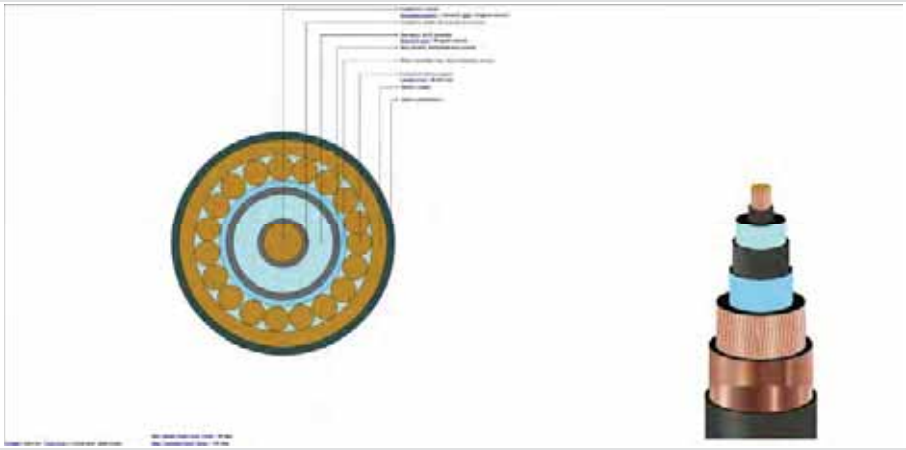
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K104-230_500kV,45_DOC,20__65_,5000kcmilInCu,@4061_5006A DLF1
Date:	11/2/2024 10:42:47 AM

No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		500C5.00X
2	Number of Cores		Single Core
3	Voltage	[kV]	500
4	Conductor Area	[in²]	3.93
5	Cable Overall Diameter	[in]	5.99
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.49
Conductor Shield			
19	Thickness	[in]	0.059
20	Diameter	[in]	2.608
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	1.22
27	Diameter	[in]	5.049
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.059
30	Diameter	[in]	5.167
Non Metallic Layer - Water Swellable Tape			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.037
34	Diameter	[in]	5.241
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		36
44	Wire Gauge		Undefined
45	Thickness	[in]	0.087
46	Diameter	[in]	5.414
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Non Corrugated
54	Thickness	[in]	0.011
55	Diameter	[in]	5.436
Jacket			
56	Material		Polyethylene
57	Thermal Resistivity	[K.m/W]	3.5
58	Thickness	[in]	0.277
59	Diameter	[in]	5.99

No.	Description	Unit	1
Specific Installation Data			
60	Cable Equipment ID		500C5.00X
61	Cable Frequency	[Hz]	60
62	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
63	Loss Factor Constant (ALOS)		0.3
64	Spacing Between Cables in Section		n/a
65	Duct construction		Polyethylene in Concrete
66	Duct material thermal resistivity	[K.m/W]	3.5
67	Duct filling material		Air
68	Inner diameter of the conduit	[in]	8.678
69	Outer diameter of the conduit	[in]	10.75

Cable ID : 500C5.00X	
Cable Title	500kV, 5000kcmil Cu - 6 Seg, 1221 XLPE, Cu Conc, Taihan





Cables Report

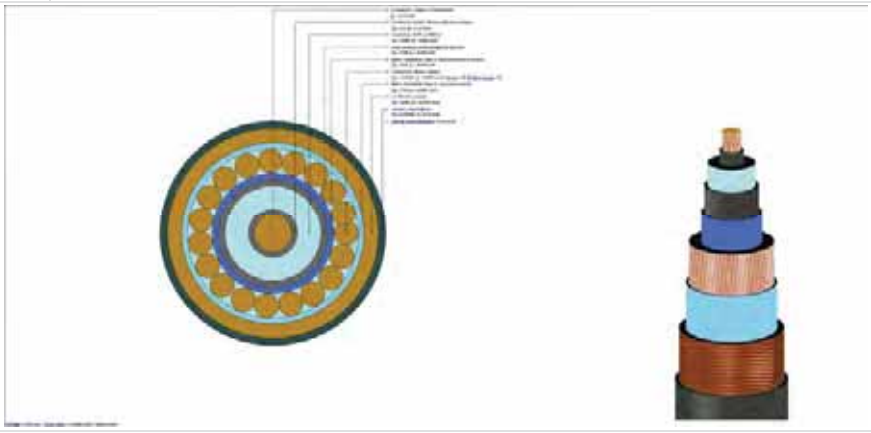
CYMCAP Version	8.1 Revision 2
Study:	Golden to Mars_G2M_New 3 Routes
Execution:	K104-230_500kV,45_DOC,20__65_,5000kcmilInCu,@4061_5006A DLF1
Date:	11/2/2024 10:42:47 AM

