Design Basis Memorandum

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1. Overview

1.1 Project Description

The Fort Providence to Hay River 72 kV & 25 kV Interconnection Project “FPHR Line” is designed to interconnect the communities of Fort Providence, Dory Point, and Kakisa to the existing transmission grid. The FPHR Line comprises the following components. (Refers to Appendix A for the Project Map)

1. New 72 kV switching station at the Fort Smith Highway Junction.
2. New 72 kV transmission line from Highway-1 / Highway-5 Junction to Kakisa Junction (length of 120 km -first 36 km includes a 25 kV underbuilt circuit and neutral-).
3. New 72/25 kV substation at Kakisa Junction.
4. New 25 kV distribution line from Kakisa Junction to Fort Providence (length of 54 km), that includes a isolated cable attached to the Deh Cho bridge for crossing of the Mackenzie river.
5. Existing single-phase 14.4 kV distribution line between Kakisa Junction and Kakisa to be upgraded to 3-phase 25 kV (length of 13 km).
6. New 25 kV/4160 V substation in Fort Providence.
7. New Kakisa 25kV substation.
8. New Dory Point 25 kV substation.

This Design Basis Memorandum (DBM) provides the preliminary facility specifications.

Provisions for underbuilt installation of the existing Fiber Optic (FO) will be made in case this become necessary.

1.2 System Characteristics

Facility voltages are described as per the following tables:

Property	Specification	
	72 kV Transmission Line Facilities	25 kV Transmission Line Facilities
Nominal Voltage	72.0 kV	25.0 kV
Normal Operating Voltage	69.0 kV - 75.0 kV	23.0 kV - 27.0 kV
Minimum Operating Voltage	68.0 kV	22.5 kV
Maximum Operating Voltage	77.5 kV	27.5 kV

1.3 Right of Way

The 72kV Line will be built on the Highway Right of Way (RoW), following the same alignment of the existing line from Hay River to Enterprise. All new transmission structures must be placed on the same side of the road as the existing distribution circuit with adequate setback from Northwestel Fiber Optic (FO).

Distance from the centreline to the edge of the RoW for the Transmission line is 8.5 m, for an assumed average Ruling Span of 100 m. Additional RoW requirement in longer spans shall be assessed in case by case basis.

1.4 Coordinates System

The FPHR Line coordinates system is UTM Zone 15N NAD 83 (CSRS) derived from differential GPS observations referred to local geodetic control networks.

1.5 Applicable Codes & Standards

The minimum standards are listed in the following. These lists are not exhaustive. Industry best practices shall be adopted where not specifically included in the list.

The listed codes and standards are referenced to establish minimum requirements. The most recent versions shall apply:

1.5.1 CSA Standards

1. CSA C22.2 No. 41, Grounding and bonding equipment
2. CSA C22.2 No 232, Optical fiber cables
3. CSA C22.3 No. 1, Overhead systems
4. CSA C22.3 No. 3, Electrical coordination
5. CSA C22.3 No. 5, Recommended practices for electrical protection – electric contact between overhead supply and communication lines
6. CSA C22.3 No. 6, Principles and practices of electrical coordination between pipelines and electric supply lines
7. CSA C22.3 No. 60826, Design criteria of overhead transmission lines
8. CSA C22.3 No. 60826, Design criteria of overhead transmission lines
9. CSA C49.1, Round Wire, Concentric Lay, Overhead Electrical Conductors
10. CSA-C57, Electric power connectors for use in overhead line conductors
11. CSA C71-1, Insulation coordination-part 1: Definitions, principles and rules
12. CSA C71-2, Insulation coordination-part 2: Application guide
13. CSA C83, Communication and powerline hardware
14. CSA C411.1, AC suspension insulators

15. CSA C411,4, Composite suspension insulators
16. CSA C411.6, Line post composite insulators for overhead distribution lines
17. CSA C411.7, Composite insulators for guy wires
18. CSA C61089, Round wire concentric lay overhead electrical stranded conductors
19. CSA G12, Zinc-coated steel wire strand
20. CSA O15, Wood Utility Poles and Reinforcing Stubs
21. CSA O80, Wood Preservation

1.5.2 IEEE Standards

22. IEEE 524, Guide to the installation of overhead transmission line conductors
23. IEEE 738, Standard for calculating the current-temperature of bare overhead conductors
24. IEEE C135.1, Standard for Zinc-Coated Steel Bolts and Nuts for Overhead Line Construction

1.5.3 Other References

25. Industry Canada ICES-004, “Interference Causing Equipment Standard, AC High Voltage Power Systems”
26. ANSI C29.12, Standard For Insulators Composite - Suspension Type
27. Canadian Aviation Regulations, Standard 621.19, Standards Obstruction Markings
28. Canadian Pacific Railway, Crossing Manual

2. Climate

2.1 Wind Load

To meet the typical reliability objectives for the transmission line, 50-year return gust values have been selected for structure strength design. Both 50-year return wind and 5-year return wind will be applied for electrical clearance design.

2.2 Ice Load

The project area is not expected to be subject to significant amounts of either glaze ice deposits or significant wet snow events.

In-cloud icing is common in many areas of the Northwest Territories and Yukon. Hence a load case consisting of in-cloud icing, without wind, is included.

2.3 Combined Ice & Wind Load

The region southwest of Great Slave Lake is in the CSA Medium B Loading area as defined by CSA C22.3 No.1-15. This loading consists of 12.5 mm glaze ice and a 300 Pa wind pressure, at -20° C. This load case, with the overload factors specified in the CSA Standard.

The Rime Icing & Wind loading is included to reflect loading conditions that have been observed in northern areas of Alberta reasonably proximate to the project area.

2.4 Unusual Climatology

The proposed transmission line will not traverse mountainous areas that might be subject to unusual weather conditions. Hence there is no requirement for weather loadings like Tornados, Hurricanes, Extreme Ice, Microbursts.

The 25 kV segment of the facility will cross the Mackenzie River within conduit attached to the Deh Cho Bridge, and will therefore not be subject to unusual weather conditions at the river crossing.

2.5 Pollution Level

The transmission line is located in an area of low contamination.

2.6 Weather Conditions

The following are weather load cases for detailed design of the Transmission line.

Weather Loading Conditions				
Loading Condition	**Temp (°C)**	**Wind (Pa)**	**Radial Ice/Snow (mm)**	**Ice/Snow Density (kg/m^3)**
CSA Medium B	-20	300	12.5	900
Rime Icing & Wind	-15	230	40	350
Max Cold (Uplift)	-50	0	Bare	-
50-year return wind	0	750	Bare	-
5-year return wind	0	415	Bare	-
Mean Annual	0	0	Bare	-

3. Conductors, Insulators, and Support Hardware

Shield wire will not be used on either the 72 kV or 25 kV facilities.

3.1 Conductor Physical Details

Single 1/0 ACSR "Raven" Conductor is chosen for the following lines:

- Phase conductor for the 72kV line from Fort Smith to Kakisa Junction.
- Phase conductor and neutral conductor for the 25 kV under build line on the 72 kV structures from Fort Smith to Pellet Mill.
- Neutral conductors for the new 25 kV line from the Kakisa Junction to Fort Providence.

The characteristics of single 1/0 ACSR "Raven" Conductor are included in the following table:

1/0 ACSR "Raven" Conductor	
Property	**Specification**
Stranding Al./Steel	6/1
Conductor Diameter (mm)	10.1
Total Mass (kg/m)	0.2165
Cross-Section Area Al./Total (mm^2)	53.51/62.43
Rated Tensile Strength (kN)	18.9
DC resistance @20°C (ohm/km)	0.5363

The phase conductor for the new 25 kV line from the Kakisa Junction Substation to Fort Providence section shall be single 266.8 ACSR "Waxwing" type. Summaries of the conductor characteristics are included in the following table:

266.8 ACSR "Waxwing" Conductor	
Property	**Specification**
Stranding Al./Steel	18/1
Conductor Diameter (mm)	15.45
Total Mass (kg/m)	0.431
Cross-Section Area Al./Total (mm^2)	135.2/142.7
Rated Tensile Strength (kN)	31.2
DC resistance @20°C (ohm/km)	0.2130

The 1.7 km of insulated cable to be installed in conduit and/or rack under the Deh Cho bridge is assumed to be 3-phase XLPE.

The phase conductor and neutral for the 25kV line from Kakisa Junction to Kakisa shall be single No. 2 AWG ACSR "Sparrow" type. Summaries of the conductor characteristics are included in the following table:

No. 2 AWG ACSR "Sparrow" Conductor	
Property	**Specification**
Stranding Al./Steel	6/1
Conductor Diameter (mm)	8.01
Total Mass (kg/m)	0.136
Cross-Section Area Al./Total (mm^2)	33.63/39.22
Rated Tensile Strength (kN)	12.4
DC resistance @20°C (ohm/km)	0.8534

3.2 Conductor Tension Limits

The limiting conductor tensions for producing sag and tension charts are shown in the following table:

Limiting Conductor Tensions (Sag and Tensions Charts)					
Weather Condition	**Condition**	**Temp (°C)**	**Wind (Pa)**	**Radial Ice (mm)**	**% UTS**
CSA Med B (900 kg/m^3)	Final	-20°	300	12.5	50%
Rime Icing (350 kg/m^3)	Final	-15°	230	40	75%
Max Cold - Uplift	Initial	-50°	0	Bare	50%
Cold - Vibration	Initial	-30°	0	Bare	30%
Mean Annual	Final	0°	0	Bare	20%
Mean Annual	Initial	0°	0	Bare	25%

3.3 72 kV Insulators

The preferred insulation to be used for all applications on the 72 kV transmission system shall be synthetic silicone rubber type. It is intended that all insulation be limited to the use of Type J (ANSI 52-5) hardware. To manage uplift in certain situations it may be necessary to utilize porcelain insulators.

- 72 kV Suspension Insulators:

Tangent Applications shall use insulators with y-clevis-ball end fittings, whereas ball-socket type insulators are to be used for dead end and heavy angle applications.

72 kV Suspension Insulators				
Insulation Properties	**Type J Deadend**	**Type J Tangent**	**Porcelain Deadend 5 bell**	**Porcelain Tangent 4 bell**
Section Length (m)	0.876	0.730	0.730	0.584
Min. Normal Leakage Dist. (mm)	1550	1450	1600	1280
Arcing min Dist. (mm)	660	660	900	750
ANSI Dry Low Freq. Flashover (kV)	250	225	350	280
ANSI Wet Low Freq. Flashover (kV)	225	200	250	200
ANSI CIFO Negative (kV)	400	385	550	420
ANSI CIFO Positive (kV)	400	385	525	400
SML or M&E Strength (KIPS)	30	30	30	30
Min Design Working Load (KIPS)	15	15	15	15

72 kV Suspension Insulators				
Insulation Properties	**Type J Deadend**	**Type J Tangent**	**Porcelain Deadend 5 bell**	**Porcelain Tangent 4 bell**
Estimated Mass (lbs)	7	7	50	40

- 72 kV Line Post Insulators:

The standard end fittings for Tangent and Light Angle applications shall be drop eye for horizontal posts, and trunnion clamps for vertical posts. Horizontal line posts may use optional trunnion clamp end fittings.

All insulation used must meet or exceed the following minimum mechanical and electrical properties for line post insulators, and should be standardized whenever possible.

72 kV Post Insulators			
Insulation Properties	**Horizontal**	**Vertical**	**Jumper Post**
Section Length (m)	0.876	0.876	0.876
Min. Normal Leakage Dist. (mm)	1700	1700	1700
Arcing min Dist. (mm)	675	675	675
ANSI Dry Low Freq. Flashover (kV)	270	270	270
ANSI Wet Low Freq. Flashover (kV)	255	255	255
ANSI CIFO Negative (kV)	435	435	435
ANSI CIFO Positive (kV)	425	425	425
SCL Minimum Strength (kN)	20.0	20.0	20.0
MDCL Minimum Strength (kN)	10.0	10.0	10.0

3.4 25 kV Insulators

The standard distribution insulation for Tangent and Light Angle applications shall be porcelain pin type on vertical post arrangement. Horizontal line posts may use optional trunnion clamp end fittings. Clevis-Tongue type polymer insulators are to be used for dead end and heavy angle applications.

25 kV Post Insulators		
Insulation Properties	**Horizontal**	**Vertical**
Section Length (m)	0.4	0.4
Min. Normal Leakage Dist. (mm)	465	465
Arcing min Dist. (mm)	265	265
ANSI Dry Low Freq. Flashover (kV)	110	110
ANSI Wet Low Freq. Flashover (kV)	90	90

25 kV Post Insulators		
Insulation Properties	**Horizontal**	**Vertical**
ANSI CIFO Negative (kV)	240	240
ANSI CIFO Positive (kV)	200	200
MDCL Minimum Strength (KN)	5.3	5.3
Design Tension Strength (KN)	9	9

25 kV Suspension Insulators		
Insulation Properties	**Horizontal**	**Vertical**
Section Length (m)	0.460	0.460
Min. Normal Leakage Dist. (mm)	725	725
Arcing min Dist. (mm)	290	290
ANSI Dry Low Freq. Flashover (kV)	150	150
ANSI Wet Low Freq. Flashover (kV)	130	130
ANSI CIFO Negative (kV)	280	280
ANSI CIFO Positive (kV)	260	260
SML or M&E Strength (kN)	67	67
Min Design Working Load (kN)	33	33
Estimated Mass (lbs)	11	11

3.5 Guy Strain Insulators

All guys passing through the energized conductor levels for anchoring shall include a guy strain insulator installed into the guy wire at the phase height. There shall be isolation of the guy wire above and below the phase conductor. The strength reduction factor of the guy strain insulator shall be 0.5. The guy strain insulator shall be selected so that the factored strength rating is matched to the factored guy wire capacity.

