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SODA MOUNTAIN LINE DESIGN CRITERIA

Soda Mountain Solar Project - 500kV Transmission Line

Report Date

June 18, 2025

Prepared for:

VC Renewables

Prepared by:

Stantec Engineering Services

SODA MOUNTAIN LINE DESIGN CRITERIA

Revision	Description	Author	Quality Check	Engineer of Record	Date
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SODA MOUNTAIN LINE DESIGN CRITERIA

Prepared by ____(signature)

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Reviewed by ____(signature)

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Approved by ____(signature)

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Purpose

The items discussed in this Design Criteria Document (DCD) shall form a basis for transmission line design practice referencing Stantec's requirements and recommendations for design and application of transmission line structures. Use of this document shall establish a common design methodology, ensure compliance with applicable codes, and ensure consistency with industry standards and best practices.

This DCD characterizes the specific design requirements for the project in terms of desired function, including operating conditions, performance, material characteristics, and compliance with applicable codes, standards, and regulations. The criteria outlined in this document describes and documents the parameters, assumptions, conditions, and other design requirements upon which the design, calculations, specifications, construction drawings and other design deliverables will be based.

A route map has been provided in Appendix A - Project Overview Map

The DCD also serves to promote discussions between project stakeholders on technical and scoping matters that need to be addressed prior to the commencement of detailed design activities. It is expected that design details and the scope-of-work will progressively elaborate as the project evolves. Multiple versions of the DCD may transpire as these details are established as follows.

- Preliminary DCD – High level overview and specification of the Project's design criteria and scope of work.
- Final DCD – Thorough overview and specification of the Project's design criteria and scope-of-work.

If needed, the Final DCD will be updated during the detailed design process to record significant modifications to the projects design criteria.

Abbreviations

ACSR	Aluminum Conductor Steel Reinforced
ASCE	American Society of Civil Engineers
BIL	Basic Lightning Impulse Insulation Level
EPRI	Electric Power Research Institute
FAA	Federal Aviation Administration
FAD	Foundation Analysis & Design
G.O. 95	California's General Order 95
IEEE	Institute of Electrical and Electronics Engineers
LIDAR	Light Detection and Ranging
MFAD	Moment Foundation Analysis & Design
NESC	National Electric Safety Code
ROW	Right-of-Way

1.0 PROJECT SCOPE

1.1 PROJECT SUMMARY

The Soda Mountain Solar Project is located in San Bernardino County, California. The transmission line portion of the project consists of a gen-tie line and a tie-in loop. The gen-tie portion of the project consists of a single-circuit 500kV transmission line that spans approximately 1.5 miles, connecting the solar facility substation to the proposed Soda Mountain Switching Station. The tie-in loop consists of approximately 0.33 miles of transmission line, connecting the proposed Soda Mountain Switching Station to the existing Marketplace-Adelanto 500kV transmission line.

The line will be designed and constructed to meet the minimum requirements of the G.O. 95. The Project falls within the G.O. 95 Light District and will meet the requirements for Grade A Construction. See Appendix B – Project Weather Cases for details regarding local weather cases applied to the project. The NESC will be referenced and utilized where Engineering Judgement dictates is necessary for sound design.

1.1.1 Definitions

Engineer

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Client

VC Renewables
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Telephone: 713-230-1000
Representative: Dustin Thaler

1.2 PROJECT DETAILS

1.2.1 Route Details

The Project route selection was provided by Client.

1.2.1.1 Right-of-Way (ROW)

It is assumed that the Project Area is owned fully by Owner of project. Therefore, Stantec will not be performing ROW calculations or assistance with ROW procurement.

1.2.1.2 Site Topography

Ground survey data was not provided for this project. Publicly available survey data will be used to analyze code required clearances.

1.2.1.3 Site Access

The Project will be accessible from local roads.

1.2.1.4 Existing Infrastructure

The tie-in loop portion of the transmission line will connect to the existing Marketplace-Adelanto 500kV transmission line. VC Renewables has established where the Soda Mountain line will tie-in to the Marketplace-Adelanto line and where the proposed switching station will be located. The tie-in loop will be limited to the right-of-way provided. Stantec has not been involved with permitting/approval efforts for the tie-in to the existing line, therefore is not responsible for or guaranteeing other companies' cooperation or satisfaction with placement of new structures. All clearances to existing infrastructure should be checked and reviewed by construction and VC Renewables.

Analysis of the existing Marketplace-Adelanto line structures are not within the engineering scope and must be checked and reviewed by VC Renewables. Any modifications or impacts to that line due to the tie-in are VC Renewables' responsibility to manage with the asset owner.

1.2.1.5 Foreign Utilities

Construction shall identify and avoid all existing underground facilities. Transmission lines will be designed to meet required clearances from all foreign utilities.

1.2.1.6 State Land and Biological Considerations

It is assumed that the land surrounding the new transmission line is privately owned. There are no state land or biological considerations to be considered and incorporated into the final transmission line design. VC Renewables to verify and confirm this assumption. Any state land or biological considerations identified by VC Renewables must be communicated to Stantec for potential impact on design criteria.

1.2.1.7 Department of Transportation (DOT)

Roads along the alignment are interstate highways and are exposed to heavy traffic. Client has tasked Stantec with performing the permitting with the California Department of Transportation for an encroachment permit to cross Interstate 15. The transmission line team has provided a highway crossing exhibit to be used in the permitting process.

1.2.2 Survey Information

No survey will be provided; Stantec will be using publicly available survey data to verify ground clearances and aerial clearances to meet G.O. 95 requirements. The project coordinate system shall be defined as: State Plane, NAD83, 405: California Zone 5, US Survey Foot.

1.2.3 Project Drawings

The IFR drawing set for the 10% permit support package scope shall include the following:

- Plan and Profile Drawings for the Gen-Tie and Tie-In-Loop Transmission Lines

1.2.4 Geotechnical Scope

Detailed foundation design and calculations are not included within Engineer's scope.

1.2.5 Foundations

All structures will be on drilled pier foundations. Detailed foundation design and calculations are not included within the design scope for this project. Drilled pier foundations will meet or exceed G.O. 95 recommendations. Each structure in the transmission line is a steel monopole.

1.2.6 Wire Details

It is assumed that the Soda Mountain Solar transmission line shall utilize a 795 kcmil 26/7 ACSR Drake overhead conductor in a triple bundle. For more detailed information regarding the design of the project wires, see Section 5.0 of this document.

1.2.7 Insulators

It is assumed that insulators utilized on the project shall be polymer strain and suspension insulators. Insulator design or bill of material is not included in the Engineer's scope. Engineer of Record is responsible for detailed insulator selection.

1.2.8 Transposition Structures

Use of transpositions structures are not anticipated for this project.

1.2.9 Existing Structure Removals

It is anticipated that one structure from the existing Marketplace-Adelanto 500kV transmission line will be removed to create the tie-in loop to the proposed Soda Mountain switching station. Analysis of the existing Marketplace-Adelanto line structures are not within the engineering scope and must be checked and reviewed by VC Renewables. Any modifications or impacts to that line due to the tie-in are VC Renewables' responsibility to manage with the asset owner.

1.2.10 Site Visits

Site visits will not be required for this project.

2.0 STRUCTURAL DESIGN SPECIFICATIONS

New structures shall consist of steel monopoles. Anticipated structure above ground height is 180'.

All Structures will be modelled in PLS-CADD as M1 stick structures at this stage of design. Modelled M1 stick structures are anticipated to match installed structures in basic geometry and attachment points. The scope of this preliminary engineering phase explicitly excludes the detailed structural analysis and design of structures. The detailed design and structural analysis of structures will be finalized by the Engineer of Record (EOR) during a subsequent detailed design phase. The information presented in this section covering structural design specifications serve as a preliminary guide to structure design and is to be finalized by the EOR.

2.1 STRUCTURAL DESIGN

2.1.1 Deadend Structures

Deadend structures, otherwise known as failure containment structures, are defined as structures that are designed to support the full structural loading with either all ahead or all back span wires disconnected. For complex structures where the circuit(s) takes off in more than two directions, Stantec shall further analyze the structure to determine the worst-case scenario of cut wires. The structure shall be designed to support any combination of detached wire loading for each deadend load case.

Deadend structures shall be steel monopoles on drilled pier foundations.

Deadend structures are designed for all intact load cases as well as controlling deadend loading cases.

2.1.2 Tangent Structures

Tangent structures are defined as structures that are designed to support the vertical and lateral loading of the wire for typical spans. Tangents typically are not designed to support large lateral loading and line angle shall be kept below 3 degrees for a typical structure location.

Tangent structures shall be steel monopoles on drilled pier foundations.

2.1.3 Running Angle Structures

Running angle structures are defined as those that are designed to support the vertical and lateral loading of the wire. Running angle structures differ from tangents in that the path of the centerline departs more than 3 degrees at the structure location. Because of this larger angle, to structurally support the wire while also maintaining clearances, structure configurations differ from typical tangents. The structures are not designed to support longitudinal loading with all ahead or all back span wires disconnected.

Running Angle structures will not be used in this project.

2.1.4 Structure Loads

This Design Criteria Document (DCD) establishes preliminary parameters for structural loads; however, the scope of this current preliminary engineering phase explicitly excludes the detailed structural analysis and design of transmission line structures. This comprehensive engineering, including final calculations and design verification, will be undertaken by the designated Engineer of Record (EOR) during a subsequent detailed design phase. The information presented in this section, including the anticipated minimum structure load cases outlined in Table 1, serves as a foundational starting point and preliminary guidance for the EOR. All structures will ultimately be designed in accordance with G.O. 95 loading criteria, which is the dictating design code in the project area, and may incorporate additional criteria as recommended within documents such, as the RUS Bulletin 1724E-200. The Engineer of Record will be responsible for finalizing all structure load cases and completing the definitive structural design.

Table 1 Minimum Loading Conditions

Load Case Description	Weather Case	Wind Loading (PSF)	Ice Thickness	Temp. (°F)	Cable Condition	Deflection Limit % of Pole AGL
G.O. 95 Light Loading	G.O. 95 Light	8	0	25	Initial	10%
NESC 250C	Extreme Wind	18.5	0	60	Initial	10%
Deflection	60 Deg F	0	0	60	Final	1%
Uplift	Cold Uplift	0	0	20	Initial	
Construction	Construction	2	0	40	Initial	

2.1.4.1 G.0. 95 Light Loading

G.O. 95 light: Requirements set forth in the latest edition of the G.O. 95. Grade A Construction shall apply to all power line structures with all wires intact.

- Apply intact loads to all structures.
- Apply broken wire loads to DE structures.

2.1.4.2 Deflection

Deadend structures

Deadend structures are limited to deflecting no more than 10% of the above ground pole height (AGH) at the everyday weather case. This is to control both the tension in each section of wire as well as the visual appearance of the line to the public.

Non-deadend structures

Non-deadend structures are limited to deflecting no more than 10% of the AGH at the everyday weather case.