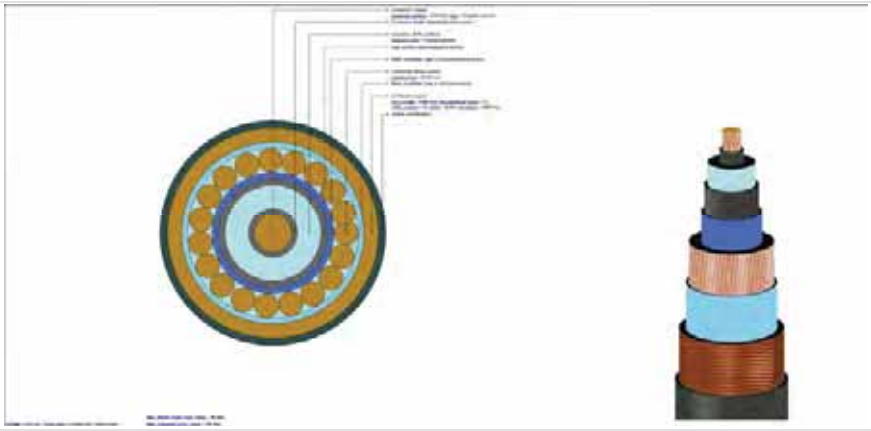
No.	Description	Unit	1
General Cable Information			
1	Cable Equipment ID		230C5.00X1
2	Number of Cores		Single Core
3	Voltage	[kV]	230
4	Conductor Area	[in²]	3.931
5	Cable Overall Diameter	[in]	5.22
6	Maximum Steady-State Conductor Temperature	[°C]	90
7	Maximum Emergency Conductor Temperature	[°C]	105
Conductor			
8	Material		Copper
9	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
10	Temperature Coefficient at 20°C	[1/K]	0.00393
11	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.4529262
12	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
13	Construction		6 Segments
14	Conductor Insulation System		Extruded
15	Milliken Wires Construction		Insulated Wires
16	Ks (Skin Effect Coefficient)		0.35
17	Kp (Proximity Effect Coefficient)		0.2
18	Diameter	[in]	2.54
Conductor Shield			
19	Thickness	[in]	0.1
20	Diameter	[in]	2.74
Insulation			
21	Material		XLPE Unfilled
22	Thermal Resistivity	[K.m/W]	3.5
23	Dielectric Loss Factor - (tan delta)		0.001
24	Relative Permittivity - (epsilon)		2.5
25	Specific Insulation Resistance Constant at 60°F - (K)	[MΩ.1000ft]	1858
26	Thickness	[in]	0.906
27	Diameter	[in]	4.552
Insulation Screen			
28	Material		Semi Conducting Screen
29	Thickness	[in]	0.05
30	Diameter	[in]	4.652
Non Metallic Layer - Water Swellable Tape 1			
31	Material		EXTRUDED SEMICONDUCTIVE SCREEN
32	Thermal Resistivity	[K.m/W]	2.5
33	Thickness	[in]	0.02
34	Diameter	[in]	4.692
Concentric neutral/Skid wires			
35	Are Concentric Neutral Wires Around Each Core?		n/a
36	Material		Copper
37	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
38	Temperature Coefficient at 20°C	[1/K]	0.00393
39	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
40	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
41	Wire Type		Round Wires
42	Length of Lay	[in]	45.562
43	Number of Wires		46
44	Wire Gauge		14
45	Thickness	[in]	0.064
46	Diameter	[in]	4.82
Sheath			
47	Is Sheath Around Each Core?		n/a
48	Material		Copper
49	Electrical Resistivity at 20°C	[µΩ.cm]	1.7241
50	Temperature Coefficient at 20°C	[1/K]	0.00393
51	Reciprocal of Temperature Coefficient of Resistance (BETA)	[K]	234.5
52	Volumetric Specific Heat (SH)	[J/(K*cm³)]	3.45
53	Corrugation Type		Longitudinally Corrugated
54	Corrugation height	[in]	0.006
55	Tape overlap	[in]	0.499999999
56	Tape width	[in]	15.91299998
57	Tape thickness	[in]	0.008
58	Accumulaton factor		1.2
59	Thickness	[in]	0.006
60	Diameter	[in]	4.912
Jacket			
61	Material		Polyethylene
62	Thermal Resistivity	[K.m/W]	3.5
63	Thickness	[in]	0.154
64	Diameter	[in]	5.22