3.6 Fitting Hardware

Strength rating of hardware shall be specified during detailed design.

With the exception of conductor clamps, hardware shall be forged steel with minimum impact properties of 20 Joules at -20° C. Deadend insulators and hardware shall be designed to have a strength rating equal to, or exceeding, the rated strength of the conductor. The general application of design hardware shall include minimum mechanical strengths as well as material properties. Generally all hardware shall be approved for use in extreme low temperature environments, which is to include cold weather properties on all hardware specified by the manufacturer. In addition, a minimum UTS of 110KN shall be used for all ANSI 52-3&5 type hardware. All bolts used in attachment of hardware shall be a minimum of

92.5KN. All steel hardware used in power line construction shall be galvanized to appropriate standards.

3.7 Conductor Accessories

Design criteria for each hardware component shall be specified during detailed design.

3.8 Vibration Protection

Stockbridge type vibration dampers shall be used to control aeolian vibration on the phase conductors. The phase damper design and installation locations shall be as per the damper manufacturer specifications.

4. Electrical Design Criteria

All applicable Codes and Regulatory clearance requirements shall be met, complete with a design, survey, and construction buffer.

4.1 Clearances over Ground

The clearances over ground given below are minimum values at maximum conductor sag under the thermal operating and Ice Loading conditions.

1. Thermal operating conditions:
    - 100°C for 25 and 72 kV conductors
    - 60°C for neutral conductors
2. Ice Loading conditions:
    - CSA Medium B loading
    - Rime Icing & Wind shall be used to check for ground clearances

To ensure the ground clearances specified in the table under the max. conductor sag conditions, the errors related to structure construction, wire sagging, etc. shall be taken into account. The listed clearance buffers in the table are the minimum values to add. The resulting clearances shall be used for line design.

Electrical Clearances over Ground			
Location of Conductors	**Clearance (72 kV)**	**Clearance (25 kV)**	**Clearance (0 kV)**
Basic above ground clearance	5.2 m + 0.9 m buffer	4.75 m + 0.9 m buffer	4.42 m + 0.9 m
Minimum clearance above ground when crossing major roads or Highways	12 m + 1.2 m buffer	12 m + 1.2 m buffer	10 m + 1.2 m buffer
Minimum clearance above ground when crossing underground facilities	5.5 m + 1.2 m buffer	5.2 m + 1.2 m buffer	4.8 m + 1.2 m buffer

Electrical Clearances over Ground			
Location of Conductors	**Clearance (72 kV)**	**Clearance (25 kV)**	**Clearance (0 kV)**
Minimum clearance above railways	8.1 m + 1.2 m buffer	7.6 m + 1.2 m buffer	7.3 m + 1.2 m buffer
Minimum clearance over Kakisa River	N/A	12 m + 1.2 m buffer	12 m + 1.2 m buffer

The final design may adjust and refine the buffers show in addition to the above-mentioned clearance values. Note that some of the clearances are greater than the clearance specified in the CSA minimums, but are used to provide general consideration for ground errors, large equipment, future upgrades, and remoteness of locations.

4.2 Clearances to Structures

The minimum clearance from the energized components to any structure components for switching surge flashover or 60 Hz frequency flashover under all loading conditions shall be designed to the following air gaps:

- For 72 kV lines, the min. air gap = 718 mm.
- For 25 kV lines, the min. air gap = 216 mm.

The suspension insulator swing shall be designed to maintain the above air gaps under the following conditions:

- 60 Hz frequency clearances from the energized conductors to the structure under the 50-year return wind pressure of 750 Pa.
- switching surge clearances from the energized conductors to the structure under a 5-year return wind pressure of 415 Pa.

The minimum electrical clearance between overhead conductors and substation 72 kV bus system shall be 2.2 m. The clearance shall be calculated with conductor under maximum sag (between metallic parts).

4.3 Lightning Performance

The region southwest of Great Slave Lake is not a high-risk lightning area, with a typical expectation of less than 0.5 flashes per square kilometer per year. The lightning performance of this line shall be equivalent to that of similar 72 kV lines in the Hay River area by ensuring that the structure geometry is similar to that of other 72 kV facilities in the area.

4.4 Corona & Field Effects

An Electromagnetic Field Effects study of the line has been completed for the 72 kV facilities. The electric field, magnetic induction, audible noise and radio interference have been calculated considering the lowest point of the conductors in the span at 100° C conductor temperature with no wind and no ice. The values were calculated for maximums within the right-of-way and at the edge of the right-of-way. All of the calculated parameters are within recognized limits and are comparable to other AC lines with similar configurations. The BPA

CAFE program was used to determine the levels of electric field, magnetic field, audible noise, and radio interference.

The line shall be designed to meet applicable standards. The Contractor shall perform field measurements after the line is energized to ensure that the radio noise levels are acceptable.

5. Structural and Foundation Design Criteria

5.1 Failure Sequence

The line shall be designed assuming a specific sequence of failure, which shall be coordinated by appropriate choice of overload factors and selection of component strength. The sequence shall be:

1. Tangent towers to fail first, followed by their foundations.
2. Angle and deadend towers to fail, followed by their foundations.
3. Conductor system, including deadend insulators and hardware.

The adjustment of the overload factors for different structures are applied to achieve the desired sequence of failure.

5.2 Structures

Single wood pole structures will be used for both 72kV and 25kV lines.

All structural design shall employee non-linear deterministic calculation methodologies. If the line designer chooses to use the CSA reliability based method to determine component strength, details of the methodology, including the strength reduction factors, shall be provided.

Typical Structures & Foundation Drawings for 72 kV and 25 kV lines are attached in Appendix B.

5.3 Foundations

5.3.1 Geotechnical Conditions

There is limited access to geotechnical information for pole foundations or anchoring conditions. The following table shows a breakdown, of soil types, made by Midgard in the 2013 report. The report provides specific recommendations (drawing numbers) for pole foundation and anchoring types. The referred drawings are attached in Appendix B.

Geotechnical Conditions			
Line %	**Description of Condition**	**Recommended Pole Foundation**	**Recommended Anchor Type**
33%	4 inches of peat over brown calcareous gravelly loam	T15-SD-9940	T15-SD-9949
26%	Thin organic litter over 2 to 4 inches of yellowish brown loam, over 16 to 20 inches	T15-SD-9993	T15-SD-9949

Geotechnical Conditions			
Line %	**Description of Condition**	**Recommended Pole Foundation**	**Recommended Anchor Type**
	of yellowish brown stony gravelly sandy loam, over shattered sandstone.		
14%	3 to 12 inches of peat over mottled calcareous loamy sand or sand	T15-SD-9940	T15-SD-9923
9%	12 to 40 inches of black disintegrated peat; frozen below a depth of about 18 inches.	T15-SD-9948	T15-SD-9923
9%	Thin organic litter over 6 to 10 inches of brown gravelly loam, over yellowish brown very stony gravelly sandy loam that grades into sandstone.	T15-SD-9993	T15-SD-9949
6%	6 to 12 inches of peat over calcareous silty clay loam	T15-SD-9993	T15-SD-9923
3%	3 inches of organic litter over 5 inches of grayish silty clay loam, over calcareous grayish silty clay loam	T15-SD-9993	T15-SD-9949

5.3.2 Foundation in Muskeg

Soil conditions for a significant portion of the line route are anticipated to consist of a layer of muskeg or permafrost over clay till, sandy soil, or bedrock. The depth of the muskeg and permafrost is expected to vary throughout the line route, and should be verified by geotechnical investigations when the final project design is commenced. A variety of different foundations will be used, depending on the actual soil conditions found at each structure location and can by grouped in two main types as follows:

1. Crib or culvert arrangement (with rock fill), where permafrost and/or bog depth is shallow (i.e. less than the pole burial depth).
2. Wooden platform supporting crib or culvert with rock fill and additional side-guying of the structure, where permafrost and/or bog depth is greater than pole burial depth.

5.3.3 Anchoring

Suitable anchoring will be defined during detailed design. The following anchoring System is being consider:

1. Triple Helix screw anchors,
2. Log Anchor, and
3. Grouted Rock anchors.

5.4 Loading Cases

5.4.1 Over Load Factors (OLFs)

Wood Pole Minimum Load Factors								
Load Case	**Structure Type**	**Grade 2 Load Factors**			**Grade 1 Load Factors**			
		V	**T**	**L**	**V**	**T**	**L**
CSA Medium B	Tang./Angle	1.5	1.3	1.0	2.0	1.9	1.2
	Deadend	1.5	1.3	1.3	2.0	1.9	1.9
Rime Icing & Wind	Tang./Angle	1.5	1.3	1.0	2.0	1.9	1.2
	Deadend	1.5	1.3	1.3	2.0	1.9	1.9
Max Cold (Uplift)	Tang./Angle	1.5	1.3	1.0	2.0	1.9	1.2
	Deadend	1.5	1.3	1.3	2.0	1.9	1.9
50-year return wind	Tang./Angle	1.5	1.3	1.0	2.0	1.9	1.2
	Deadend	1.5	1.3	1.3	2.0	1.9	1.9
Allowable Wood Working Stress	Un-anchored Angle & DE	1.0	1.0	1.0	1.0	1.0	1.0
Sagging (no wind, bare, -20°C initial)	All	1.5	1.5	1.5	1.5	1.5	1.5
Stringing (no wind, bare, -20° C initial)	All	2.0	2.0	2.0	2.0	2.0	2.0
Tie-down (no wind, bare, -40° C initial)	All	2.0	2.0	2.0	2.0	2.0	2.0

The minimum load factors for structural components are in accordance with appropriate standards and additional recommended specifications:

Structural Components Minimum Load Factors			
Structural Component	**Application**	**Grade 2 Load Factor**	**Grade 1 Load Factor**
Foundation (typical)	Poles & Anchors	2.0	2.0
Foundation (saturated soils)	Poles & Anchors	Site Specific Soil Calculations Req.	Site Specific Soil Calculations Req.
Insulator String (SML)	Suspension & Deadends	2.0	2.0

Structural Components Minimum Load Factors			
Structural Component	**Application**	**Grade 2 Load Factor**	**Grade 1 Load Factor**
Insulator Posts (MDCL)	Tangents & Light Angles (max design combined loadings)	1.0	1.0
Insulator Posts (MDCL)	Tangents & Light Angles (everyday combined loadings)	3.0	3.0
Crossarms	Steel	Vert. = 1.15 Long. = 1.10	Vert. = 1.30 Long. = 1.20
Crossarms	Wood	Vert. = 2.00 Long. = 1.60	Vert. = 2.00 Long. = 1.60
Guy Assemblies	All guy hardware	1.25	1.60
Guy Strain Insulator	All	2.0	2.0

All structural members (e.g.: crossarms) capable of supporting a lineman shall be designed for an additional vertical load of 1.0 kN, in addition to supporting the mass of conductors without ice covering for all load cases.

5.4.2 Broken Wire Loads

The tangent and light angle structures shall be designed for an unbalanced longitudinal load. The load shall be the RSL resulting from the 40 mm radial ice load on all phase wires, on both sides of the structure and with the ice dropped on any phase. Failure containment structures in the form of either deadends, heavy angles, or longitudinal tangent support, shall be provided at maximum 6 kms intervals.

The rationale for the above loads is that inclusion of unbalanced longitudinal loads, representing differential ice loading and broken wires, is critical to ensuring reliable performance of transmission lines by reducing the risk of longitudinal cascades. The recommendations above represent common industry practice for resolving these types of loads.

The deadend type structures shall be designed for full tension of all cables attached to the structure, for any of the design loading cases, with wire deadended on one face of the structures and no wire on the other face. This can also represent a station entrance application and will also accommodate any expected stringing or other loading condition for these structures.

5.4.3 Construction & Maintenance Loads

All the structures shall be designed taking into account the loads imposed by assembly & erection, wire stringing & tie-down, and maintenance operations. For tie-down operations, a maximum wire slope of 1 vertical to 3 horizontal shall be assumed, with all wires being tied down at initial tensions at -40°C.

5.4.4 Substation A-frame Loading limits

The loading on the first structure (after A-frame) shall be adjusted to reduce loadings on the A-frame. A-frame loadings are expected to be designed for tension limits in the order of 5 kN per attachment. The actual design loadings shall be determined and provided during detailed design stage.

5.5 Structure Spotting

The major design parameters and related considerations are documented below. Key design parameters include:

1. Electrical clearance over the ground and to structure components as defined in sections 4.1 and 4.2.
2. Structure Strength per weather loads and OLFs.
3. Conductor Uplift Loading Condition: A condition of initial tensions at -50°C shall be used to check for uplift on suspension insulators.
4. Transmission Line RoW shall be inside the 60 m. highway corridor, therefore maximum 100 m span length for swing out will be considered. Additional RoW requirement in longer spans shall be assessed in case by case basis.
5. Anti-cascade structures are considered at each 6 km or less. This condition should be re-evaluated during detailed design.
6. The min. set back distance to water body is 20 m.