2.1.4.3 Stringing/Construction

Deadend Structures

Stringing loads are used to ensure structural adequacy under potential loading applied during construction. Loads are applied simultaneously at all phase and shield wire locations and are based upon all wires sloping down to either pullers, tensioners, or temporary anchors. The horizontal and vertical component of these loads are calculated based upon the wires being at 3H:1V slope.

Non-Deadend Structures

Construction cases shall also be considered to account for caught-in-block conductor or failing conductor splices. Any one conductor or static wire is assumed to bind in a running block during installation. The block is assumed to swing 45 degrees, which will result in a vertical load equal to the longitudinal load.

2.1.5 Wind Direction

Stantec shall consider wind applied to all spans simultaneously. Wind shall be applied in the direction of greatest effect and largest applied stress. Stantec may choose to analyze complex structures by modeling the wind in every direction and selecting the single wind direction that governs the pole design.

2.1.6 Miscellaneous Loads

2.1.6.1 Aerial Markers

Use of aerial markers are not anticipated for this project.

2.1.6.2 Aerial Taps

Use of aerial taps are not anticipated for this Project.

2.1.6.3 Conductor Weights

Conductor weights are not anticipated to be used on the Project.

2.1.7 Safety Factors

The required strength factors are shown in Table 2 Safety Factors (SF) for Structures.

Table 2 Safety Factors (SF) for Structures

Component / Material	G.O. 95 Light Loading	NESC 250C	Deflection and Uplift	Construction
Steel Poles / Tubular Arms	1.5	1	1	1.5
Insulators [(1)]	3	2	1	3
Hardware	2	1.25	1	2
Foundation	1.5	1	1	1

1. See section 3.1.3 Insulator Safety Factors for details for insulator strength reduction factors.

2.1.8 Structure Deflection Limits

Loading eccentricates induced by structure deflections under load shall be included in the design of the poles. Deflection limits for each load case can be found in Table 1 .

2.1.9 Vibration

Vibration calculations will not be run as part of the engineering scope for this project.

2.1.10 Climbing Provisions

Climbing provisions will not be provided within the design of this Project.

2.1.11 Structure Numbers

The Client shall provide a structure numbering convention during detailed design.

3.0 INSULATORS, HARDWARE, GUYS, SWITCHES

3.1 INSULATORS

Within the framework of this preliminary Design Criteria Document (DCD), the definitive selection, detailed engineering specification, and design verification of the transmission line insulators are not encompassed. The subsequent information and anticipations provided in this section, such as the expectation to use glass suspension and strain insulators for various structure types, serve as initial guidance and a basis for discussion. The comprehensive engineering, including the final determination of insulation values (e.g., leakage distance, flashover characteristics as outlined in Table 4, which are currently preliminary), adherence to strength factors, and confirmation of suitability for all operational and environmental conditions, will be undertaken by the designated Engineer of Record (EOR) during the subsequent detailed design phase. As such, the complete design of insulators will be done during detailed design, where the EOR will finalize all insulator specifications based on project-specific requirements and applicable standards.

3.1.1 Insulation Values

Minimum insulation values for the new 500kV line will be determined during detailed design. Table 3 values to be confirmed during detailed design.

Table 3 Insulation Values

500 kV Insulator Assembly	Leakage Distance (in)	60-Hz Dry Flashover (kV)	60-Hz Wet Flashover (kV)
xx-kip Deadend	-	-	-
xx-kip Suspension / DE	-	-	-

3.1.2 Glass Insulators

It is anticipated that all glass insulators shall consist of a FRP rod consisting of E-glass fibers and Epoxy-based Resin. The core of the glass insulator shall be completely covered by a continuous housing consisting of a sheath-weathered system. The Weather sheds and sheath shall be bonded together during the vulcanization process or molded into one piece by injection molding. Metal end fittings shall be designed to transmit the mechanical load to the core. Engineer of Record to finalize insulator specifications during detailed design phase.

3.1.3 Insulator Safety Factors

G.O. 95 Table 4 and NESC Table 277-1 dictate the required insulator safety factors.

3.2 HARDWARE

Hardware specified on the power line shall be designed to meet the requirements specified within G.O. 95. All hardware shall be selected to have an ultimate strength greater than or equal to the element it attaches to the pole. Hardware shall also have dimensional compatibility with all structure attachment points and be able to support all allowable swing angles.

3.2.1 Clamps and Splices

All deadend clamps and connectors will be bolted type hardware. Splices shall be assumed to be full tension unless utilized for the installation of jumper wire. Splices shall not be placed over major crossings such as roadways, railroads, waterways or within one (1) span of a deadend structure.

3.3 GUYING SPECIFICATION

3.3.1 Guy Wires

The use of guy wires, anchors, and guy strain insulators are not anticipated for this project.

3.4 SWITCHES

The use of switching equipment is not anticipated on any structures of this project.

4.0 FOUNDATIONS

4.1 DRILLED PIER SPECIFICATIONS

4.1.1 Structure Types

The following structures on drilled pier foundations are proposed for the Project.

Tangent structures and deadend structures shall be on drilled pier foundations following G.O. 95 recommendations. Due to the preliminary stage of design, foundations will not be fully designed or analyzed. Foundation design will be performed by the Engineer of Record during the detailed design phase.

5.0 WIRE SPECIFICATIONS

5.1 OVERHEAD CONDUCTORS

5.1.1 500 kV Conductors

Client has selected project conductors. Stantec has not performed a conductor selection study or provided engineering input on conductor selection in any way. Existing conductor information was not provided.

5.2 PHYSICAL WIRE CHARACTERISTICS

It is assumed that the Soda Mountain Solar transmission line shall utilize a 795 kcmil 26/7 ACSR Drake overhead conductor in a triple bundle. The Engineer of Record will confirm the conductor selection during the detailed design phase of the project. The table below summarizes the physical properties of the conductors and shield wires used on the project. See Appendix -G for ACSR “DRAKE” conductor cut sheet.

Table 4 Proposed Conductor Properties

Code word / Name	Size (kcmil)	Type	Stranding	Diameter (in.)	Unit Weight (lbs./ft.)	Rated Strength (lbs.)
DRAKE	795	ACSR	26/7	1.107	1.093	31,500

5.3 WIRE TENSION LIMITS

Conductor design tensions are shown in Table 5 below. Conductor design tensions have been limited to less than 22% RBS at 20°F to limit Aeolian vibrations.

Table 5 Conductor Tension Limits

Weather Case	% Of Ultimate RBS	Cable Condition
NESC Tension Limit (261H1c)	35	Initial RS
NESC Tension Limit (261H1c)	25	Creep RS
G.O. 95 Light Loading 43.2	50	Initial RS
20 °F Design Tension	22	Initial RS

5.4 VIBRATION

5.4.1 Galloping

Due to project locale, galloping will not be analyzed within the scope of this project.

5.4.2 Aeolian

Aeolian Vibration is a high-frequency, low-amplitude oscillation generated by a low velocity, steady state wind blowing across conductors or shield wires. Aeolian vibration occurs in open, flat areas where a smooth laminar wind velocity of approximately 2 mph may occur. Per the RUS Bulletin 1724E-200, the frequency of vibration depends mainly on the conductor size and wind velocity and is generally between 5 and 100 Hz for wind speeds in the range of 0–15 mph. This type of vibration may cause fatigue damage to the conductor, particularly at or near the suspension clamp. It may also cause cyclic stress variations near the resonant condition of the conductor's supporting member causing fatigue cracks. Highly tensioned conductors in long spans are particularly subject to aeolian vibration fatigue.

The most effective way to reduce this type of vibration is to reduce the line tension. In addition, the installation of dampers may reduce or eliminate this vibration. The conductor and damper suppliers will be consulted regarding the use of dampers on the conductor and shield wire.

For this Project, at the Client's discretion, it is not expected that vibration dampers will be installed on each phase conductor of every span to mitigate aeolian vibration. Stantec recommends analyzing conductors for vibration performance, though conductor tensions will be kept below code-recommended vibration-mitigating tension limits.

5.4.3 Corona-Induced Vibrations

Another conductor vibration phenomenon associated with extra high voltage (EHV) transmission lines is corona induced oscillation. Corona is a pulsing discharge of current (see section 5.5 for expanded definition of corona). The occurrence of corona is greater at sharp points and under moist conditions where water droplets have formed along the underside of a conductor. Each burst of corona discharge from the water drops produces an upward physical impulse. Once excited, the mechanics of water drop deformation and corona generation modulate to produce a sustained motion effect. Corona-induced vibration has been studied since the early 1970's and has been successfully simulated in laboratories. Corona-induced vibrations are relatively small and normal damping for wind induced conductor movement has historically been adequate to control this type of oscillation.

Corona and Corona-induced vibrations are expected to be present at 500kV.

5.5 CORONA

Corona discharges occur when the electric field at the surface of a conductor exceeds the breakdown strength of air. In areas where corona is present, the air is electrically ionized and conducts electricity. If the voltage is further increased, the air in the corona area is broken down resulting in a disruptive discharge, or spark, across the corona area.

The magnitude of the surface electric field is inversely proportional to the conductor size. Therefore, larger conductors reduce the electric field at the surface.

Corona is a source of power loss, therefore making it a high level of concern to the Owner. Corona also causes Radio Influence (RI), Television Interference (TVI) and audible noise (Crackling and humming). Additionally, the prolonged presence of high corona levels can damage components of the transmission line such as insulators and conductor attachment hardware. This can cause additional future costs in the form of line repairs and outages.

Corona is expected to be present at 500kV.

5.6 CREEP-STRETCH

For modeling purposes, the maximum sag option (instead of creep or load) shall be selected to determine the maximum sag case between creep and load. Creep and load are defined as follows:

- Weather case for final after creep shall be:
  - 60°F, 0PSF (Ambient)
- Weather case for final after load shall be:
  - 25°F, 0.0” Ice, 8 PSF Wind (G.O. 95 Light)

6.0 GROUNDING

6.1 STRUCTURE GROUNDING

Stantec recommends the maximum acceptable structure ground resistance to be 10 ohms on all structures. Acceptable ground resistance shall be determined by Client, as this has not been included within Stantec's design scope.

6.2 BONDING

Shield wires shall utilize mechanical bonding to either a copper ground wire or the steel structure itself, at the hardware connection point, to provide a direct path to the installed ground rods.

6.3 LIGHTNING ARRESTERS

The use of lightning arresters at any location shall not be permitted without written approval.

6.4 FENCE GROUNDING

Fences are often accessible to the public and other personnel; therefore, inductive coupling effects should be considered. The NEC Article 250, IEEE Std 80, and NESC all discuss the importance to ground nearby fence installations under different situations.

For this project, the following approach is recommended. To reduce the potential for voltage buildup on nearby fences with non-metal posts, where the fence is parallel and within the ROW, it shall be grounded as indicated in Table 6.