No.	Description	Unit	1
Specific Installation Data			
65	Cable Equipment ID		230C5.00X1
66	Cable Frequency	[Hz]	60
67	Sheath / Shield Bonding		1 Conductor 1 Point Bonded Triangular
68	Loss Factor Constant (ALOS)		0.3
69	Spacing Between Cables in Section		n/a
70	Duct construction		Polyethylene in Concrete
71	Duct material thermal resistivity	[K.m/W]	3.5
72	Duct filling material		Air
73	Inner diameter of the conduit	[in]	6.963
74	Outer diameter of the conduit	[in]	8.625

Cable ID : 230C5.00X1

Cable Title: 230kV, 5000 kcmil Cu - 6 Seg, 906 XLPE, Cu cn, Prysmian





APPENDIX B UG CABLE CUTSHEETS

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XLPE insulated, concentric neutral high voltage power cable with segmental oxidized Copper conductor, metal moisture barrier tape, HDPE jacket

Type Designation: P/N 20235918 5000 kcmil Segmental Oxidized Copper 230kV

Reference Standards	ICEA S-108-720, AEIC CS9		
Temperature Rating	Maximum conductor operating temperature:	90° C	
	Maximum conductor emergency operation temperature:	105° C	
	Maximum permissible conductor temperature at short circuit:	250° C	
Construction:			
Conductor	Class B segmental compacted oxidized Copper conductor		
	Nominal cross-sectional area	5000 kcmil	2535 mm²
	Number of segments	6	
	Number of strands per segment (1 Aluminum center wire)	85	
	Approximate diameter	2.540 inches	64.5 mm
Conductor Shield	[2] Semi-conducting tape applied helical intercalated	50% overlap	
	[2] Semi-conducting tape applied helical intercalated	50% overlap	
	[1] Extruded semi-conducting thermoset	Super Smooth	
	Minimum point thickness	30 mils	0.76 mm
Insulation	Extruded cross-linked polyethylene compound	Super Clean	
	Minimum point thickness	815 mils	20.7 mm
	Nominal thickness	906 mils	23.0 mm
	Maximum eccentricity (Tmax-Tmin)/Tmax	10%	
Insulation Shield	[1] Extruded semi-conducting thermoset		
	Minimum point thickness	40 mils	1.02 mm
	Maximum point thickness	100 mils	2.54 mm
Bedding	[2] Water swellable semi-conducting tape applied helical intercalated	50% overlap	
Concentric Neutral	[46] Wires, #14 AWG, solid bare soft drawn copper		1.63 mm
Bedding	[1] Copper tape	gapped	
	[2] Water swellable semi-conducting tape applied helical	50% overlap	
Metal Moisture Barrier	[1] Laminated Copper tape applied longitudinally folded and bonded to the jacket	6 mils	0.15 mm
Jacket	Extruded black high density polyethylene compound, graphite coated		
	Minimum point thickness	125 mils	3.18 mm
	Maximum point thickness	185 mils	4.70 mm
Complete Cable	Approximate diameter	5.22 inches	132.5 mm
	Approximate weight	22.8 lbs/ft	33.9 kg/m