6. Substation Design Criteria

6.1 General

The substations shall be designed for continuous and reliable service, safety to all personnel (during construction, operations or maintenance) and equipment, ease of maintenance and operation with electrical and mechanical protection of equipment, interchange ability of equipment, minimal spare parts with consideration and provision for the addition of future loads and expansion if required.

This preliminary design criteria is developed from the MIDGARD Design Basis Memorandum for substations and provides basic requirements for substation/switching station designs for this project. The design shall be carried out as per required codes, standards and specifications that apply for substation projects in Northwest Territories, Canada.

6.2 List of Stations

The project includes following stations:

New stations:

- Fort Smith Highway Junction 72 kV Switching Station
- Kakisa Junction 72/25 kV Substation
- Fort Providence 25/4.16 kV Substation

Modifications of Existing Stations:

- Kakisa Substation (in Kakisa Community)
- Fort Providence Diesel Generation Station
- Dory Point Substation (Dory Point Diesel Plant)

6.3 Station configurations

Preliminary configurations for each station are shown on the Overall Single Line Diagram (H361430-00000-260-288-0001. -Refers to Appendix C-). Configuration of the existing stations are not available at this stage. Detail design consultant shall obtain the drawings for the existing station, verify the configurations and propose required modifications.

The new 72 kV system is fed from existing NUL substation at Pine Point. According to the SLD (SSL-T5), the 72 kV system should be a Wye grounded configuration based on winding configurations of transformer (701T) in NUL substation, which needs to be verified during the detailed design stage.

It is assumed that the Kakisa Junction Substation will remain radially fed via the Fort Smith Highway Junction Switching Station and will not be integrated into a networked power system over the 20-year planning horizon. Therefore, no allowance has been made for multiple 72 kV line terminations.

6.4 Electrical Equipment

All electrical equipment shall be designed and constructed to operate continuously with minimal maintenance at an un0manned substation in remote conditions with climate conditions specified in this document.

The electrical equipment shall have successful supply records to be used for substation projects in Norther Canada at same voltage level.

6.4.1 72 kV Shunt Reactor

The 72 kV line is expected to remain lightly loaded relative to the line's Surge Impedance Loading (SIL) across all forecast load conditions throughout the 20-year planning horizon. It is therefore assumed that a shunt reactor will be required in Kakisa Junction Substation at all times to maintain 72 kV bus voltage within tolerance. The reactor size and need should be verified by appropriate power system studies at detailed design stage.

A circuit switcher is proposed for the shunt reactor protection. Investigations shall be conducted if the 72 kV line has to be de-energized during reactor fault or maintenance.

6.4.2 72/25 kV Transformer & Regulator

A single two-winding 3-phase 72/25 kV 1.5 MVA Delta-Wye oil insulated transformer will be installed in the Kakisa Junction substation. The transformer will not be equipped with an On Load Tap Changer (OLTC). A separate regulator will be provided to maintain 25 kV line voltages, for ease of maintenance and to coordinate with existing spares.

It may be possible to eliminate the regulator within the Kakisa Junction substation since there are no intermediate loads between Kakisa Junction and Dory Point. A pole-mounted regulator can be installed on the 25 kV tap to Kakisa community substation to maintain voltages at the

Kakisa load centre within requirements, and separate regulators can be installed at the Dory Point and Fort Providence load centres.

6.4.3 25 kV Switchyard in Kakisa Junction Substation

A single 25 kV breaker will be provided at Kakisa Junction substation. Outdoor air-insulated configuration is proposed for 25 kV equipment to avoid large foundation of switchgear and underground 25kV cables for connections. Fully enclosed explosion proof metal clad switchgear for 25 kV switchyard of Kakisa Junction Substation is an alternative option and will be reviewed during detailed design stage.

Footprint allowance will be made for a second 25 kV breaker for 25 kV feeders.

The 25 kV circuit to Dory Point and Fort Providence will be equipped with a neutral conductor to provide a positive ground return path and to ensure effective rapid clearing of single phase faults, due to expected high structure footing resistances.

6.5 Control Building

The control building will be a pre-fabricated modular structure. There is limited control and indication at this substation, so the rack space requirements will be minimal.

Control building will include battery banks & chargers, AC/DC panels, protection and control panels and SCADA/Telecom panels. Electrical heaters and air-conditioning units shall be designed and provided with the control building to maintain comfort temperature suitable for personals and equipment installed in the building.

The battery bank shall be located in a separated cell in the control building. The battery bank will be rated to supply power for all critical loads for least eight (8) hours.

The building elevation shall be determined so that the clear height from the underside of the building to finished grade is greater than the maximum snow depth.

6.6 Protection, SCADA & Telecom

Protection schemes will include:

- 72 kV Line distance protections
- Breaker failure protections
- 72 kV bus protections (if required)
- Transformer differential
- Transformer primary and secondary instantaneous and time overcurrent
- 72 kV reactor instantaneous and time overcurrent
- 25 kV feeder protections

It is expected that multifunction digital protection devices will be utilized for protection and control.

SCADA monitoring points will include 72 kV and 25 kV bus voltages, transformer primary and secondary phase currents, transformer temperature, transformer gas, reactor phase currents and reactor gas (if applicable).

It is assumed that voice and SCADA communication between the system control centre and the Kakisa Junction substation will be via Power Line Carrier (PLC) and leased lines/satellite link. There will be few monitoring points and little remotely operable equipment at the substation, so the low baud rate offered by a PLC system should not be any significant constraints.

If an option to attach ADSS optical fibre cable to the new 72 kV and 25 kV facilities is chosen, then it will be possible to provide secure broadband communications into the substation.

6.7 Substations Shielding

Shielding studies shall be carried out during detail designs.

Strategically placed lightning rods at the top of a number of the substation structures and lightning masts shall be designed to ensure adequate shielding for the substations.

6.8 Substation Auxiliary System

The source of auxiliary power shall be obtained from substation service transformer(s) connected to the MV buses (72 kV bus of Fort Smith Highway Junction Switching Station and 25 kV bus of Kakisa Junction Substation). Backup AC power can be obtained from local community distribution systems (if applicable) or from diesel generator installed in the stations.

The auxiliary system shall include all loads required for the station including control building heating and air-conditioning.

6.9 Outdoor Lighting and LV Cabinets

Outdoor lighting fixtures as well as LV cabinets shall be mounted on the structures. Cables feeding the lighting and other equipment shall be carried in cable trenches.

Substation lighting shall meet the minimum lighting levels for the appropriate circumstances of outdoor and roadway areas given in the latest editions of applicable standards. Outdoor substation lighting shall be LED or induction style (no metal halide/high-pressure sodium lamps permitted). Emergency lights operated off the batteries shall be provided in the control building.

6.10 Cables and Cable-trenches

The Contractor shall design, supply and install power, control and communication cables within the substation fence per applicable codes and standards. The cables shall be installed in trenches, ducts or trays, in such way to minimize risk of mechanical damage and fire hazards.

All wiring for instrument transformers, control and auxiliary power shall be 600 V or 1,000 V insulated stranded copper conductor. Standard multiconductor control cable, fully color coded for easy identification shall be used.

Control cable and Power cable shall be segregated within the cable trench per applicable codes and standards.

6.11 Site Preparation & Grounding

Since geotechnical and soil conditions are unknown for the station sites . Generic site preparation requirements are assumed.

The substation areas shall be graded such that it properly drains, and such that water shall not stand in the substation or the surrounding area. Storm water management features may be installed as required. Any accumulation of rain water in the transformer oil containment reservoir shall be separated from any oil and treated such that it is suitably disposable on site.

Organic soil will be removed from the substation site and replaced with suitable structural fill. A ground grid will be installed into the graded and compacted foundation soil, extending at least 1 m outside of the substation fence. After equipment and building foundations have been installed, the entire substation site will be covered with an insulating layer of washed gravel (thickness to be determined after ground potential rise has been analyzed) to mitigate step potential for workers inside the substation during fault conditions. It is expected that a large number of deep-driven ground rods will need to be connected to the ground grid to achieve effective substation grounding.

The 25 kV neutral conductor may also need to be bonded to the ground grid to enable consistent protection operation and to provide a reliable neutral path for single phase loads connected to the 25 kV circuit. The substation will be enclosed with a 6 foot high wire fence topped with barbed or razor wire. All fence segments, fence posts and gate posts will be bonded to the ground grid.

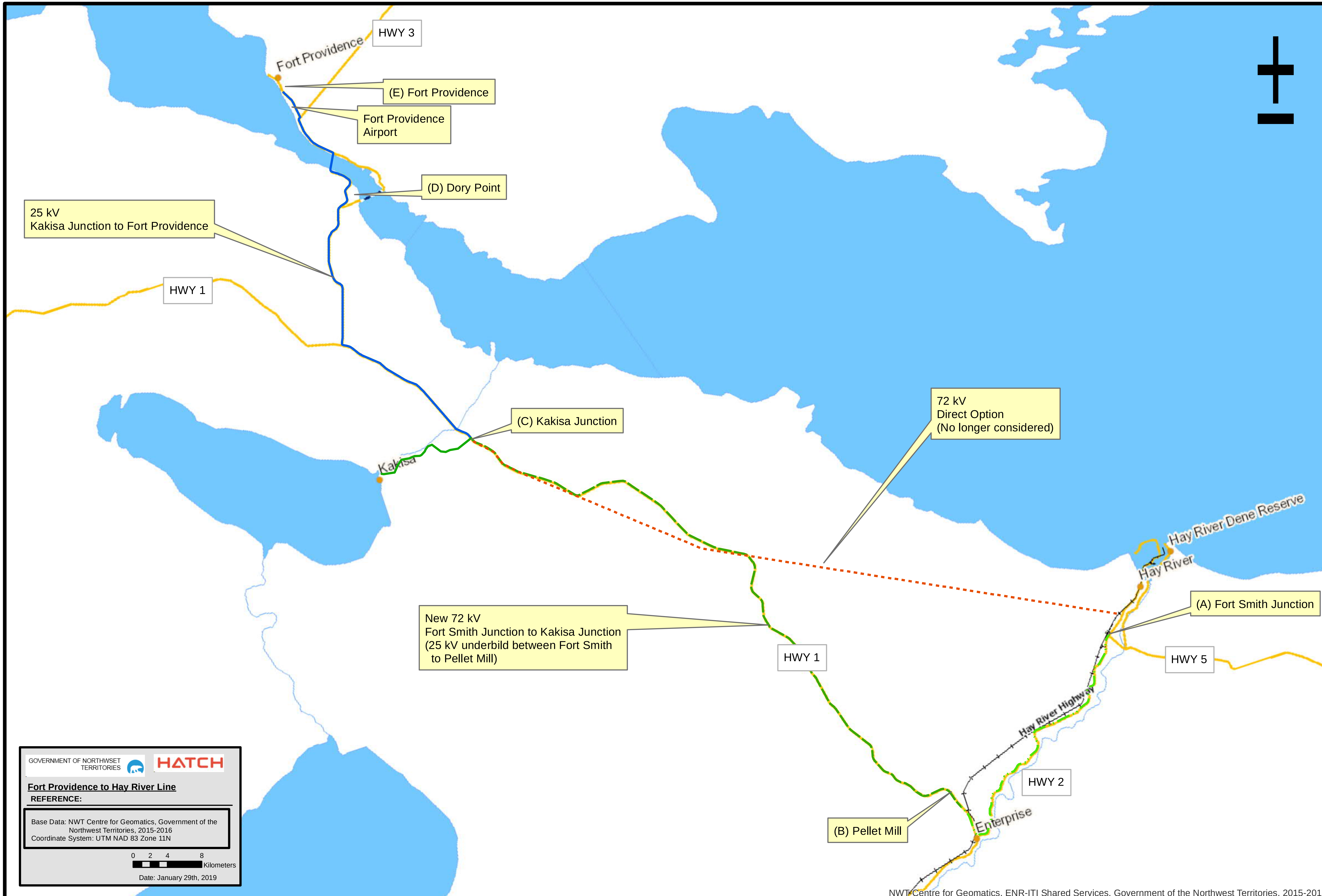
6.12 Foundations

All equipment, bus and building foundations will be designed to mitigate frost-jacking, which can be expected to occur in this climatic zone.

6.13 Modular Construction

In detail design stage, modular construction for the substations shall be applied. Such as, substation components will be fabricated offsite using modular construction techniques, to avoid the high cost and seasonal construction restrictions that would be involved in on-site construction. For example, the control building and low voltage switchgear (if applicable) will be fabricated offsite and transported to site fully assembled.