Table 6 Parallel Fence Grounding Requirements

Distance from Centerline (ft)	Minimum Parallel length (ft)	Grounding Interval along Fence line (ft)
0-100	500	250
100-200	2000	500

7.0 CLEARANCE DESIGN SPECIFICATIONS

This section covers the applicable G.O. 95 vertical and horizontal clearance requirements from Tables 1 and 2 and all additional recommendations. Stantec includes an added safety buffer to all clearances to account for construction tolerances. At the current stage of 10% design, Table 7 lists the project weather cases that are being used to check clearances. Engineer of Record to finalize weather cases used to check clearances during detailed design.

7.1 CLEARANCE RELATED WEATHER CASES

Weather cases that shall be included as part of clearance analysis include the following:

Table 7 Project Weather Cases

Weather Description	Wind Velocity (mph)	Wind Pressure (psf)	Wire Temperature (F)	Ice Thickness (in)
G.O. 95 Light	55.902	8	25	0
60°F, 0PSF	0.0	0	60	0
60°F, 8PSF BLOWOUT	55.902	8	60	0
MOT 194°F, 0PSF	0.0	0	194	0
NESC 6PSF	48.4	6	60	0
NESC 250C	85	18.5	60	0

1. Weather Load Factor equals 1 for all cases

7.2 VERTICAL CLEARANCES

7.2.1 Vertical Clearance to Ground and Objects

Vertical Clearances to ground and objects below the transmission line shall be checked for the weather conditions listed in Table 8 at a minimum. Additional weather cases may also be applied.

Table 8 Weather Cases to Vertical Clearance Checks to Ground

Case #	Temperature	Wind	Ice	Cable Condition
1	194 °F (MOT)	No Wind	No Ice	Final
2	60°F	8 psf	No Ice	Final
3	60°F	No Wind	No Ice	Final

Ground clearances are defined in Appendix C – Ground Clearance Tables

7.2.2 Vertical Clearances Between Wires

Vertical Clearances between wires carried on the same structure shall be analyzed for the conditions defined in the table below. These conditions and associated wire-to-wire clearances will be analyzed based upon the intact condition of conductor. Wire-to-wire clearance shall be based on G.O.-95 Table 2.

Table 9 Weather Conditions for Vertical Clearance Checks Between Wires

Upper Conductor	Lower Conductor
60 ^{o}F, 0" Ice, 0 psf, Final	60 ^{o}F, Final

7.3 HORIZONTAL CLEARANCES

7.3.1 Horizontal Clearances to Objects

Clearances to objects shall meet G.O.-95 Table 1. Clearance considerations shall be met for the following weather conditions

1. No Wind Considerations:
   a. 194^{o}F, No Ice, Final Sag
2. G.O. 95 Light, Final Sag
3. 60^{o}F, 8 psf wind, Final Sag

Horizontal clearance requirements to objects are defined in Appendix F – Object Clearance Tables. Stantec does not have aerial survey data within the project area. Horizontal clearances to aerial objects will not be checked at this stage of design, but the clearance requirements are provided.

7.3.2 Horizontal Clearances Between Wires

If vertical clearance is met, horizontal clearance will not control and therefore not be considered. If Vertical clearance is not met, the horizontal wire-to-wire clearance shall be based on G.O.-95 Table 2.

7.4 RIGHT-OF-WAY (ROW) AND CONDUCTOR BLOWOUT

ROW clearances shall comply with applicable codes including G.O.-95, RUS, Local, State, and Owner Standards when required. Conductor blow-out clearances shall consider tip deflection, foundation rotation, insulator and/or hardware swing, and the conductor displacement under the weather cases listed below. Stantec considers building setback requirements as part of this calculation. Calculating required ROW was not included within engineering scope. At the current stage of 10% design, blowout displacement is calculated using applicable weather cases combined with clearances to buildings and vegetation. To account for pole deflection, an additional 10% of the pole height is incorporated as a buffer. With the current methodology, conductor blowout remains within the provided right-of-way at all locations. Engineer of Record to finalize conductor blowout methodology and confirm wires remain within the provided right-of-way.

7.5 LIVE LINE MAINTENANCE

The Project is not explicitly being designed for live line maintenance. NESC rule 441 shall be followed for live line maintenance clearance requirements when required.

7.6 VEGETATION CLEARANCE

It is assumed that prior to construction of the Project, all vegetation within the ROW will be cleared.

It is also assumed that trees grow or someday will grow at the edge of the ROW, and that normal growth cycles will result in further encroachment into the Vegetation Management Width. Because of this, only checking the Conductor Movement Envelope (CME) is insufficient as a ROW requirement. Vegetation management in the area adjacent to the ROW edges is required to prevent grow-in and comply with Minimum Vegetation Clearance Distance (MVCD) as specified in the NERC FAC-003-0 Transmission Vegetation Management directive.

Figure 1 Application of the MVCD

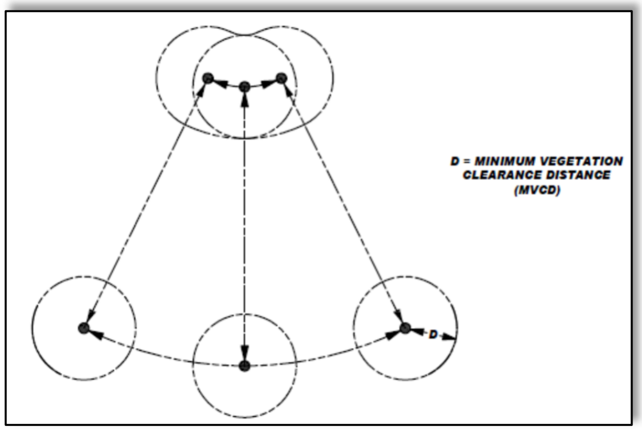


Figure 2 FAC-003 Table 2 “Minimum Vegetation Clearance Distance

FAC-003 — TABLE 2 — Minimum Vegetation Clearance Distances (MVCD)[16]
For **Alternating Current** Voltages (feet)

(AC) Nominal System Voltage (KV)	(AC) Maximum System Voltage (kV)[17]	MVCD (feet) Over sea level up to 500 ft	MVCD (feet) Over 500 ft up to 1000 ft	MVCD feet Over 1000 ft up to 2000 ft	MVCD feet Over 2000 ft up to 3000 ft	MVCD feet Over 3000 ft up to 4000 ft	MVCD feet Over 4000 ft up to 5000 ft	MVCD feet Over 5000 ft up to 6000 ft	MVCD feet Over 6000 ft up to 7000 ft	MVCD feet Over 7000 ft up to 8000 ft	MVCD feet Over 8000 ft up to 9000 ft	MVCD feet Over 9000 ft up to 10000 ft	MVCD feet Over 10000 ft up to 11000 ft
765	800	8.2ft	8.33ft	8.61ft	8.89ft	9.17ft	9.45ft	9.73ft	10.01ft	10.29ft	10.57ft	10.85ft	11.13ft
500	550	5.15ft	5.25ft	5.45ft	5.66ft	5.86ft	6.07ft	6.28ft	6.49ft	6.7ft	6.92ft	7.13ft	7.35ft
345	362	3.19ft	3.26ft	3.39ft	3.53ft	3.67ft	3.82ft	3.97ft	4.12ft	4.27ft	4.43ft	4.58ft	4.74ft
287	302	3.88ft	3.96ft	4.12ft	4.29ft	4.45ft	4.62ft	4.79ft	4.97ft	5.14ft	5.32ft	5.50ft	5.68ft
230	242	3.03ft	3.09ft	3.22ft	3.36ft	3.49ft	3.63ft	3.78ft	3.92ft	4.07ft	4.22ft	4.37ft	4.53ft
161*	169	2.05ft	2.09ft	2.19ft	2.28ft	2.38ft	2.48ft	2.58ft	2.69ft	2.8ft	2.91ft	3.03ft	3.14ft
138*	145	1.74ft	1.78ft	1.86ft	1.94ft	2.03ft	2.12ft	2.21ft	2.3ft	2.4ft	2.49ft	2.59ft	2.7ft
115*	121	1.44ft	1.47ft	1.54ft	1.61ft	1.68ft	1.75ft	1.83ft	1.91ft	1.99ft	2.07ft	2.16ft	2.25ft
88*	100	1.18ft	1.21ft	1.26ft	1.32ft	1.38ft	1.44ft	1.5ft	1.57ft	1.64ft	1.71ft	1.78ft	1.86ft
69*	72	0.84ft	0.86ft	0.90ft	0.94ft	0.99ft	1.03ft	1.08ft	1.13ft	1.18ft	1.23ft	1.28ft	1.34ft

* Such lines are applicable to this standard only if PC has determined such per FAC-014 (refer to the Applicability Section above)

8.0 ENVIRONMENTAL AND PERMITING CONSIDERATIONS

8.1 AESTHETIC CONSIDERATIONS

While not an environmental concern in terms of regulatory or ecological impact, and while not a quantifiable design criteria representative of the rest of this document, aesthetics is an important consideration that must be discussed early during the process of designing a transmission line. A more aesthetic design can not only assist in overcoming public opposition to a project, but it may also alter perceptions of the completed project. Some utilities have had success with developing unique, quasi-artistic design elements intended to blend lines into the background (weathering steel poles, ocular conductors, minimizing pole height to blend into the background, minimizing guy patterns, etc.) Similarly, designs should incorporate elements that help structures “look right” and avoid unwarranted concern from the public. Typically, such efforts will consist of efforts to limit or mask structure deflections and eliminate the perception that they are over-loaded or failing. Measures like Camber, Pole Raking, Upswept Post Insulators, and Curved Davit Arms all fall into this category.

While project cost will dictate the level of aesthetic consideration, Stantec will be aware this important aspect and always be looking for solutions to provide aesthetically conscious designs without exclusive impact to the project cost. For example, often a clean line, simple design can be more aesthetic, and can also be more cost effect, than a complicated design with many angles.

8.2 PERMITTING

Stantec is responsible for obtaining an encroachment permit to cross Interstate 15 from the California Department of Transportation.