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Marking:

Marks of Origin	Emboss or indent print on the outer sheath: manufacturer, type of insulation, insulation thickness, conductor size and material, rated voltage, year of manufacture at intervals of not more than three feet.
	Length marking

Electrical Data:

Nominal voltage	230 kV	
Highest system voltage	242 kV	
Basic impulse insulation level (BIL)	1050 kV	
Maximum DC resistance of conductor at 25 °C	0.00224 Ω/kft	
Maximum voltage stress (conductor shield / insulation interface)	196 V/mil	7.7 kV/mm
Minimum voltage stress (insulation / insulation shield interface)	117 V/mil	4.6 kV/mm
Capacitance (nominal)	0.080 µF/kft	0.262 µF/km
Dielectric Constant	2.4	
Maximum permissible short-circuit current (thermal)	15 Cycles	
Composite Metallic Sheath (concentric neutral and laminated copper sheath) - ICEA P-45-482 (T_{init} at 75 °C and T_{final} 200 °C)	40 kA	

Mechanical Data:

Minimum bending radius	104 inches	2.64 m
Maximum pulling tension (with pulling eye)	40,000 lbs	18,143.7 kg
Maximum sidewall-pressure	1,500 lbs/ft	2,232.2 kg/m

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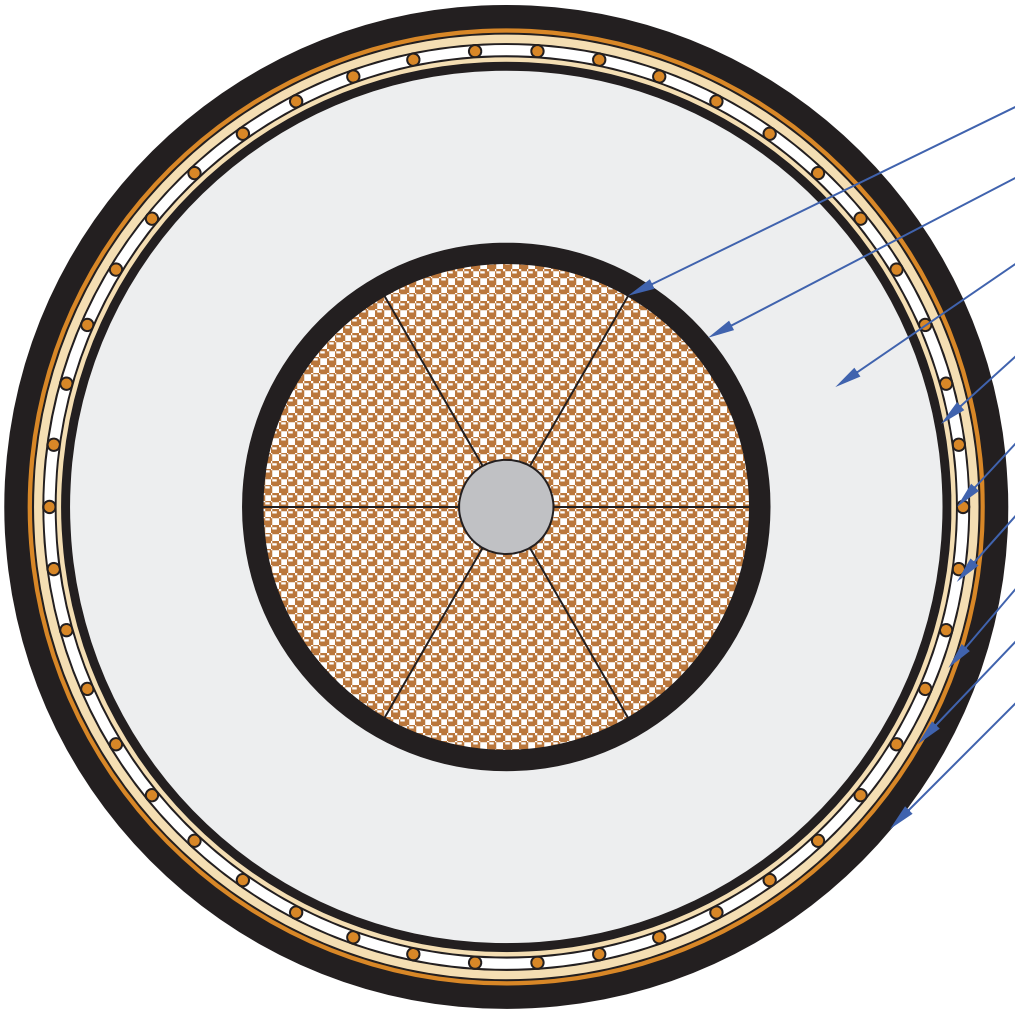