Appendix A:
Project Map



HWY 3
Fort Providence
(E) Fort Providence
Fort Providence Airport
(D) Dory Point
25 kV
Kakisa Junction to Fort Providence
HWY 1
(C) Kakisa Junction
Kakisa
72 kV
Direct Option
(No longer considered)
Hay River Dene Reserve
Hay River
(A) Fort Smith Junction
New 72 kV
Fort Smith Junction to Kakisa Junction
(25 kV underbild between Fort Smith to Pellet Mill)
HWY 1
HWY 5
Hay River Highway
HWY 2
Enterprise
(B) Pellet Mill
GOVERNMENT OF NORTHWSET TERRITORIES
HATCH
Fort Providence to Hay River Line
REFERENCE:
Base Data: NWT Centre for Geomatics, Government of the Northwest Territories, 2015-2016
Coordinate System: UTM NAD 83 Zone 11N
0 2 4 8 Kilometers
Date: January 29th, 2019
NWT Centre for Geomatics, ENR-ITI Shared Services, Government of the Northwest Territories, 2015-2016

Appendix B:
Typical Structures & Foundation Drawings

Typical 25 kV Structures (Neutral Conductor Not Shown):

- Drawing D15-SD-3172: Single Pole Tangent Structure
- Drawing D15-SD-3274: Single Pole Light Angle Structure
- Drawing D15-SD-3276: Single Pole Medium Angle Double Arm Structure
- Drawing D15-SD-3380: Double Deadend Inline Single Pole Structure
- Drawing D15-SD-3382: Single Pole Double Deadend Flat with Deflection
- Drawing D15-SD-3903: Three Phase Riser Pole Underground Dip

Typical Neutral Conductor:

- Drawing D15-SD-3914: Neutral Wire Deadend Structure
- Drawing D15-SD-3916: Neutral Wire Angle Structure
- Drawing D15-SD-3918: Neutral Wire Tangent Structure

Typical 72 kV Structures:

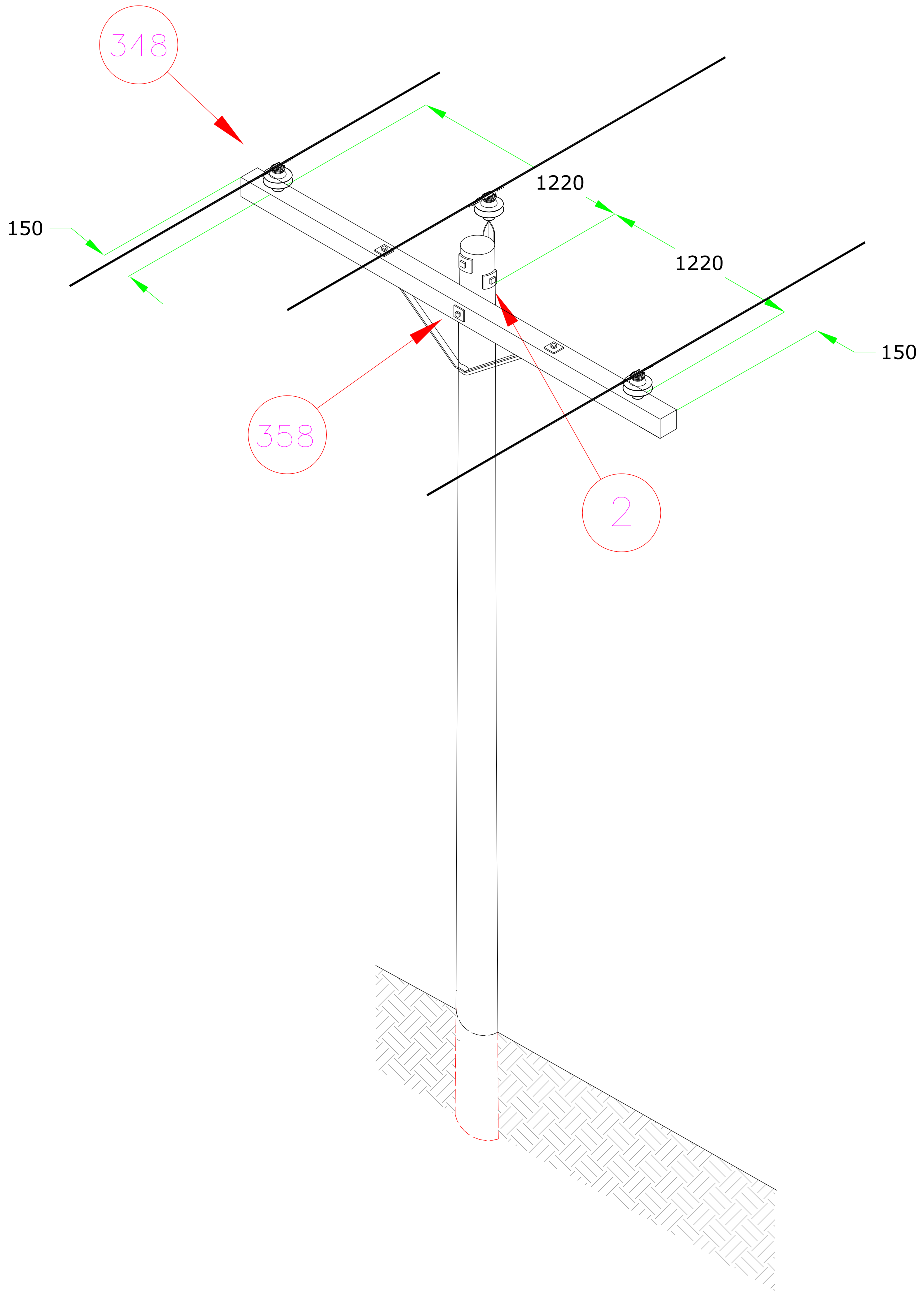
- Drawing T15-SD-4123: Tangent H-Frame Structure with Steel Arm
- Drawing T15-SD-4176: Single Pole Tangent Delta Structure
- Drawing T15-SD-4208: Single Pole Vertical Light Angle Structure with Post Insulators
- Drawing T15-SD-4210: Single Pole Vertical Medium Angle Structure
- Drawing T15-SD-4211: Light Angle H-Frame Structure with Steel Arm
- Drawing T15-SD-4276: Single Pole Light Angle Delta Structure
- Drawing T15-SD-4302: Double Deadend Tangent Single Pole Structure with Double Steel Arms
- Drawing T15-SD-4310: Single Pole Vertical Double Deadend Heavy Deflection Structure
- Drawing T15-SD-4326: Double Deadend Tangent H-Frame Structure with Double Steel Arms
- Drawing T15-SD-4334: Three Pole Double Deadend Structure with Deflection

Typical Pole Foundations:

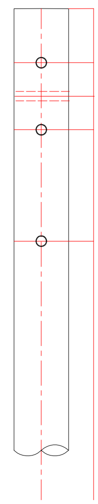
- Drawing T15-SD-9940: Shallow Depth Very Soft / Loose Soil Extra Embedment and Barrel
- Drawing T15-SD-9948: Anchored Structure Foundation in Wet Mineral Soil
- Drawing T15-SD-9993: Typical Culvert Foundation

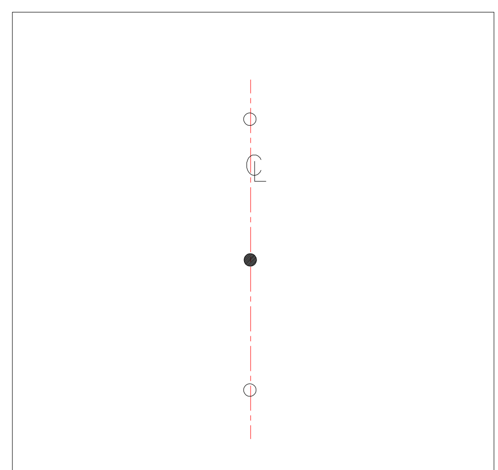
Typical Anchors:

- Drawing T15-SD-9923: Helix Screw Anchor
- Drawing T15-SD-9949: Log Anchor



ALL HOLES TO BE DRILLED 13/16" UNLESS OTHERWISE NOTED.





PLAN VIEW

NOTES:

- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- MAX DEFLECTION - TYPICAL < 2°
- TYPICAL UNFACTORED ALLOWABLE MAX LOADS WITHOUT SPECIFIC DESIGN CALCULATIONS: VERTICAL LOAD/PHASE= 3.5kN, TRANSVERSE LOAD/PHASE= 2.7kN
- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

REVISIONS

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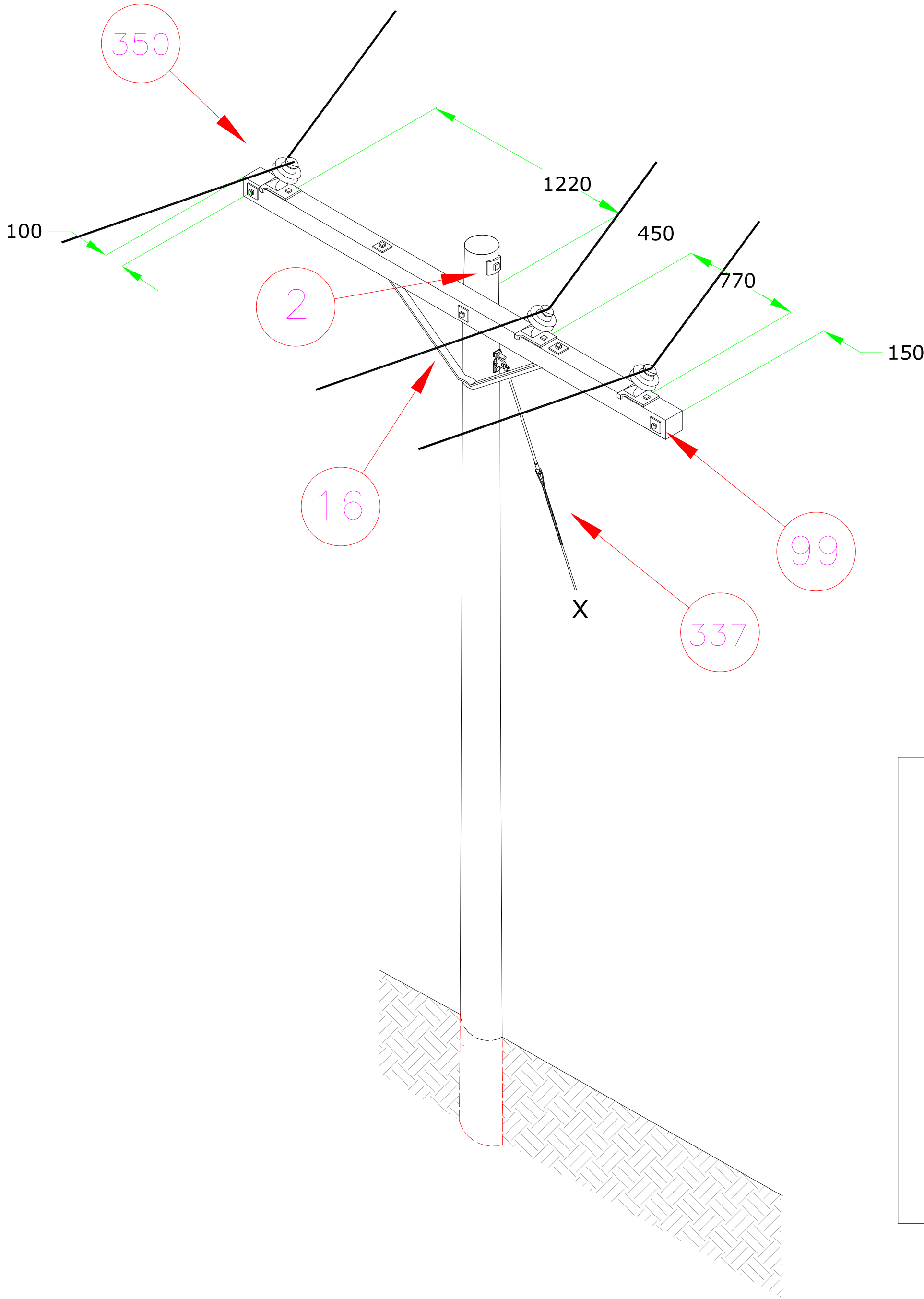
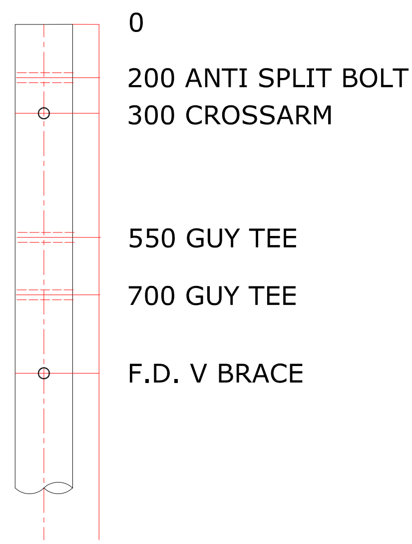
R0	AM	08-10-16	NEW DRAWING - RELEASE FOR FINAL REVIEW	DBS

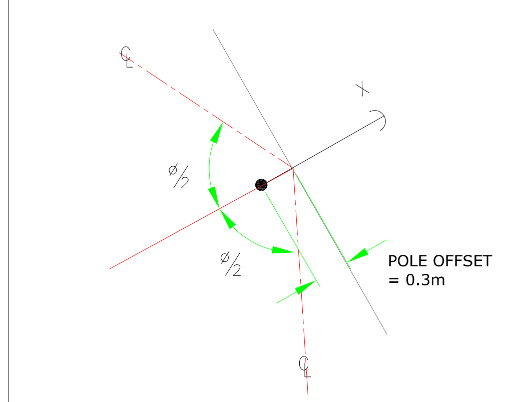
SINGLE POLE TANGENT FOR 25kV
3 PHASE
STRUCTURE TYPE 3172

	DRAWING NUMBER:	REV:
NT ENERGY	D15-SD-3172	R2

ALL HOLES TO BE DRILLED 13/16" UNLESS OTHERWISE NOTED.