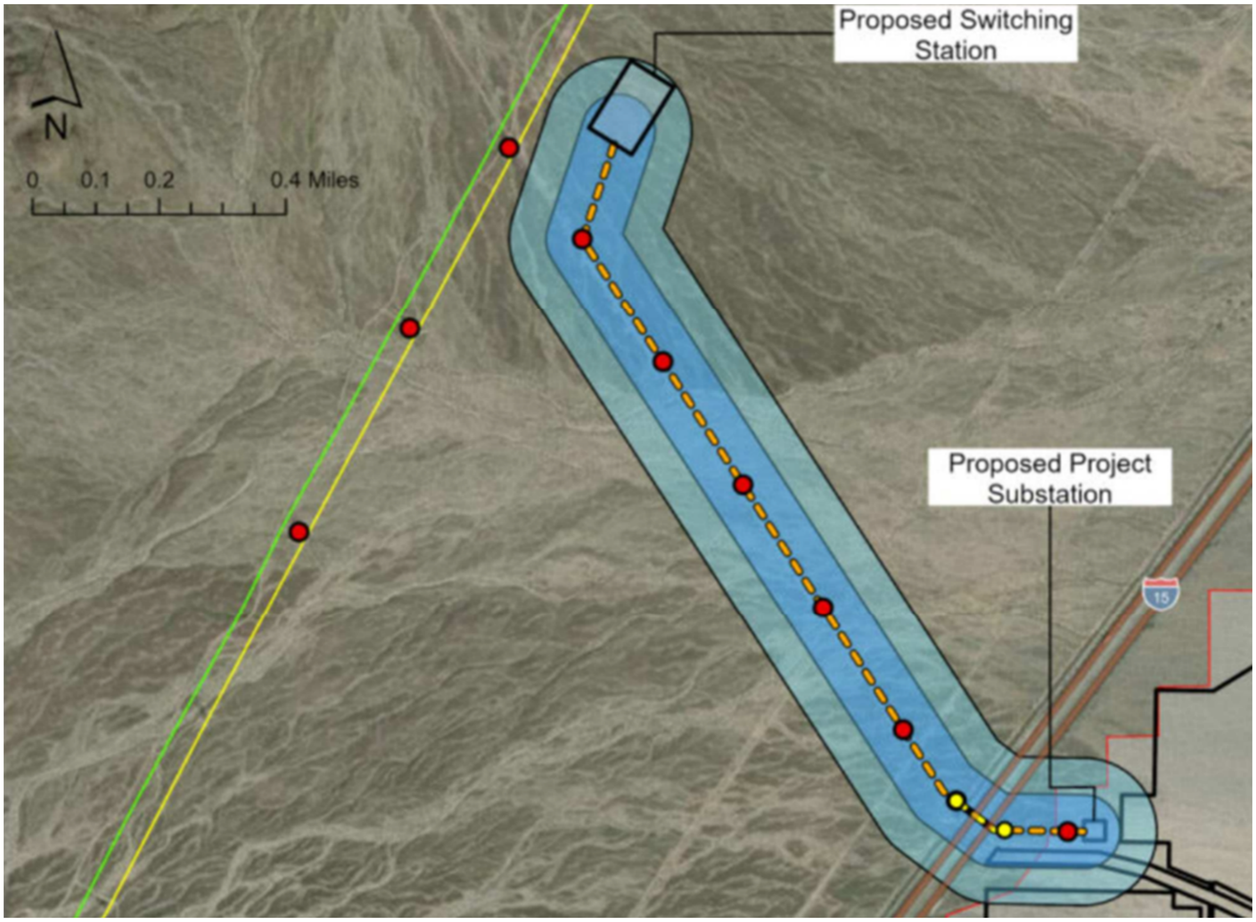
Other permitting efforts are on-going by other project stakeholders. Details included in this DCD may serve as a technical reference for these efforts.

9.0 REFERENCES

The design for the Project shall be performed in accordance with the latest accepted revision of the following list of codes and standards in addition to any superseding *Owner* standards.

- AC Transmission Line Reference Book - 200kV and Above
- American Concrete Institute (ACI)
  - ACI 318, Building Code Requirements for Structural Concrete
  - ACI 336.3, Report on Design and Construction of Drilled Piers.
- American Institute of Steel Construction (AISC)
  - AISC Steel Construction Manual, Latest Edition
- American National Standards Institute (ANSI)
- American Society of Civil Engineers (ASCE)
  - ASCE Manual and Reports on Engineering Practice No. 74: Guideline for Electrical Transmission Line Loading
  - ASCE Manual No. 7-05: Minimum design loads for buildings and other structures.
  - ASCE 48, Design of Steel Transmission Pole Structures
  - ASCE 10, Design of Lattice Steel Transmission Structures
  - ASCE 91, Design of Guyed Electrical Transmission Structures
  - ASCE 104, Recommended practice for Fiber Reinforced Polymer Products for Overhead Utility Line Structures.
  - ASCE 141, Wood Pole Structures for Electrical Transmission Lines
- American Society for Testing Materials (ASTM)
- American Welding Society (AWS)
- California Public Utilities Commission (CPUC)
  - General Order No. 95 (G.O. 95, Rules for Overhead Electric Line Construction)
- Concrete Reinforcing Steel Institute (CRSI)
- Electric Power Research Institute (EPRI)
- Institute of Electrical and Electronics Engineers (IEEE)
  - IEEE 738: Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors.
  - IEEE 1243-1997: Guide for Improving the Lightning Performance of Transmission Lines
  - IEEE 1307: Trial Use Guide for Fall Protection for the Utility Industry
- Handbook for Improving Overhead Transmission Line Lightning Performance
- MFAD v5.2 Manual, Fad Tools International, LLC
- National Electric Safety Code C2-2017 (NESC 2017)
- Power System and Railroad Electromagnetic Compatibility Handbook
- Rural Utility Service
  - RUS Bulletin 1724E-200: Design Manual for High Voltage Transmission Lines
- Transmission Line Reference Book: 115k-345kV Compact Line Design

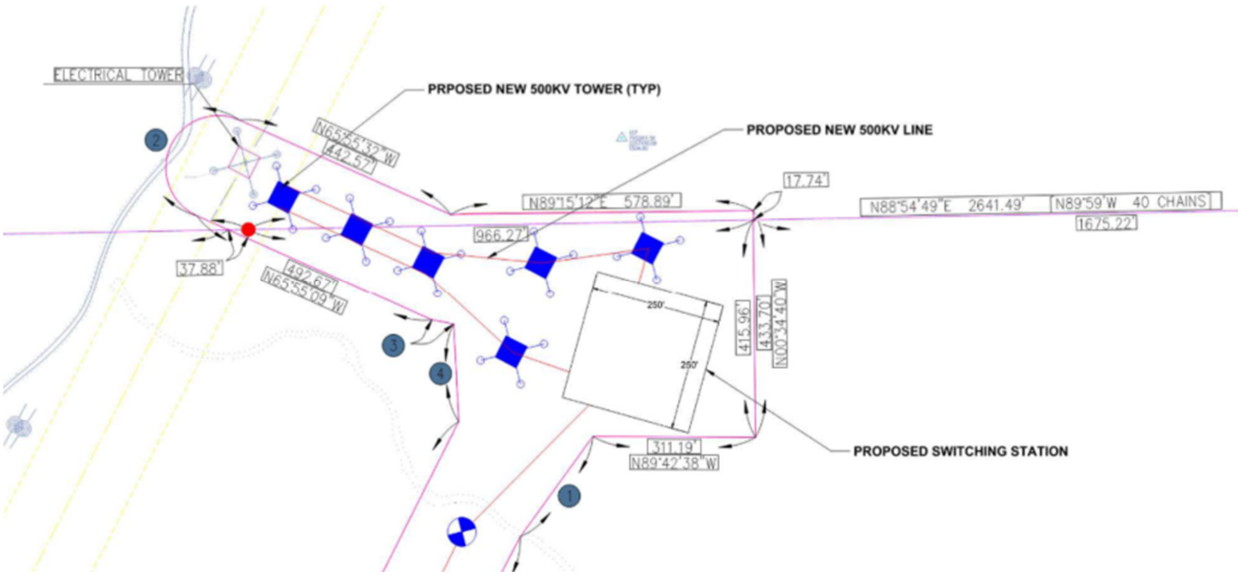
Appendix A – PROJECT OVERVIEW MAP



500kV Gen Tie Line Route – Project Substation to Switching Station

SODA MOUNTAIN LINE DESIGN CRITERIA

– Project Overview Map



Tie-In Loop – Marketplace-Adelanto Existing 500kV Line to Switching Station

Appendix B – PROJECT WEATHER CASES

Description	Wind (PSF)	Ice (PSF)	Ambient Temp (ºF)	Wire Temp
60 Deg F			60	60
167 Deg F			90	167
194 Deg F			104	194
G.O. 95 Light Loading 43.2	8		25	25
Blowout	8		60	60
NESC 6PSF	6		60	60
NESC 250C	18.5		60	60
Construction	2		40	40

Appendix C – GROUND CLEARANCE TABLES

G.O.-95 Table 1 Vertical Clearances above ground, roadway, rail, or water surfaces (ft)

Description	500 kV Clearance	Recommended Buffer	500 kV Design Clearance
Tracks, Rails of Railroads (except electrified railroads using overhead trolly conductors)	39	5	44
Roads, Streets, and other areas subject to truck traffic	35	5	40
Driveways, Parking Lots, and Alleys	35	5	40
Other land traversed by vehicles, such as cultivated, grazing, forest, orchards, etc.	35	5	40
Spaces and ways subject to pedestrian or restricted traffic only	30	5	35
Water areas not suitable for sail boating or where sail boating is prohibited	30	5	35
Water Areas Less than 20 acres	32	5	37
Water Areas Over 20 to 200 acres	40	5	45
Water Areas Over 200 to 2000 acres	46	5	51
Water Areas Over 2000 acres	52	5	57

Appendix D – CROSSING CLEARANCE TABLES

G.O.-95 Table 2 Clearances Between Wires, Conductors, and Cables Carried on Different Supporting Structures (ft)

Description	500 kV Clearance	Included Buffer	500 kV Design Clearance
Span Wires, Guys and Messengers	18.2	3	21.2
Trolley Contact Conductors, 0-750 volts	19.7	3	22.7
Communication Conductors	19.7	3	22.7
Supply Conductors, Service Drops and Trolley Feeders, 0-750 volts	19.7	3	22.7
Supply Conductors, 750 – 7,500 volts	19.7	3	22.7
Supply Conductors, 7,500 – 20,000 volts	19.7	3	22.7
Supply Conductors, More than 20,000 volts	19.7	3	22.7

Appendix E – PHASE CLEARANCE TABLES

G.O.-95 Table 2 Vertical Separation Between Conductors and/ or Cables on Separate Crossarms or Other Supports at Different Levels on the Same Pole in Adjoining Midspans (ft)

Description	500 kV Clearance	Included Buffer	500 kV Design Clearance
Communication Conductors	19.0	3	22.0
Supply Conductors, Service Drops and Trolley Feeders, 0-750 volts	19.0	3	22.0
Supply Conductors, 750 – 7,500 volts	19.2	3	22.2
Supply Conductors, 7,500 – 20,000 volts	19.2	3	22.2
Supply Conductors, 20,000 volts – 75,000 volts	19.2	3	22.2
Supply Conductors, More than 75,000 volts	19.2	3	22.2

G.O.-95 Table 2 Radial Separation of Conductors on Same Crossarm, Pole or Structure – Incidental Pole Wiring (ft)

Description	500 kV Clearance	Included Buffer	500 kV Design Clearance
Conductors of the same circuit 300,000 – 555,000 volts	19.2	3	22.2