CONDUCTOR:
Diameter= 2.540" (64.5mm)

CONDUCTOR SHIELD:
Diameter= 2.74" (69.6mm)

INSULATION:
Diameter= 4.55" (115.6mm)

INSULATION SHIELD:
Diameter= 4.65" (118.1mm)

BEDDING TAPE:
Diameter= 4.69" (119.1mm)

CONCENTRIC NEUTRAL:
Diameter= 4.82" (122.4mm)

BEDDING TAPE:
Diameter= 4.90" (124.5mm)

METALLIC BARRIER:
Diameter= 4.92" (125.0mm)

JACKET:
Diameter= 5.22" (132.6mm)

APPROXIMATE WEIGHT:
22.8 lbs/ft (33.9 kg/m)

Notes:

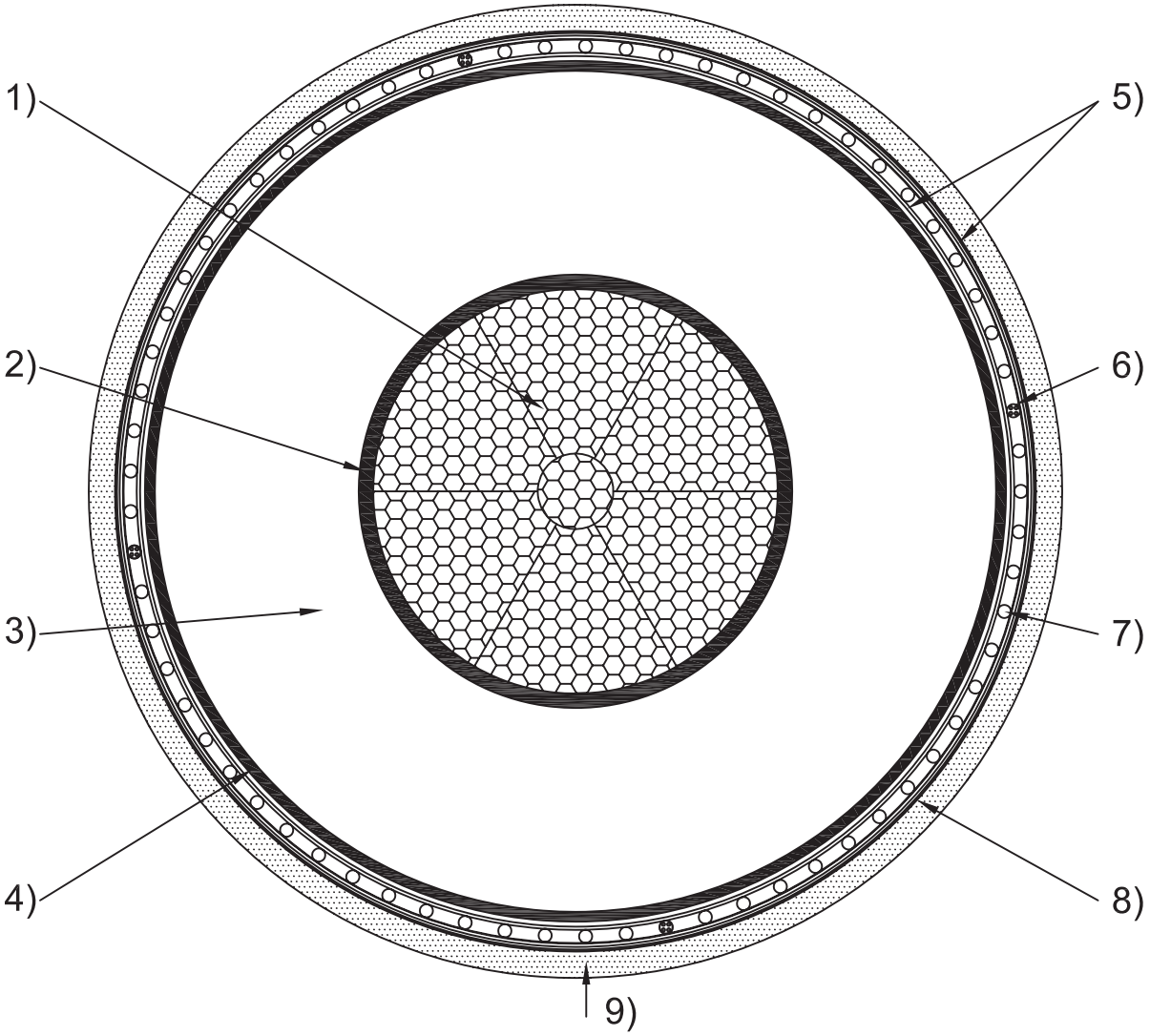
1. All dimensions are nominal and subject to manufacturing tolerances
2. Drawing is not to scale