PLAN VIEW

NOTES:

- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- TYPICAL UNFACTORED ALLOWABLE MAX LOADS WITHOUT SPECIFIC DESIGN CALCULATIONS - VERTICAL LOAD/PHASE= 2.4kN, TRANSVERSE LOAD/PHASE = 4.9kN
- DESIGNER TO CONFIRM ALL DRILLING DETAILS AGAINST MATERIALS USED
- ANCHORING REQUIRED TO BE CONFIRMED AND SPECIFIED BY DESIGNER (SEE STRUCTURE LIST)
- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER

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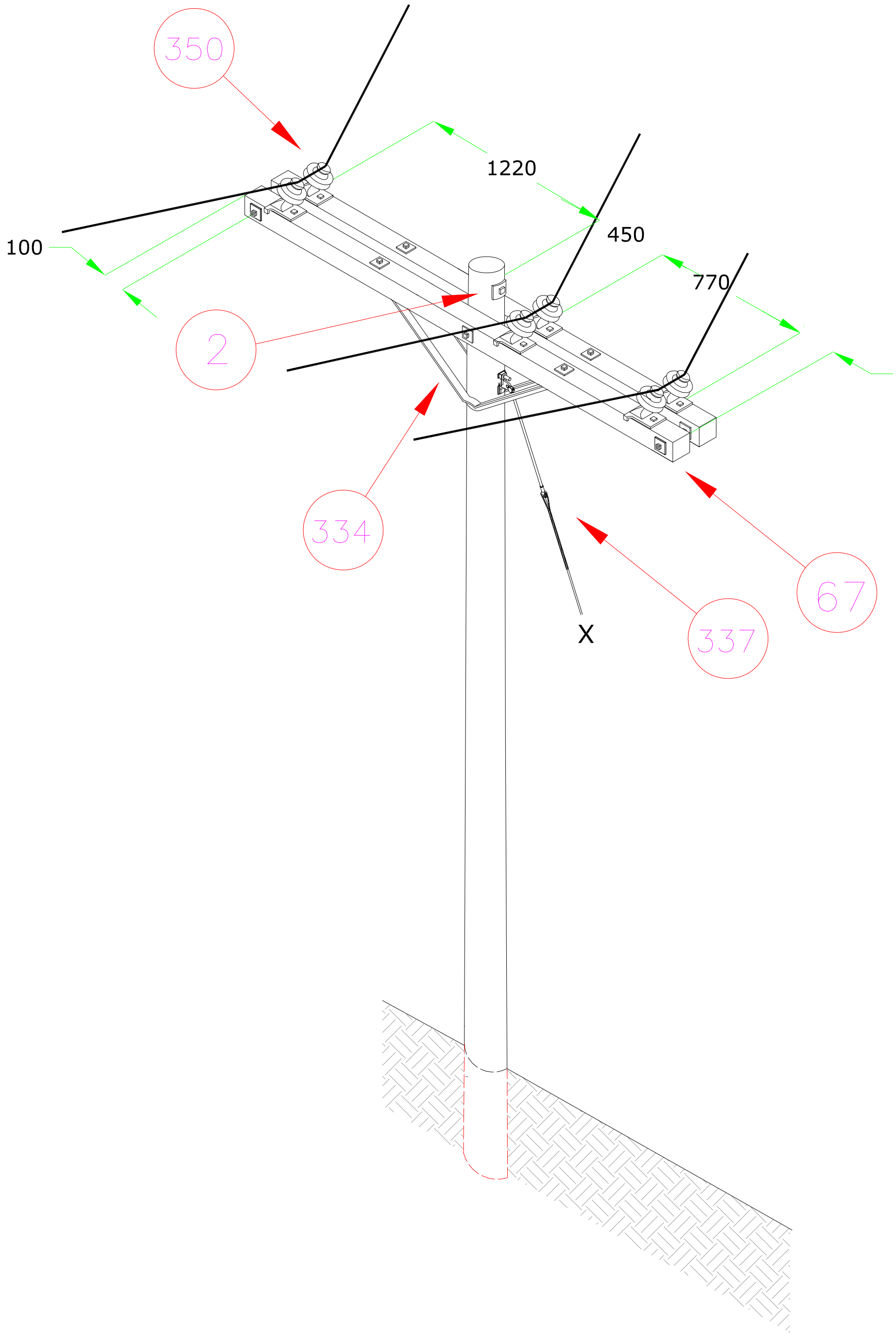
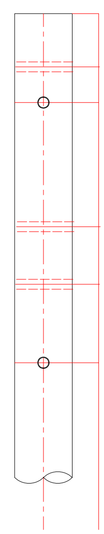
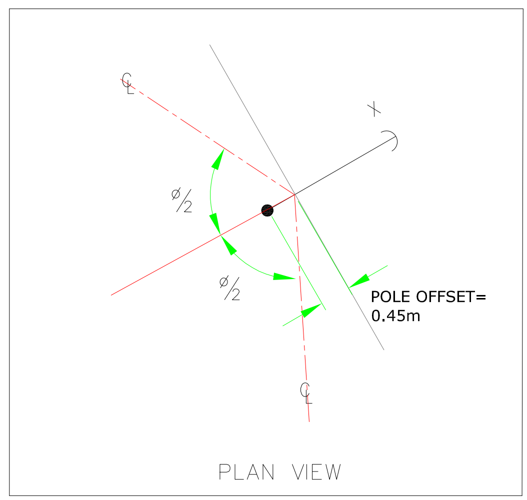
SINGLE POLE LIGHT ANGLE FOR 25kV
TYPICAL DEFLECTION: 2° - 12°
STRUCTURE TYPE 3274

	DRAWING NUMBER:	REV:
NT ENERGY	D15-SD-3274	R2



ALL HOLES TO BE
DRILLED 13/16" UNLESS
OTHERWISE NOTED.





NOTES:
- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- TYPICAL UNFACTORED ALLOWABLE MAX LOADS WITHOUT SPECIFIC DESIGN CALCULATIONS - VERTICAL LOAD/PHASE= 3.2kN, TRANSVERSE LOAD/PHASE= 6.0kN
- DESIGNER TO CONFIRM ALL DRILLING DETAILS AGAINST MATERIALS USED
- ANCHORING REQUIRED TO BE CONFIRMED AND SPECIFIED BY DESIGNER (SEE STRUCTURE LIST)
- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER

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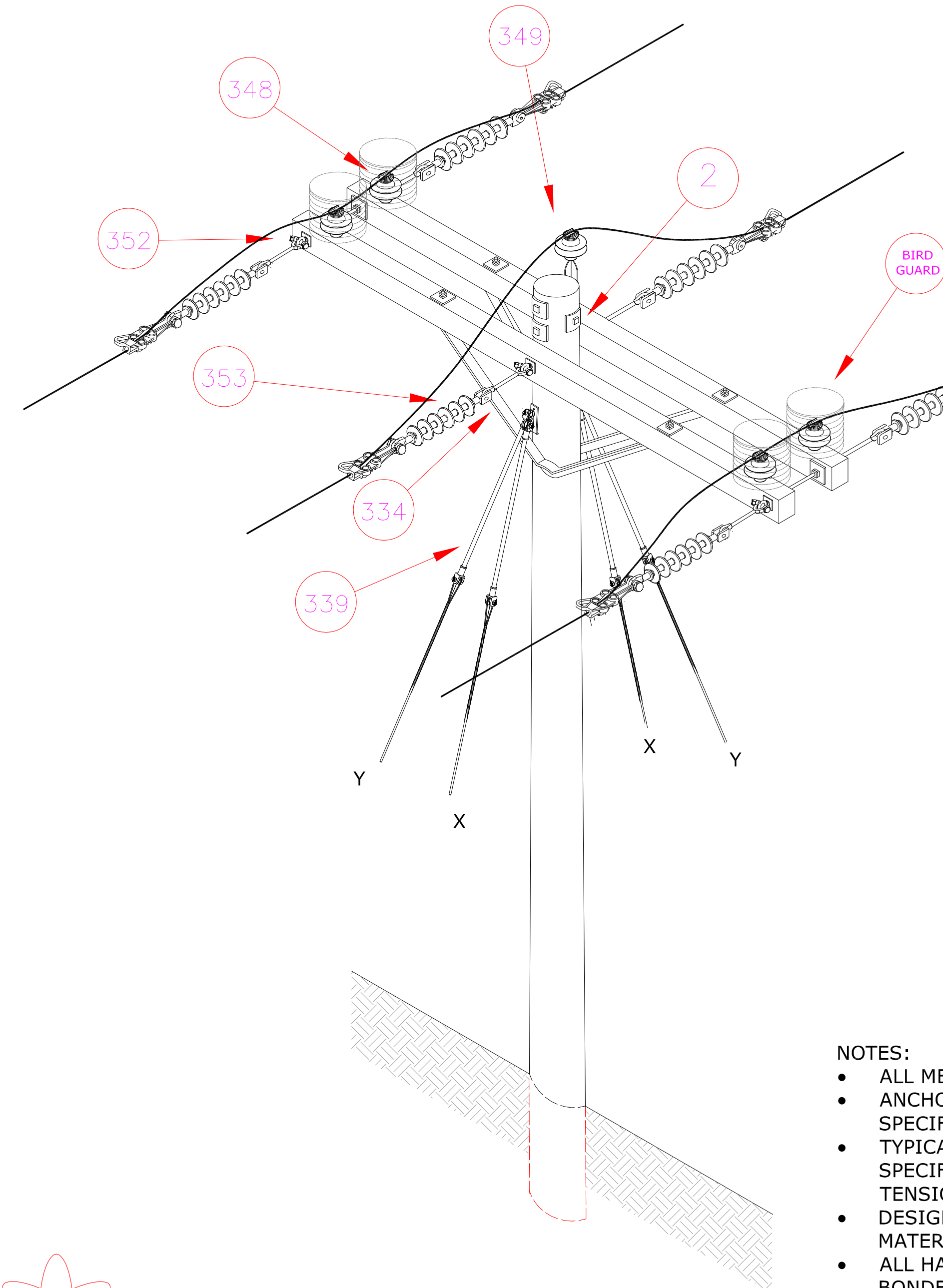
R0	AM	08-10-16	NEW DRAWING - RELEASE FOR FINAL REVIEW	DBS

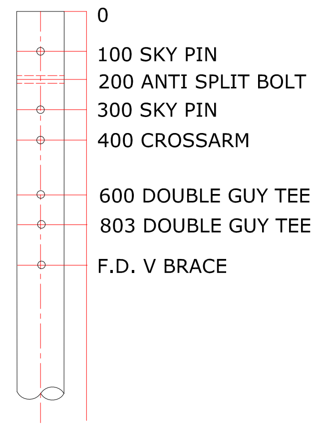
SINGLE POLE MEDIUM ANGLE FOR 25kV
DOUBLE ARM
TYPICAL DEFLECTION: 10° - 25°
STRUCTURE TYPE 3276

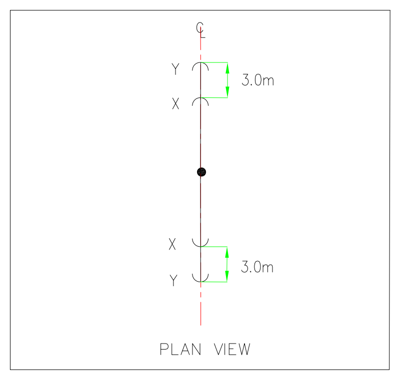
NT ENERGY

DRAWING NUMBER:	REV:
D15-SD-3276	R2



ALL HOLES TO BE DRILLED TO 13/16" UNLESS OTHERWISE NOTED.