Appendix F – OBJECT CLEARANCE TABLES

Clearance to supporting structures (lighting support, traffic signal support, intermediate poles, etc.) (ft)

Horizontal Clearance	500 kV Clearance	Design Buffer	500 kV Design Clearance
Horizontal Clearance @ 60°F, 0PSF	14.4	1	15.4

Clearance to buildings (ft)

Horizontal Clearance	500 kV Clearance	Design Buffer	500 kV Design Clearance
Walls, projections, and guarded windows	16.9	2	18.9
Unguarded windows	16.9	2	18.9
Balconies and areas readily accessible to pedestrians	16.9	2	18.9

Vertical Clearance	500 kV Clearance	Design Buffer	500 kV Design Clearance
Over or under roofs or projections not readily accessible to pedestrians	21.9	2	23.9
Over or under roofs, balconies, decks, or similar structures readily accessible to pedestrians	23.9	2	25.9

Clearance to signs, chimneys, billboards, radio and television antennas, flagpole and flags, banners, tanks, and other installations not classified as buildings or bridges

Horizontal Clearance	500 kV Clearance	Design Buffer	500 kV Design Clearance
To portions that are readily accessible to pedestrians	16.9	2	18.9

Appendix G – 795 KCMIL ACSR “DRAKE” CUTSHEET

Code Word	Size (AWG or kcmil)	Stranding (AL/STL)	Diameter(inch)				Weight (lbs/kft)			Content %		Rated Breaking Strength (lbs.)	Resistance** (Ohms/kft)		Ampacity* (amps)
			Individual Wire			Comp. Cable OD	AL	STL	Total	AL	STL		DC @ 20ºC	AC @ 75ºC	
			AL	STL	Steel Core										
Pelican	477.0	18/1	0.1628	0.1628	0.1628	0.814	447.8	70.2	518	86.45	13.55	11,800	0.0360	0.044	646
Flicker	477.0	24/7	0.1410	0.0940	0.2820	0.846	450.1	164.4	615	73.23	26.77	17,200	0.0358	0.044	655
Hawk	477.0	26/7	0.1354	0.1053	0.3159	0.858	449.6	206.4	656	68.53	31.47	19,500	0.0356	0.044	659
Hen	477.0	30/7	0.1261	0.1261	0.3783	0.883	451.1	296.2	747	60.35	39.65	23,800	0.0354	0.043	666
Osprey	556.5	18/1	0.1758	0.1758	0.1758	0.879	522.2	81.8	604	86.45	13.55	13,700	0.0308	0.038	711
Parakeet	556.5	24/7	0.1523	0.1015	0.3045	0.914	525.1	191.7	717	73.23	26.77	19,800	0.0307	0.038	721
Dove	556.5	26/7	0.1463	0.1138	0.3414	0.927	525.0	241.0	766	68.53	31.47	22,600	0.0306	0.038	726
Eagle	556.5	30/7	0.1362	0.1362	0.4086	0.953	526.3	345.6	872	60.35	39.75	27,800	0.0303	0.037	734
Peacock	605.0	24/7	0.1588	0.1059	0.3177	0.953	570.9	208.7	780	73.23	26.77	21,600	0.0282	0.035	760
Squab	605.0	26/7	0.1525	0.1186	0.3558	0.966	570.4	261.8	832	68.53	31.47	24,300	0.0281	0.035	765
Wood Duck	605.0	30/7	0.1420	0.1420	0.4260	0.994	572.0	375.6	948	60.35	39.55	28,900	0.0279	0.034	774
Teal	605.0	30/19	0.1420	0.0852	0.4260	0.994	572.0	367.4	939	60.89	39.11	30,000	0.0278	0.034	773
KingBird	636.0	18/1	0.1880	0.1880	0.1880	0.940	597.2	93.6	691	86.45	13.55	15,700	0.0270	0.033	773
Swift	636.0	36/1	0.1329	0.1329	0.1329	0.930	596.9	46.8	644	92.80	7.20	13,800	0.0271	0.033	769
Rook	636.0	24/7	0.1628	0.1085	0.3255	0.977	600.0	219.1	819	73.23	26.77	22,600	0.0268	0.033	784
Grosbeak	636.0	26/7	0.1564	0.1216	0.3648	0.990	599.9	276.2	876	68.53	31.47	25,200	0.0267	0.033	789
Scoter	636.0	30/7	0.1456	0.1456	0.4368	1.019	601.4	394.9	996	60.35	39.65	30,400	0.0256	0.033	798
Egret	636.0	30/19	0.1456	0.0874	0.4370	1.019	601.4	386.6	988	60.89	39.11	31,500	0.0266	0.033	798
Flamingo	666.6	24/7	0.1667	0.1110	0.3330	1.000	629.1	229.7	859	73.23	26.77	23,700	0.0256	0.032	807
Gannet	666.6	26/7	0.1601	0.1245	0.3735	1.014	628.7	288.5	917	68.53	31.47	26,400	0.0255	0.031	812
Stilt	715.5	24/7	0.1727	0.1151	0.3453	1.036	675.2	246.5	922	73.23	26.77	25,500	0.0239	0.029	844
Starling	715.5	26/7	0.1659	0.1290	0.3870	1.051	675.0	309.7	985	68.53	31.47	28,400	0.0238	0.029	849
Redwing	715.5	30/19	0.1544	0.0926	0.4630	1.081	676.3	434.0	1,110	60.89	39.11	34,600	0.0236	0.029	859
Coot	795.0	36/1	0.1486	0.1486	0.1486	1.040	746.2	58.5	805	92.80	7.20	16,800	0.0217	0.027	894
Cuckoo	795.0	24/7	0.1820	0.1213	0.3640	1.092	749.9	273.8	1,024	72.23	26.77	27,900	0.0215	0.027	901
Drake	795.0	26/7	0.1749	0.1360	0.4080	1.108	750.3	344.2	1,094	68.53	31.47	31,500	0.0214	0.026	907
Tern	795.0	45/7	0.1329	0.0886	0.2660	1.063	749.8	146.1	896	83.69	16.31	22,100	0.0216	0.027	887
Condor	795.0	54/7	0.1213	0.1213	0.3639	1.092	749.5	273.6	1,023	73.25	26.75	28,200	0.0215	0.027	889
Mallard	795.0	30/19	0.1628	0.0977	0.4885	1.140	751.9	483.1	1,235	60.89	39.11	38,400	0.0213	0.026	918
Chutepoke	850.0	45/7	0.1375	0.0917	0.2751	1.100	804.5	159.6	964	83.40	16.60	23,192	0.0204	0.025	935
Les Boules	864.9	42/7	0.1435	0.0797	0.2391	1.102	813.4	121.1	935	87.04	12.96	22,480	0.0201	0.025	950
Ruddy	900.0	45/7	0.1414	0.0943	0.2829	1.131	848.7	165.5	1,014	83.69	16.31	24,400	0.0191	0.024	958
Canary	900.0	54/7	0.1291	0.1291	0.3873	1.162	849.0	309.9	1,159	73.25	26.75	31,900	0.0190	0.024	961
Rail	954.0	45/7	0.1456	0.0971	0.2913	1.165	899.9	175.5	1,075	83.69	16.31	25,900	0.0180	0.023	993
Cardinal	954.0	54/7	0.1329	0.1329	0.3987	1.196	900.7	328.4	1,228	73.25	26.75	33,800	0.0179	0.023	996

Soda Mountain

500kV HVAC Underground Cable System Design Basis

June 17, 2025 – First Issue

Prepared by:
Stantec Consulting

Stantec Project Number:
224202943

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1 Introduction

As a part of the 10% Design for the Soda Mountain Transmission Line and Switching Station, Stantec was requested to provide a preliminary design for a HVAC underground cable system crossing beneath a state highway.

The HV cable system shall transmit a load of 315MVA at 500kV. The highway crossing shall be realized by means of a jack and bore installed tunnel with cables installed in ducts. The cables will be terminated at transition stations connecting to the overhead line at the respective ends.

This design report covers cable routing, installation considerations for the highway crossing, electrical system characteristics with the respective ampacity studies as well as a conceptional design for the cable sections and the transition compound to the overhead line.

This design submittal is intended to facilitate permitting efforts and initial project planning and is not for construction.

2 HV Cable System Design

2.1 Electrical Cable System Requirements

Table 1 provides a summary of the electrical requirements for the underground cable system.

Table 1 - Summary Electrical Cable System Requirements

System frequency	60 Hz
Nominal rated operating voltage, phase-to-phase, U	500 kVac rms
Nominal rated operating voltage, between phases, Uo	290 kVac rms
Maximum continuous operating voltage between phases, Um (105%*U)	525 kVac rms
Emergency 15-minute overvoltage between phases (110%*U)	550 kVac rms
Basic Impulse Level	1550 kV peak
Nominal apparent power rating	315 MVA
Daily load factor	100%
Number of 3-phase cable circuits	1
Number of cables per phase	1
Nominal rated current	364 A (required) 400 A (design value)
Cable metallic screen bonding method	Solid bonding
Required service life	40 years

2.2 Cable Routing

The approximate length of the underground cable crossing the highway is 400ft. Depending on the exact location of the underground to overhead transition compounds, the total cable system length will be around 900ft.

As an alternative to the transition compound to the overhead line at P1, the underground cable system can be extended by roughly 330ft to directly tie into the SMSP Collector Substation. This will save the land requisition and environment investigation for the transition compound at P1.