Prepared by:	Approved by:
Dale Vinczi	Frank Kuchta

Cross section of 500kV 1C x 5000KCMIL XLPE CABLE (CU / XLPE / CWS / MDPE)

6 Seg, compacted enamel coated copper conductor, XLPE insulation, Copper wire screen + CU-foil sheath, MDPE + Semi-con PE outer jacket

RATED VOLTAGE : 500 kV	CONDUCTOR SIZE : 5000 kcmil	BASIC STANDARD : AEIC CS9



No.	DESCRIPTION	MATERIAL	Thickness (mil)	Diameter Approx., inch
1)	CONDUCTOR	1 Central + 6 seg, Enamel coated copper wires	-	2.49
2)	CONDUCTOR SCREEN	Semi - conductive tape & Semi - conductive compound	59.1	2.67
3)	INSULATION	Cross - linked polyethylene [XLPE]	1220.5	5.12
4)	INSULATION SCREEN	Semi-conductive compound	59.1	5.23
5)	WATER BLOCKING LAYER	Semi-conductive swellable tape	Each 19.7 / 16.9	-
6)	FIBER OPTIC CABLE	4 Single mode fiber optic cable in S/S	78.7 x 4EA	5.49
7)	METALLIC SCREEN	Annealed copper wires with equalizing tape	86.6 x 36EA	5.51
8)	METALLIC SHEATH	PE Laminated copper tape	11.0	5.60
9)	OUTER JACKET	Black MDPE & Semi-con PE Outer Jacket	157.5 39.4	5.99
COMPLETED CABLE		- Weight : Approx. 25.5 lb/ft - Fault Duty : 25 kA / 0.5 sec - Maximum D.C. resistance of conductor at 20°C : 0.00219 ohm/1000ft - Power frequency test (Withstand) voltage : A.C 580 kV for 60 min		

DWG. No.	500E5000IXOWE-C180118	REV.	0	DIM.	inch	Scale	N/S	taihan

CREATE AMAZING.

Burns & McDonnell World Headquarters
9400 Ward Parkway
Kansas City, MO 64114
O 816-333-9400
F 816-333-3690
www.burnsmcd.com