NOTES:

- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- ANCHORING REQUIRED TO BE CONFIRMED AND SPECIFIED BY DESIGNER (SEE STRUCTURE LIST)
- TYPICAL UNFACTORED ALLOWABLE MAX LOADS WITHOUT SPECIFIC DESIGN CALCULATIONS: MAX DESIGN TENSION: 32kN
- DESIGNER TO CONFIRM ALL DRILL DETAILS AGAINST MATERIALS USED
- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

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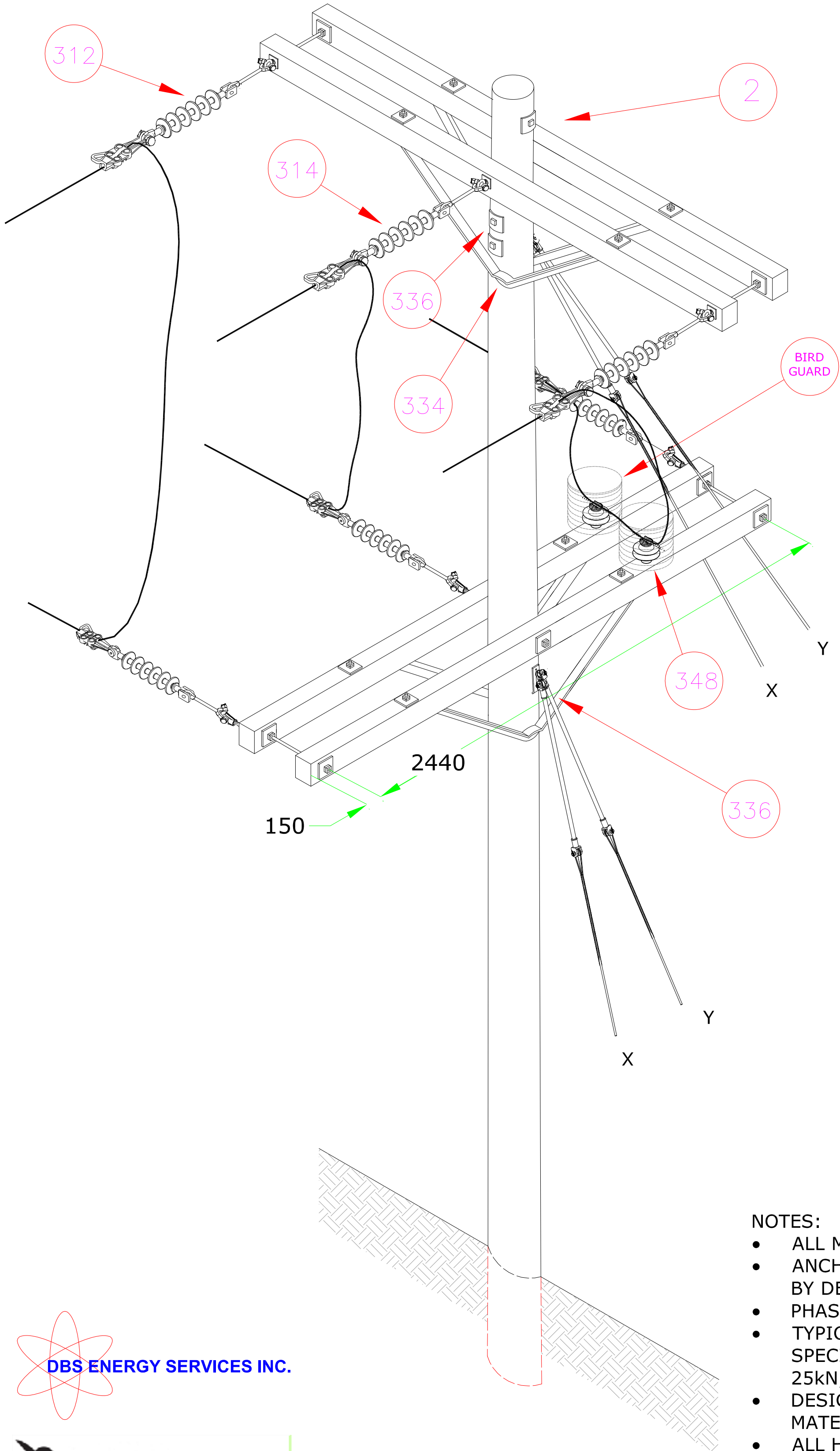
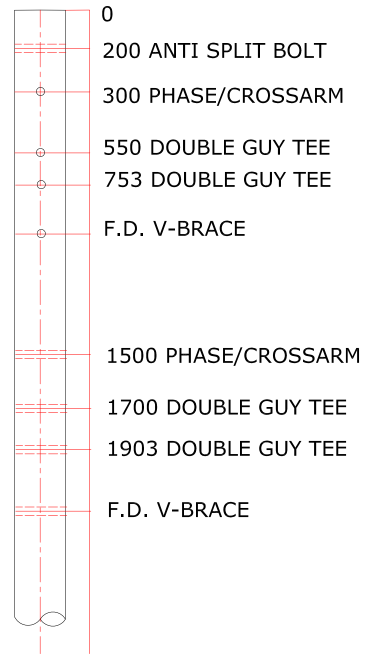
SINGLE POLE INLINE DOUBLE DEADEND
FOR 25kV
STRUCTURE TYPE 3380

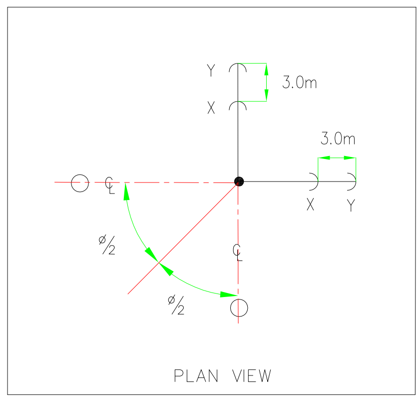
NT ENERGY

DRAWING NUMBER:	REV:
D15-SD-3380	R2



ALL HOLES TO BE
DRILLED TO
13/16" UNLESS
OTHERWISE
NOTED.





NOTES:

- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- ANCHORING REQUIRED TO BE CONFIRMED AND SPECIFIED BY DESIGNER (SEE STRUCTURE LIST)
- PHASING MAY NOT BE AS SHOWN (SEE STRUCTURE LIST)
- TYPICAL UNFACTORED ALLOWABLE MAX LOADS WITHOUT SPECIFIC DESIGN CALCULATIONS: MAX DESIGN TENSION: 25kN, WORKING TENSION: 10kN
- DESIGNER TO CONFIRM ALL DRILL DETAILS AGAINST MATERIALS USED
- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

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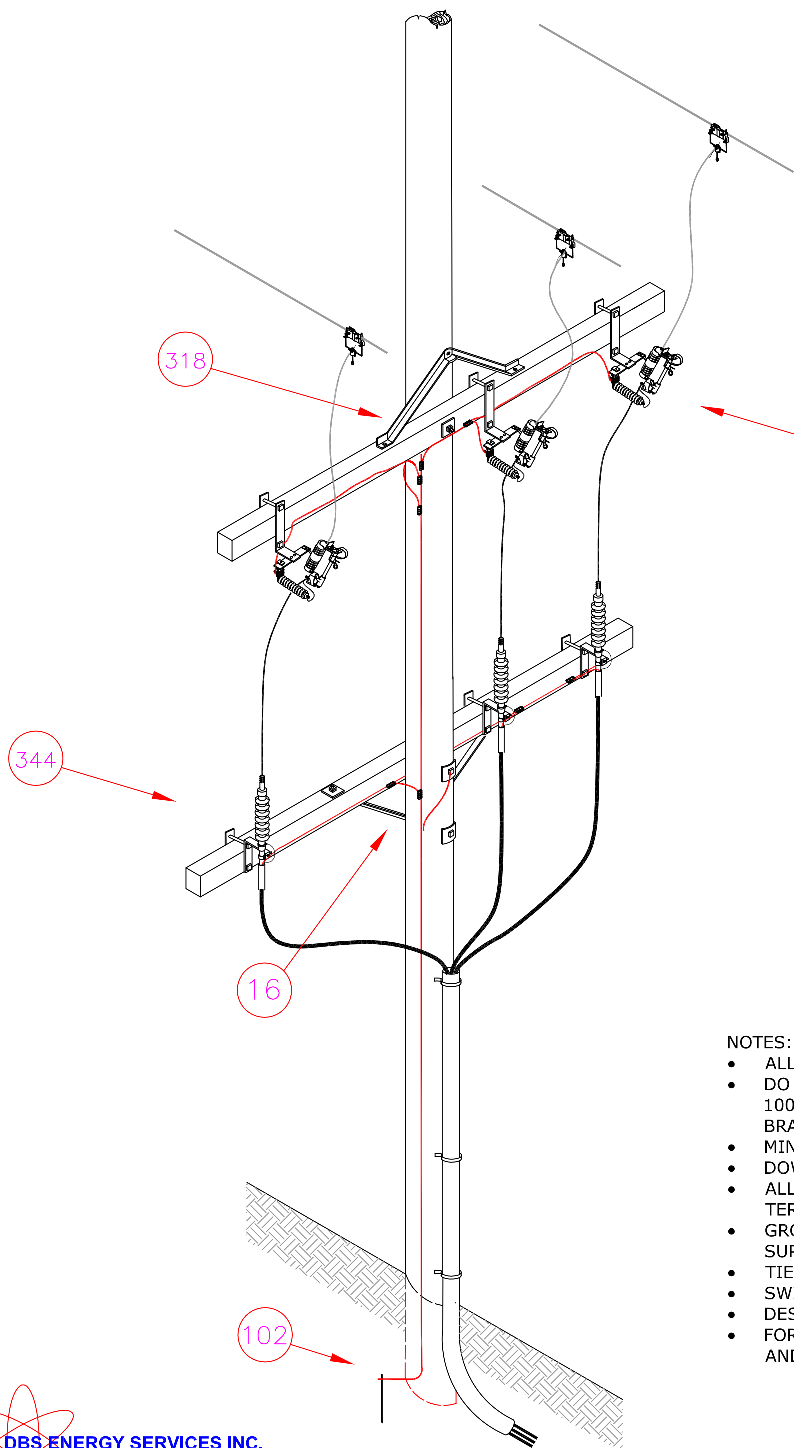
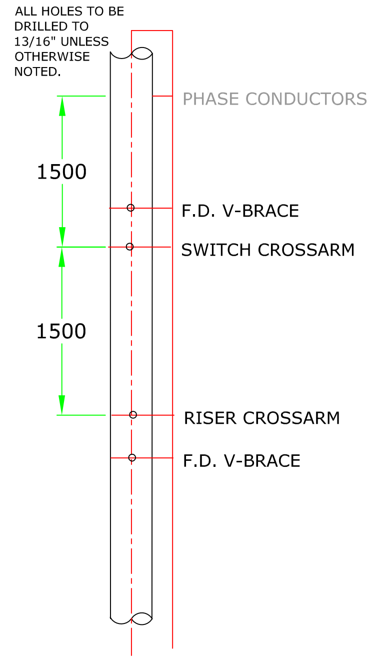
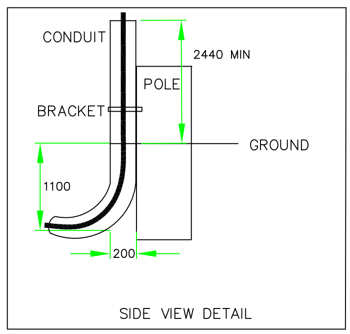
SINGLE POLE DOUBLE DEADEND FLAT WITH DEFLECTION FOR 25kV STRUCTURE TYPE 3382

NT ENERGY

DRAWING NUMBER:	REV:
D15-SD-3382	R2







NOTES:

- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- DO NOT GROUND THE CABLE SUPPORT BRACKET. MAINTAIN A MINIMUM OF 100mm CLEARANCE BETWEEN THE GROUND LEAD AND THE CABLE SUPPORT BRACKET
- MINIMUM CABLE BENDING RADIUS DURING INSTALLATION IS 400mm
- DOWNLEAD TO BE PLACED UNDER CONDUIT STRAPS
- ALLOW SUFFICIENT SLACK IN CABLES AT THE BASE OF POLE TO ALLOW FOR TERMINATION FAILURE
- GROUNDING CONDUCTOR MUST BE CONTINUOUS FROM TERMINATOR SUPPORT BRACKET TO GROUND RODS
- TIE CONCENTRIC NEUTRAL TO DOWNLEAD
- SWITCH NUMBERING TO BE ADDED
- DESIGNER TO SPECIFY AND DETERMINE FUSE SIZING
- FOR OHSW UNDERBUILT STRUCTURES DISCONTINUE THE POLE DOWNLEAD AND OHSW BONDING ABOVE THE EQUIPMENT LEVEL

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

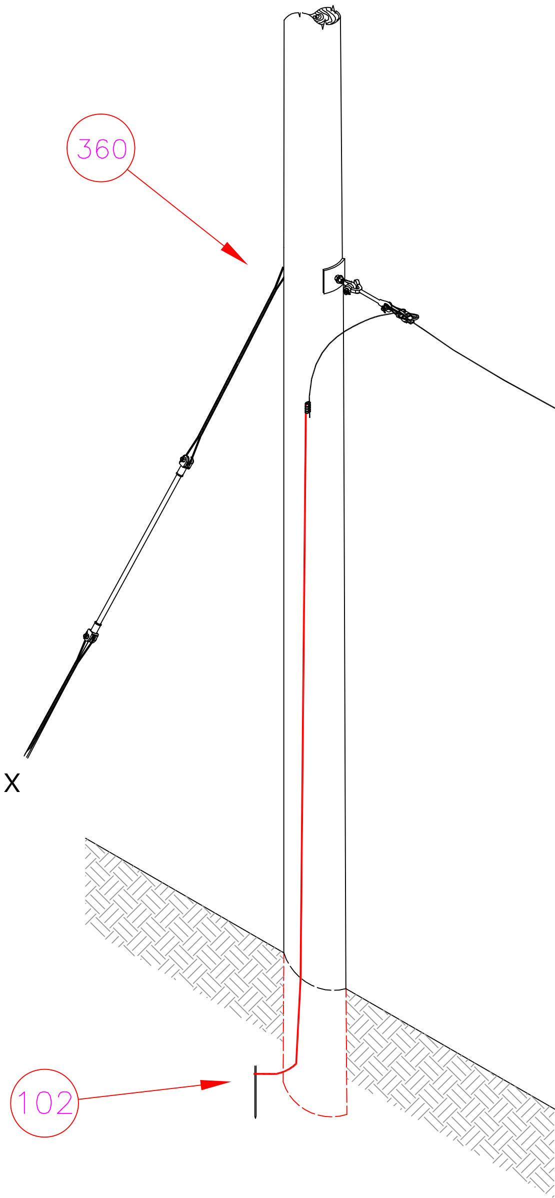
REVISIONS

NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R2	AM	13-02-08	EDIT GROUNDING ASSEMBLY NUMBER	DBS
R1	AM	09-01-05	DISCLAIMER NOTE, RELEASED FOR PACKAGE	DBS
R0	AM	08-10-20	NEW DRAWING - RELEASED FOR FINAL REVIEW	DBS

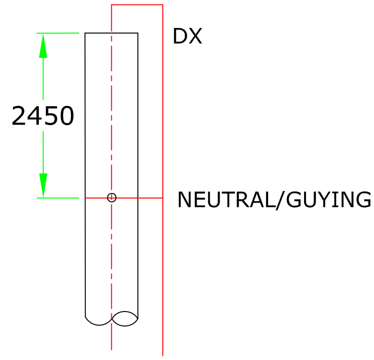
3 PHASE RISER POLE UNDERGROUND DIP FOR LIGHT CABLE STRUCTURE TYPE 3903

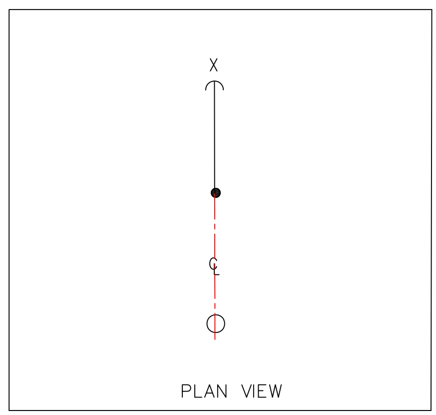
NT ENERGY

DRAWING NUMBER:	REV:
D15-SD-3903	R2



ALL HOLES TO BE DRILLED TO 13/16" UNLESS OTHERWISE NOTED.