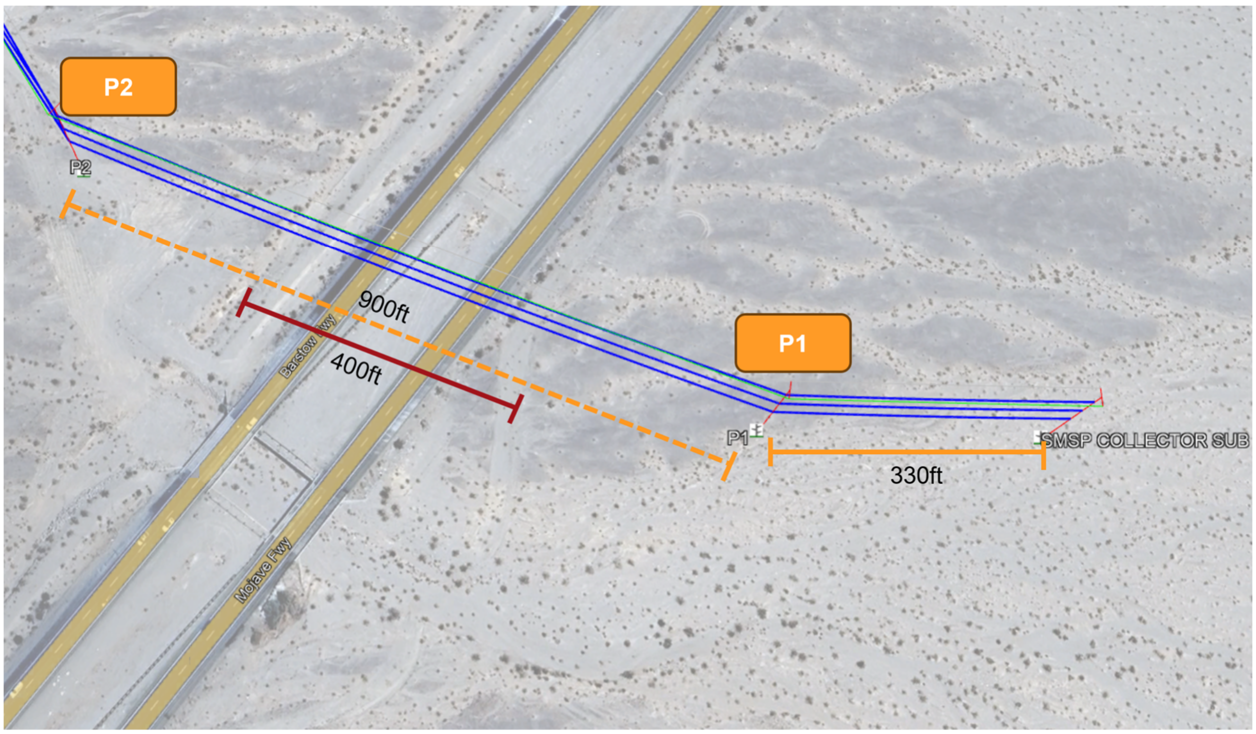

Figure 1 - Preliminary Cable System Routing Plan View

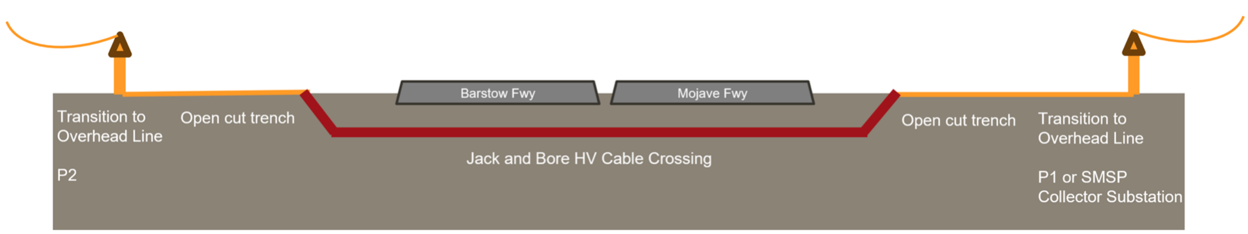

Figure 2 - Preliminary Cable System Schematic

2.2.1 Open Cut Trench

Open cut trenching is a widely used method for installing HV cables, involving the excavation of a trench along a predetermined route to accommodate the cable system. The process begins with surveying and marking the corridor, followed by excavation using machinery such as backhoes or trenchers, depending on soil conditions and project scale. Typical corridor widths range from 3 to 6 feet at the bottom to allow sufficient space for equipment access and safe working conditions, while trench depths are generally between 4 and 6 feet to ensure adequate cable burial and protection from surface activities.

HV cables are typically laid within protective conduits, such as PVC or HDPE pipes, to shield them from mechanical damage and environmental factors. For enhanced mechanical protection, especially in areas with heavy traffic or unstable soil, a concrete envelope may be cast around the conduits to provide additional structural integrity.

Backfilling is performed with native soil if it meets stability and compaction requirements; however, in cases where thermal performance is critical to prevent cable overheating, thermally stable materials like sand or specialized backfill mixes are used to ensure efficient heat dissipation and long-term reliability of the cable system.

Figure 3 - Example Duct Bank in Open Cut Trench (Source: Wappapello Lake Duct Bank Project)

2.2.2 Trenchless Highway Crossing

The preliminary design of the HV underground cable system assumed the use of jack and bore trenchless technology for the installation of a steel pipe to cross underneath the highway to ensure minimal surface disruption.

This method involves the use of a hydraulic jacking system to drive a steel casing pipe through the soil from a launch pit to a receiving pit, guided by precise alignment techniques to maintain the required trajectory and grade. The process begins with the excavation of pits on either side of the highway, followed by the installation of the steel casing, which is advanced incrementally while simultaneously removing soil via an auger within the pipe. This technique is selected for its ability to navigate challenging subsurface conditions, avoid disturbance to freeway traffic, and provide a robust conduit for the cable system, ensuring long-term reliability and protection of the utility infrastructure.

The length over which a pipe jack can be installed is dependent upon many interrelated and variable factors, such as the stability and friction characteristics of the geology being tunneled through, the self-weight and strength of the pipes, the diameter of pipe, the type of excavation method and the available jacking reaction. The major constraint will be the soil and ground water characteristics. In small diameters (up to 3 ft) jacking lengths of up to 1000 feet are generally achievable. In larger diameters, lengths more than 0.6 mile (3168 feet) are possible, depending on ground conditions and excavation methods.

Figure 4 - General layout of pipe jacking with cutting head (courtesy of Cigré TB 770)

2.3 Installation Conditions

The preliminary design of the underground cable system was performed for the installation conditions stated in the table below. Ambient temperatures consider the highest occurring seasonal temperature at the respective burial depth derived from the highest and lowest average ambient air temperatures for the region throughout the year.

Table 2 - Overview Installation Conditions

Route Section	Installation Conditions	Environmental Conditions
Connection to Transition Station or Substation (Direct buried conduits)	Installation in HDPE Ducts ID: 8” OD: 8.6” 8.6” spacing between the ducts 4ft coverage	Ambient temperature 32°C Thermal resistivity 0.9 Km/W
Highway Crossing (Jack and bore)	Cables in HDPE Ducts in Steel Pipe ID: 22.8” OD: 23.6” 23ft coverage	Ambient temperature 22°C Thermal resistivity 0.9 Km/W
Transition to Overhead Lines	Cables installed vertically in air	Air temperature 40°C Solar radiation 100W/ft^2

2.4 HV Cable Design General Description

This chapter provides a general description of the HV cable design and accessories. Please refer to chapter 2.5 for the estimated cable type and ampacity studies.

Conductor

The conductor is typically made of copper or aluminum, designed to carry the rated electrical current. For HV underground cables, the lay up of the conductor consists of either round stranded compacted wires or a Milliken design. A Milliken conductor design consists of multiple insulated, wedge-shaped conductor segments arranged in a circular pattern to form a single conductor. These segments are transposed or twisted along the cable length to ensure uniform current distribution, minimizing AC resistance and heat generation. The design also includes a central filler or core to maintain structural stability. This configuration is particularly effective for large cross-section cables used in high-voltage applications, enhancing efficiency and reducing energy losses

Insulation

The cable insulation system consists of extruded crossed linked polyethylene fully bonded to the semiconductive conductor and the insulation screens. Insulation and screens shall be extruded simultaneously using a true triple extrusion cross-head die followed by dry curing. Degassing is required in order to remove harmful by-products of the cross-linking process.

Metallic Sheath
A metal sheath is provided as a radial water barrier and path for fault current. For extruded insulated cables, a water-blocking cushion layer is applied under the metal sheath to allow thermal expansion of extruded insulation under full load condition and to limit longitudinal migration of water in case of external cable damage. Typical metal sheath designs for land cables are copper wire screens with an overlapping aluminum/copper foil, or a smooth welded aluminum sheath.

Anti-corrosion Outer Sheath
A seamless polymer corrosion protection layer with low water vapour transmission properties is applied over the metal sheath. Its thickness is designed (i) to be sufficient to withstand transient overvoltages developed between the metal sheath and an external earth plane, (ii) to provide mechanical protection against abrasion during handling, transportation, and installation activities.

2.4.1 Accessories

Cable Joints

Due to the short cable system length cable joints are not foreseen for this project.

Cable Terminations

Cable Terminations shall have polymer insulator filled with non-flammable oil. Pollution class requirements need to be coordinated with the overhead transmission line design at a later project stage

Figure 5 - Example HV Cable Terminations transition with overhead line.

Link Boxes

Link Boxes for direct earthing shall be installed at the cable terminations to connect the cables metallic sheaths to the local grounding system at the underground to overhead transition compounds.

Fiber Optic cable

A standalone fibre optic cable will be installed in a separate duct next to the HV cable system. The fibre optic cable will be connected to OPGW of the overhead transmission line at the transition compounds.

Earth continuity conductor

The earth continuity conductor (ECC) for a high-voltage (HV) cable system is a dedicated metallic conductor, typically copper or aluminum, designed to provide a low-impedance path for fault currents to ensure safe grounding. It is installed in a separate duct alongside the HV cables, maintaining continuous electrical connectivity to the earthing system.

2.5 Preliminary Ampacity Studies

The ampacity calculations were carried out with Cymcap 9.0 Rev1 modelling HVAC underground cables under steady state conditions. The conductor temperature shall not exceed 90°C for XLPE insulated cables. As per chapter 2.1 the cable system shall continuously transmit 400A per phase. The figures below show the results of the ampacity studies for the installation conditions stated in chapter 2.3.

The proposed cable type has a conductor size of 800mm² and is made of round stranded aluminum wires. The overall cable diameter is about 5”.

For all cable installations the conductor temperatures do not exceed 90°C under continuous loading conditions.

These ampacity studies at this stage serve as a proof of concept. The final cable design and conductor sizing shall be the responsibility of the cable manufacturer.

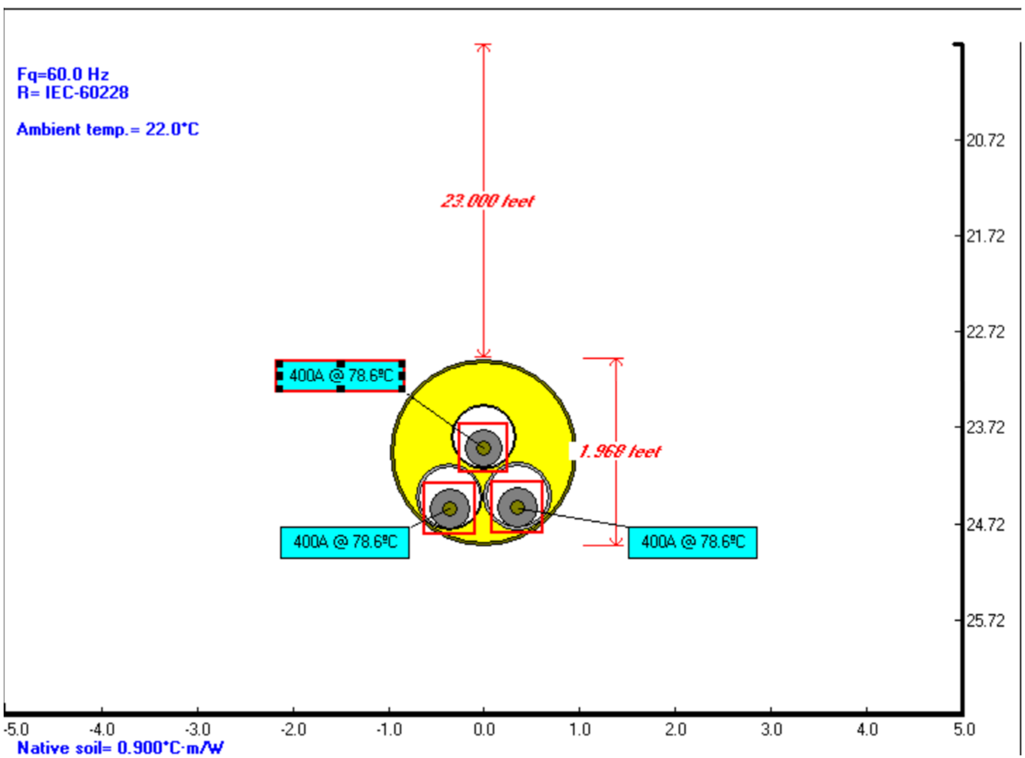

Figure 6 - Cables in HDPE Ducts in Steel Pipe

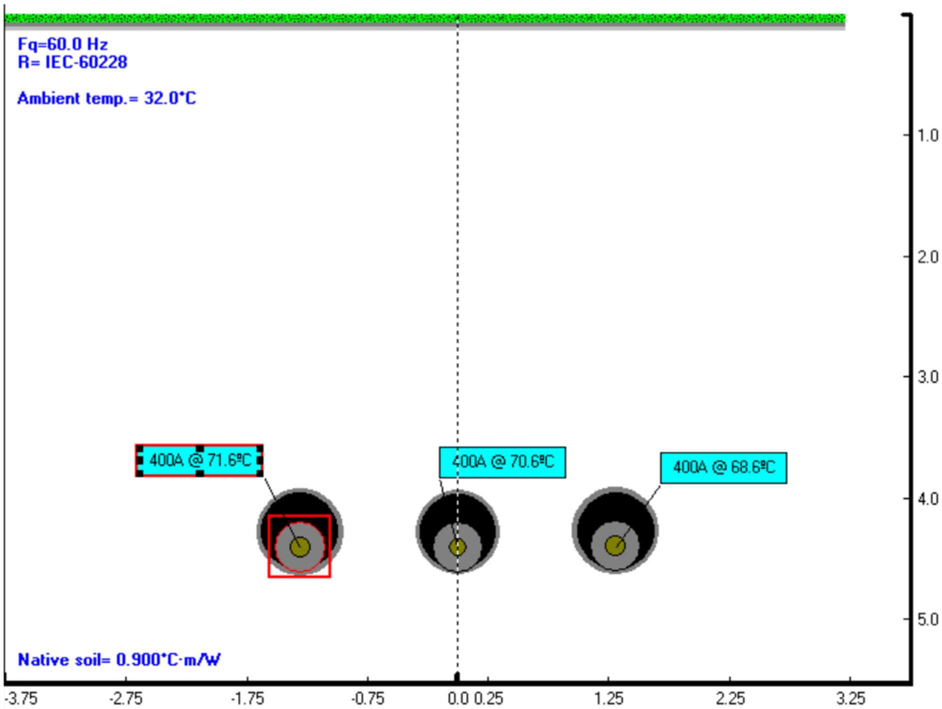

Figure 7 - Cables in directly buried HDPE conduits installed by open cut trench methods

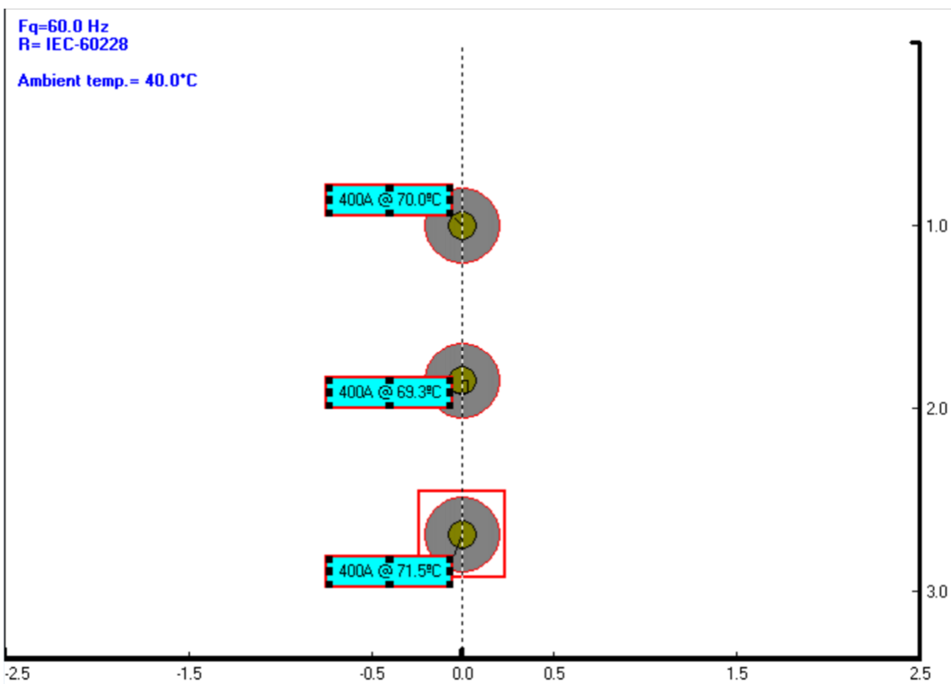

Figure 8 - Cables in Air (vertically installed)

3 Conceptual Designs

The conceptual designs provided in this chapter shall serve as a preliminary design basis considering the installation conditions, environmental conditions and the results of the ampacity studies introduced in the previous chapters.

All design drawings indicate the estimated space requirements for the HV cable system at the different routing sections and the transition compound. Please note that the drawings are not to scale and intended for construction.

3.1 Trenchless Highway Crossing

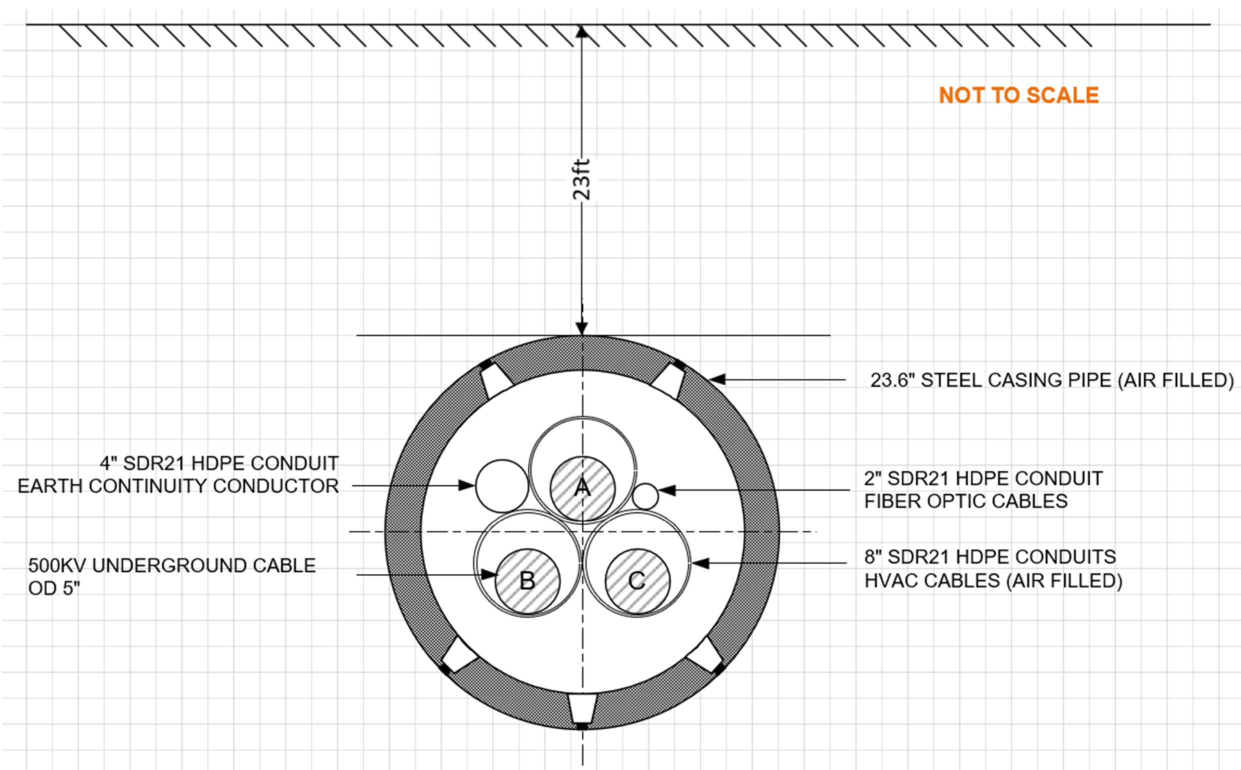

Figure 9 - Conceptual Design for HV Underground Cable Highway Crossing

3.2 Open Cut Trench

For the open cut trench sections, a 45° cut angle was assumed for the preliminary layout. The final design depends on the actual type of soil and required installation depth. A concrete envelope around the cable ducts can be considered for additional mechanical protection if required.

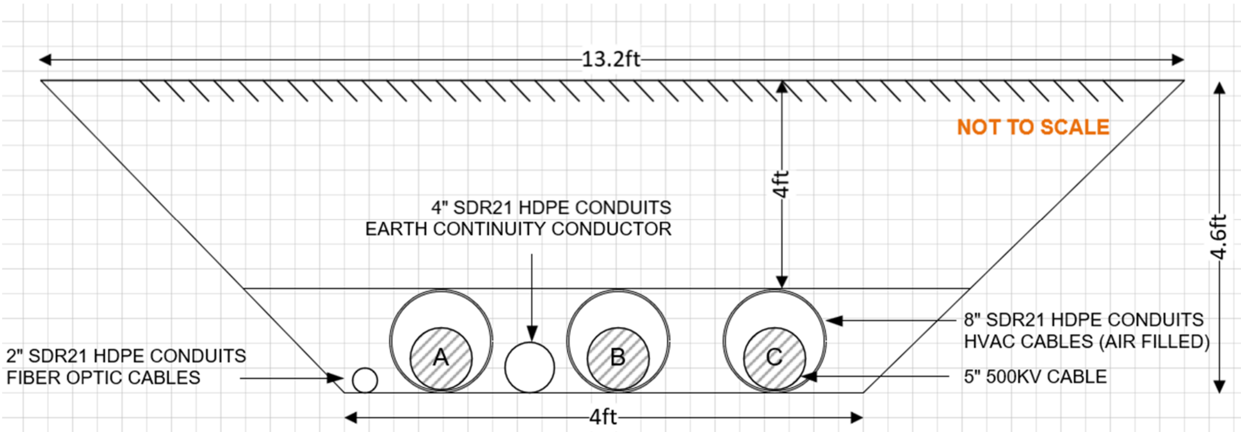

Figure 10 - Conceptual Design for HV Underground Cables in Open Cut Trench

3.3 Transition Compound

Transition compounds will be required at the respective ends of the highway cable crossing to connect the underground cable system with the overhead transmission line. This section provides a conceptual design.