NOTES:

- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- MAX SLACKSPAN APPROX 30m
- GUYING AND ANCHOR TO BE DETERMINED BY DESIGNER

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

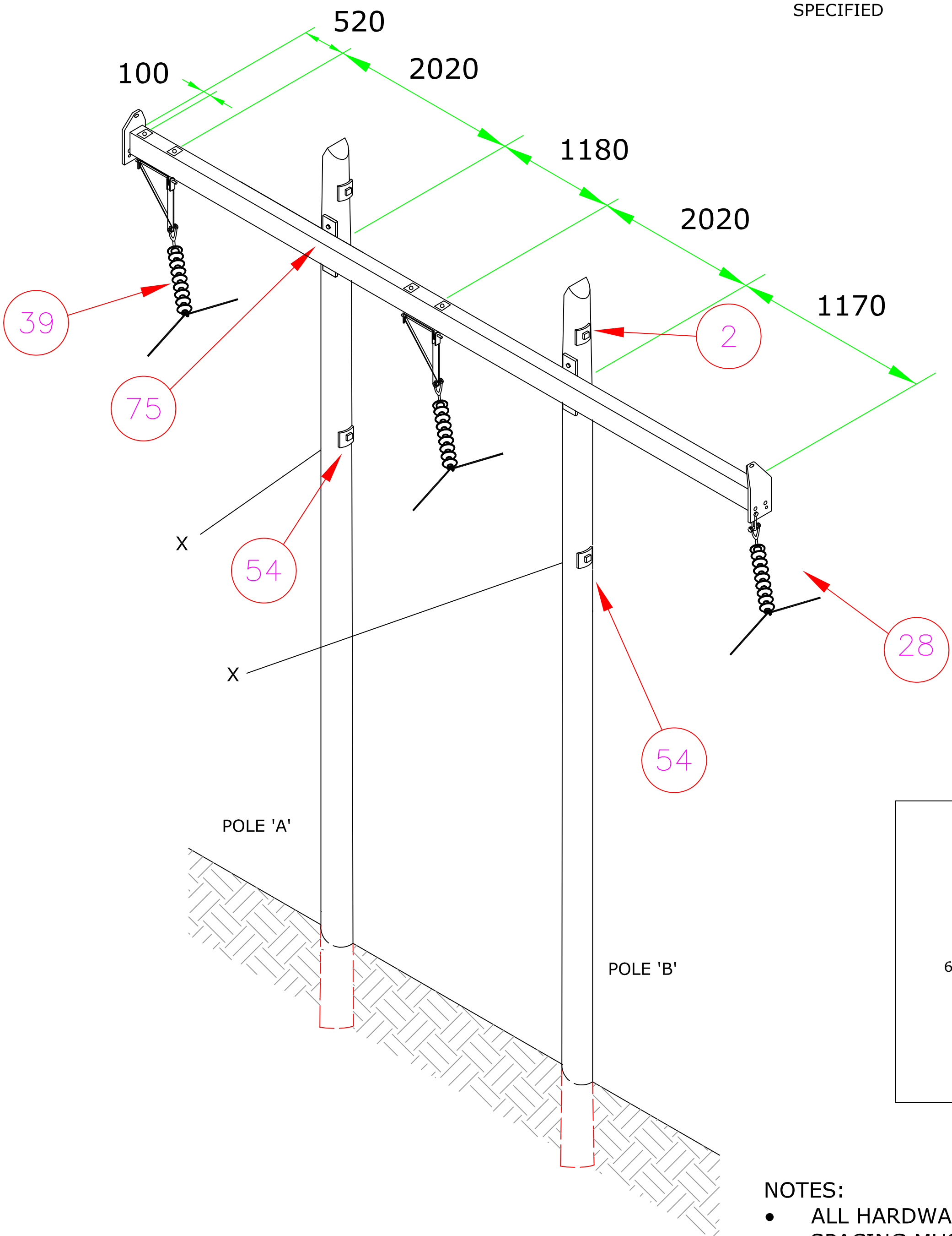
REVISIONS

NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R2	AM	13-02-08	EDIT GROUNDING ASSEMBLY, DRILL DETAIL	DBS
R1	AM	09-01-05	DISCLAIMER NOTE, RELEASED FOR PACKAGE	DBS
R0	AM	08-10-20	NEW DRAWING - RELEASED FOR FINAL REVIEW	DBS

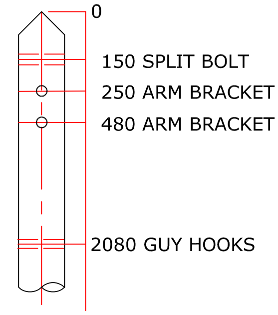
SYSTEM NEUTRAL WIRE STRUCTURE DEADEND DISTRIBUTION STRUCTURE TYPE 3914

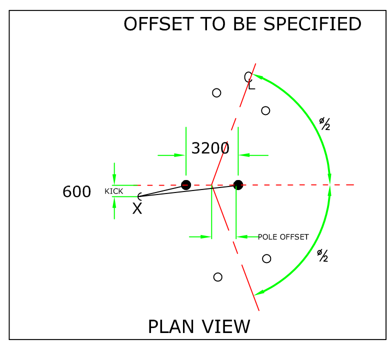
NT ENERGY

DRAWING NUMBER:	REV:
D15-SD-3914	R2



ALL HOLES TO BE DRILLED 13/16" UNLESS OTHERWISE SPECIFIED





NOTES:

- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- ANCHOR LOCATION TO BE KICKED BY DESIGNER TO ENSURE GUY WIRE CLEARS POLE
- POLE OFFSET TO BE DETERMINED BY DESIGNER
- ANCHOR TO BE KICKED OPPOSITE OF LONGER SPAN

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

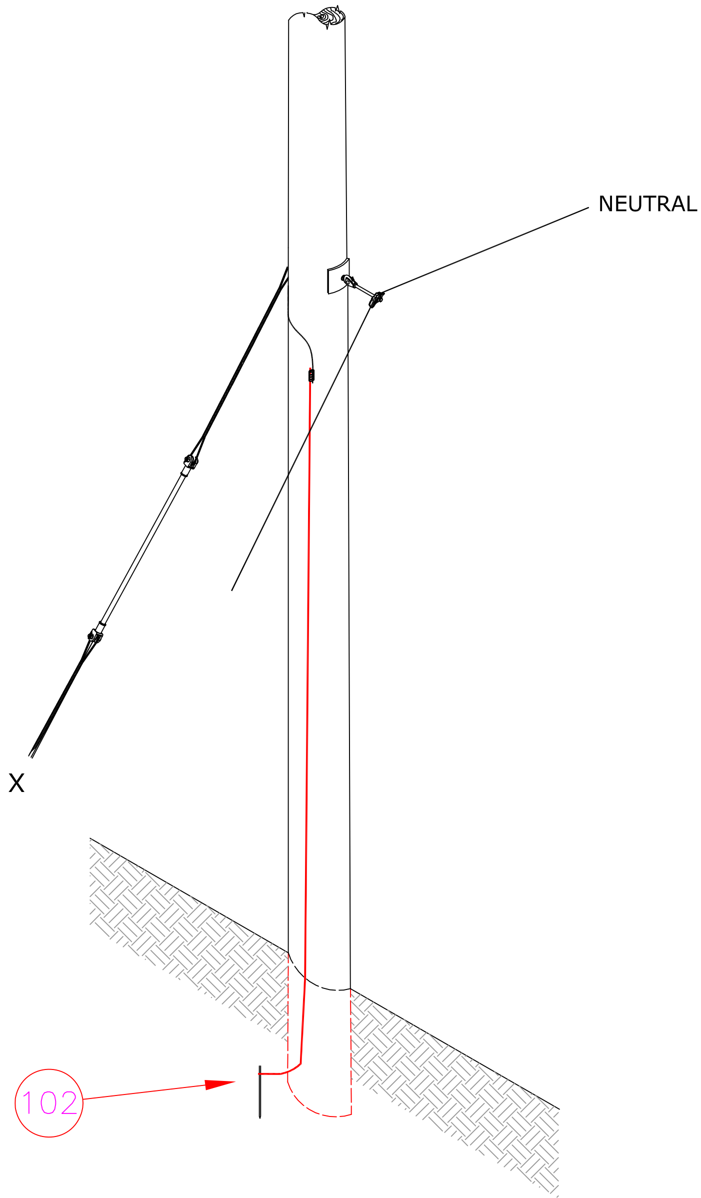
REVISIONS

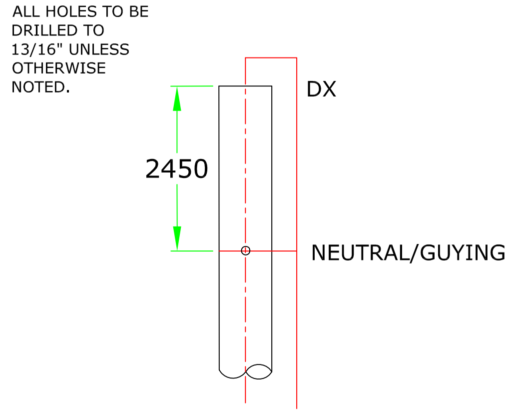
No.	BY	DATE	DESCRIPTION	DBS APP.
R0	AM	13-01-29	NEW DRAWING	

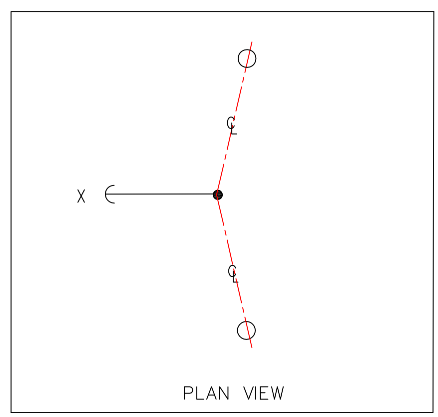
TWO POLE 72kV LIGHT ANGLE H-FRAME FOR ANGLES LESS THAN 15° TYPICALLY STRUCTURE TYPE 4211

NT ENERGY

DRAWING No.	REV.
T15-SD-4211	R0







NOTES:
- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- GUYING AND ANCHOR TO BE DETERMINED BY DESIGNER

DBS ENERGY SERVICES INC.

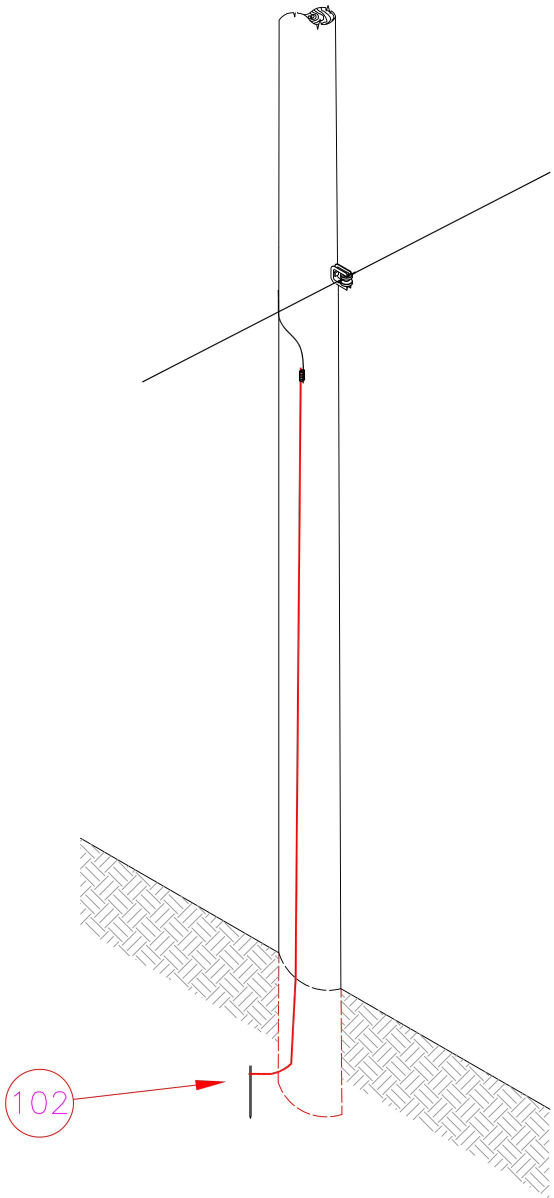
MIDGARD CONSULTING INC

REVISIONS

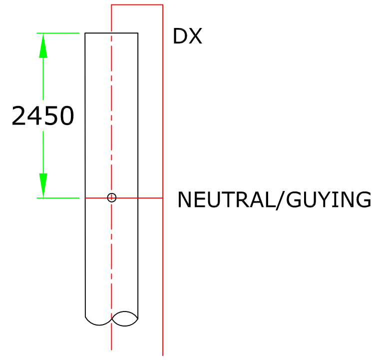
NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R0	AM	13-02-08	NEW DRAWING	DBS

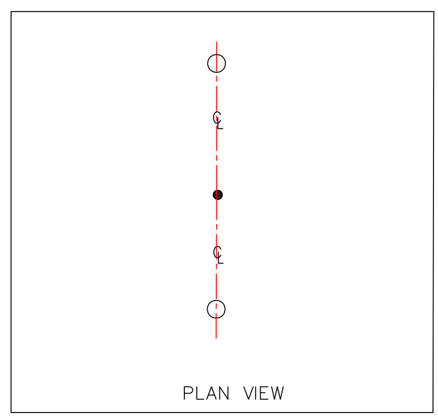
SYSTEM NEUTRAL WIRE STRUCTURE ANGLE
DISTRIBUTION
STRUCTURE TYPE 3916

NT ENERGY	DRAWING NUMBER:	REV:
	D15-SD-3916	R0



ALL HOLES TO BE DRILLED TO 13/16" UNLESS OTHERWISE NOTED.