Figure 11 - Example 400kV Transition Compound (Source: Reimagining the Grid | T&D World)

Below is a list of the major equipment which will be required at the transition compound. The required equipment should be refined during the detailed engineering stage of the project and finally confirmed when the cable supply contract is awarded. It is assumed that the transition compound will be unmanned, and personnel will visit the compound only when necessary.

- Line dead end structures
- Surge arresters
- Cable terminations
- Disconnect and ground switches
- Link boxes for cable sheath bonding
- Fibre optic splice box
- Fibre optic communications interface between underground and overhead sections

The requirement for disconnectors and ground switches can be assessed at a later project phase.

Figure 12 presents a conceptual single line diagrams (SLD) for the transition compound.

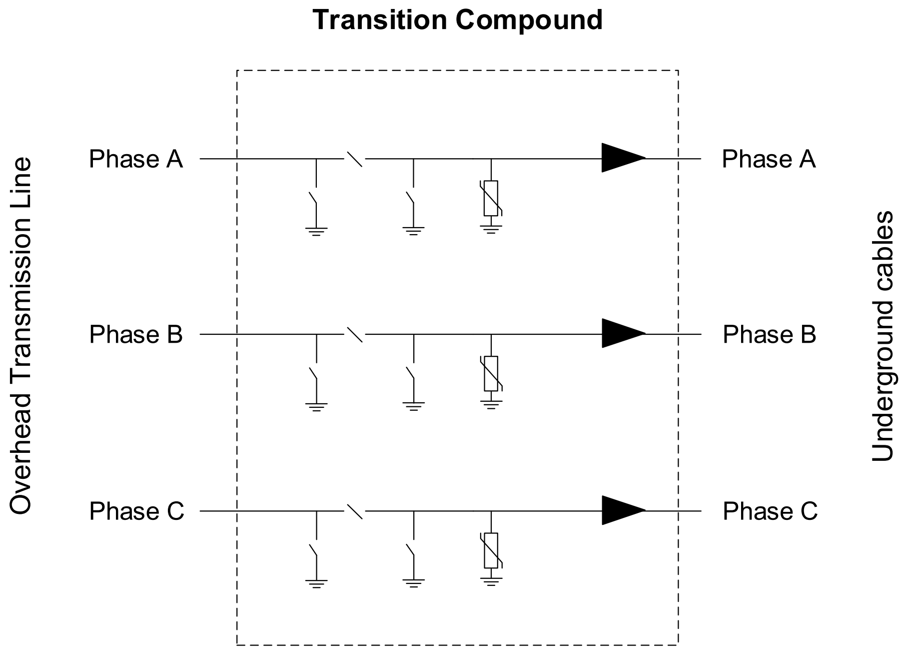

Figure 12 - Overhead to Underground Transition Station Single Line Diagram (SLD)

Grounding Requirements

The local ground grid for the transition compound shall ensure safe tolerable touch and step potentials under fault conditions.

A grounding study shall be performed in accordance with IEEE 80 using the CDEGS software.

Conceptual Plan & Profile Layouts

For consideration, Figure 13 presents a conceptual layout for an underground to overhead transition compound with a footprint of approximately 45m x 45m (148ft x 148ft).

NOTE: Protective screens around the cable terminations (see below example Figure 14) may be required to protect the terminations from vandalism and simultaneously contribute to beautification aspects by reducing visibility. However, this approach may increase the transition compound dimensions.

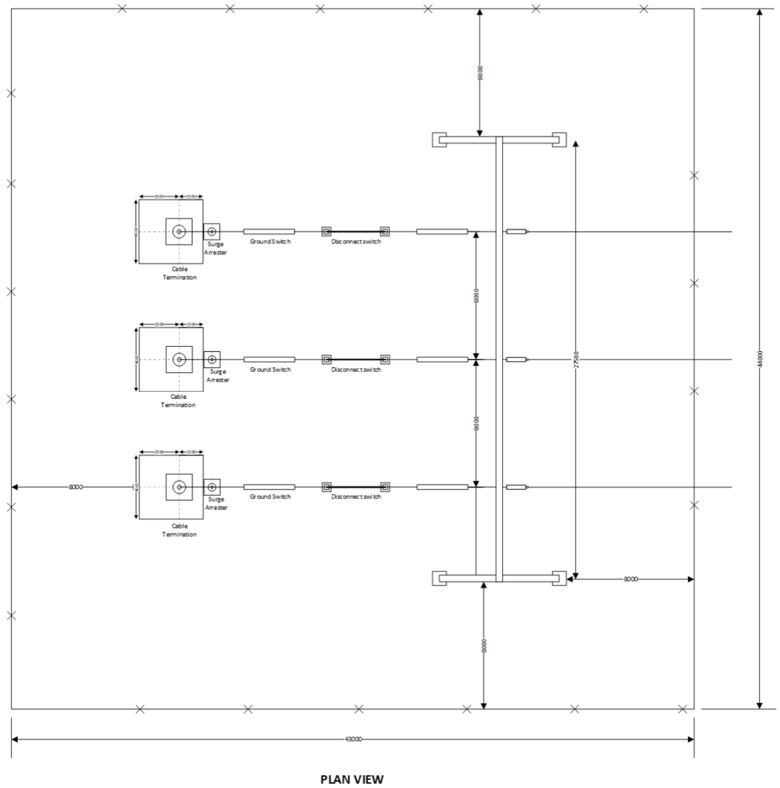

Figure 13 - Transition Compound Conceptual Arrangement

Figure 14 - Example Fenced Transition Compound (Source: [Reimagining the Grid | T&D World])

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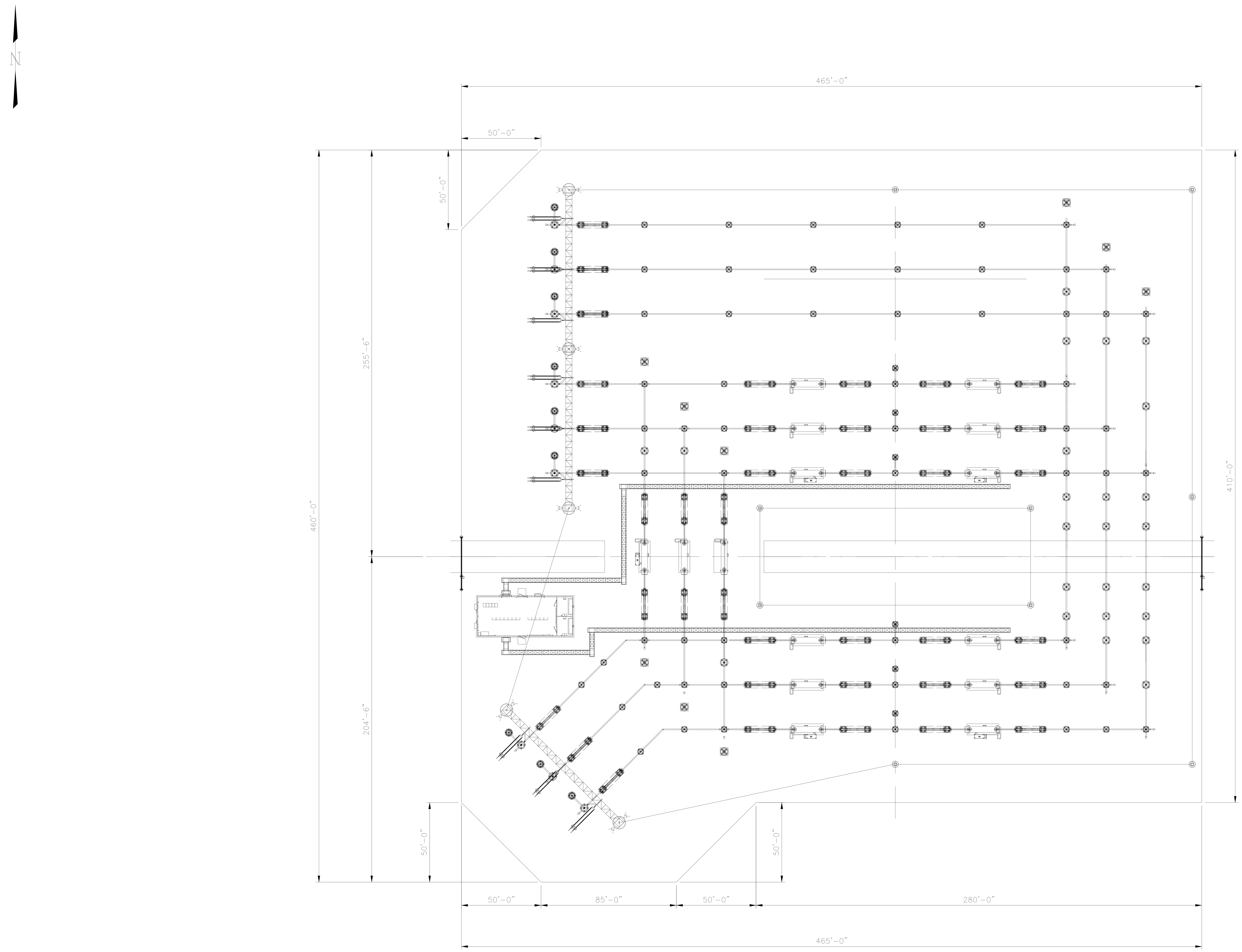
Stantec is a global leader in sustainable engineering, architecture, and environmental consulting. The diverse perspectives of our partners and interested parties drive us to think beyond what's previously been done on critical issues like climate change, digital transformation, and future-proofing our cities and infrastructure. We innovate at the intersection of community, creativity, and client relationships to advance communities everywhere, so that together we can redefine what's possible.



NO.	REVISIONS	DATE	ENG	DES/DFT	CHK

NO.	REVISIONS	DATE	ENG	DES/DFT	CHK

VC Renewables A VITOL COMPANY

Stantec Consulting Engineers

ENGINEERING RECORD	DATE
DES/DRFT BY: STC/EWL	XX/XX/XX
ENGINEERED BY: STC/KJL	XX/XX/XX
CHECKED BY: STC/XXX	XX/XX/XX

SODA MOUNTAIN SOLAR
500 kV INTERCONNECTION SWITCHING STATION
SUBSTATION LAYOUT SKETCH

CADFILE: SODA MOUNTAIN PLAN 05-15-2025.DWG | SCALE: NONE | DWG. NO. XXX | SHEET 1 OF X | REV 0