NOTES:

- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- GUYING AND ANCHOR TO BE DETERMINED BY DESIGNER

DBS ENERGY SERVICES INC.

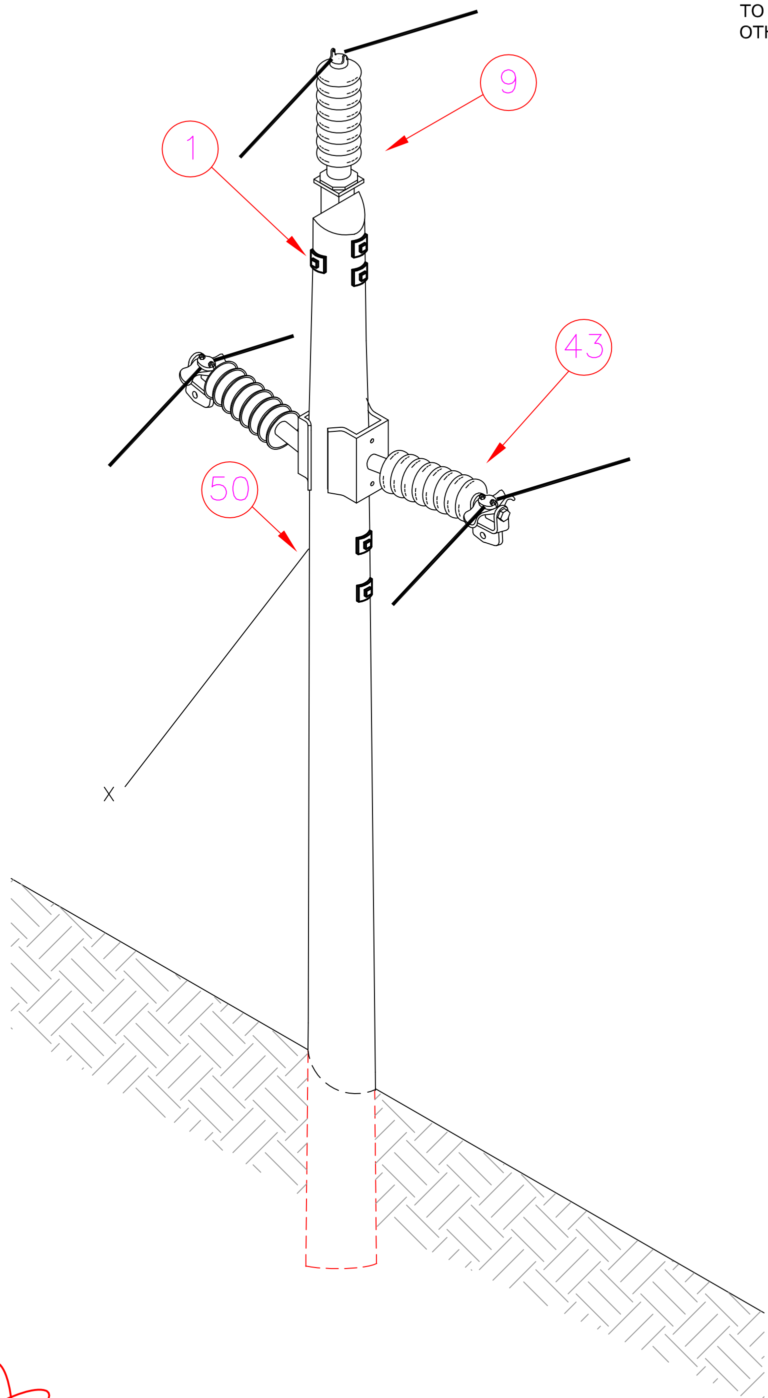
MIDGARD CONSULTING INC

REVISIONS

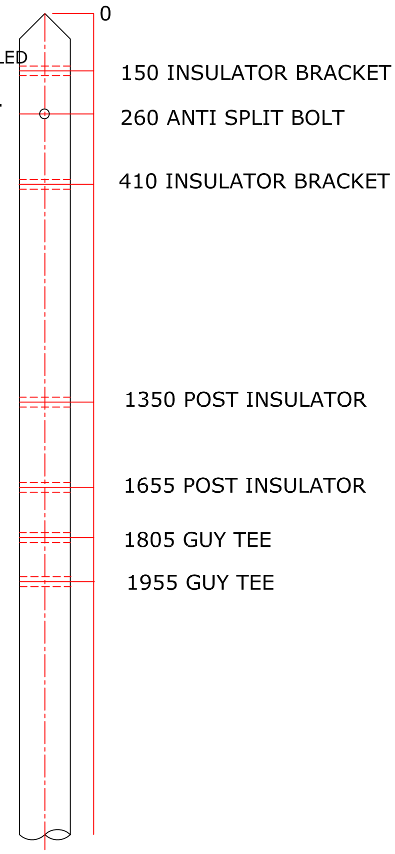
NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R0	AM	13-02-08	NEW DRAWING	DBS

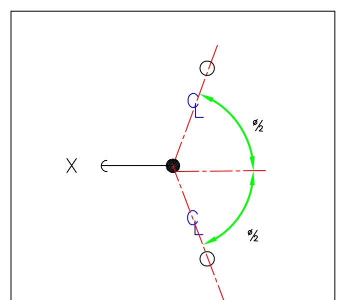
SYSTEM NEUTRAL WIRE STRUCTURE TANGENT DISTRIBUTION STRUCTURE TYPE 3918

	DRAWING NUMBER:	REV:
NT ENERGY	D15-SD-3918	R0



ALL HOLES TO BE DRILLED
TO 13/16" UNLESS
OTHERWISE SPECIFIED.





PLAN VIEW

NOTES:
1. ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
2. ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
3. FOR MAX TRANSVERSE AND VERTICAL CAPACITY CONFIRM INSULATOR AND BRACKET STRENGTHS
4. DESIGNER TO VERIFY PHASE CLEARANCES FOR MAX SPAN LENGTHS

DBS ENERGY SERVICES INC.

MIDGARD
CONSULTING INC

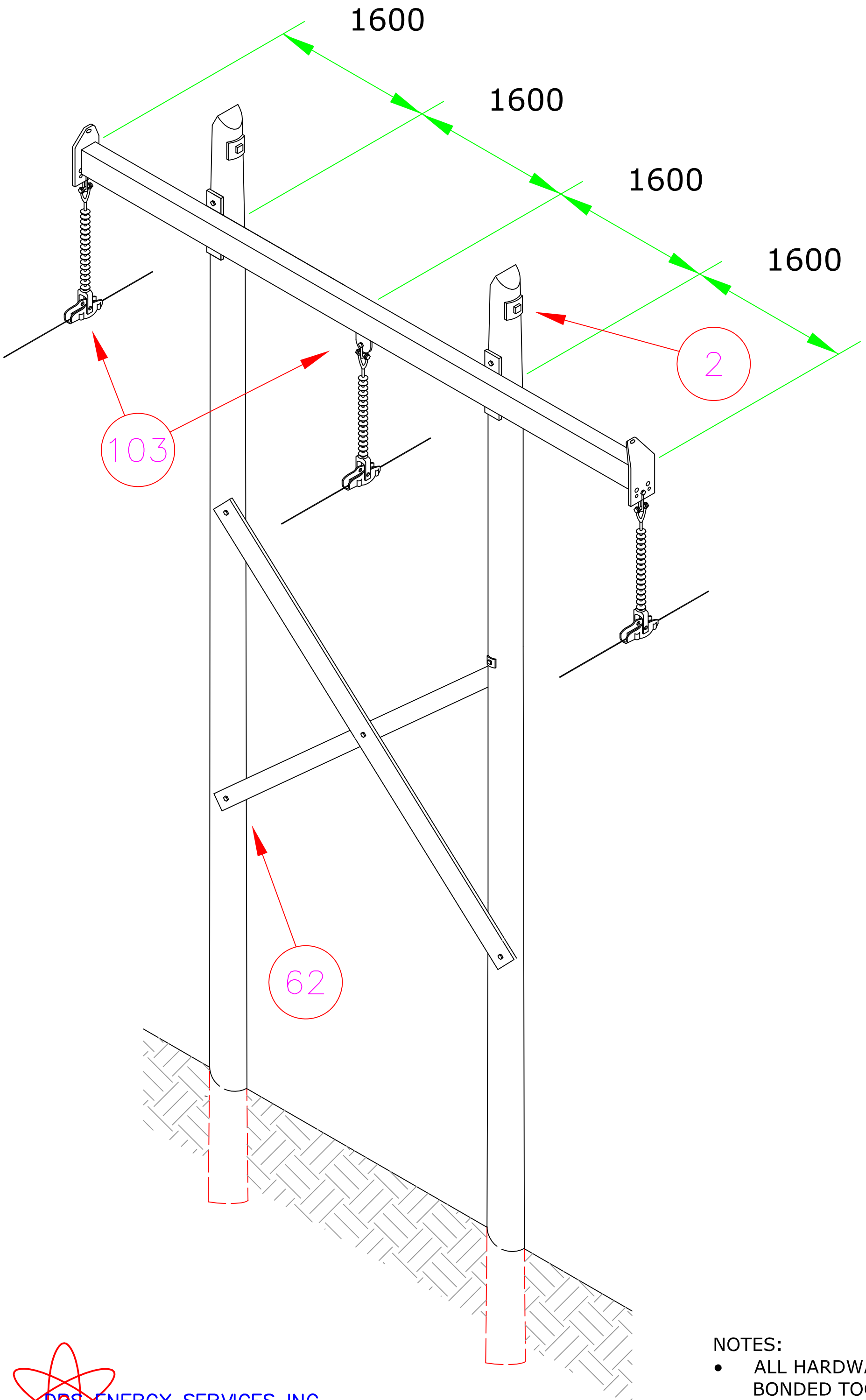
REVISIONS

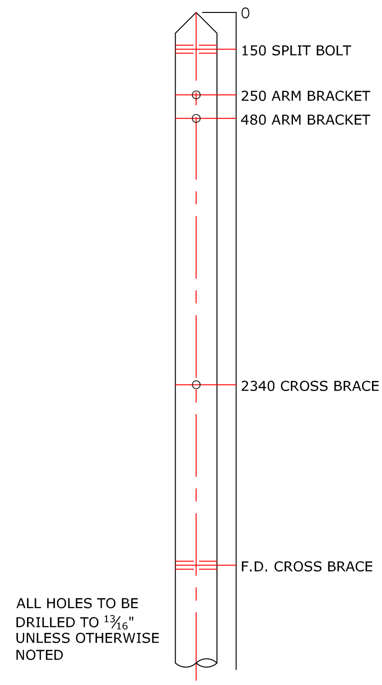
No.	BY	DATE	DESCRIPTION	APP.
R1	AM	12-11-01	REMOVE GROUND, BONDING, DOWNLEAD	DBS
R0	AM	12-06-06	NEW DRAWING	DBS

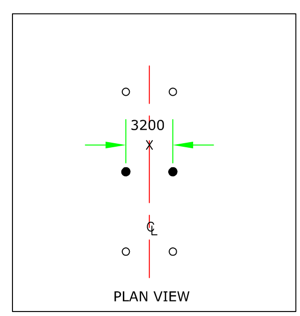
72kV SINGLE POLE LIGHT ANGLE
DELTA HORIZONTAL AND VERTICAL POSTS
STRUCTURE TYPE 4276

NT ENERGY

DRAWING No.	REV.
T15-SD-4276	R1







NOTES:
- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
- FOR MAX TRANSVERSE CAPACITY USE DOUBLE SWAY BRACING FOR POLES ABOVE 80'
- DESIGNER TO CONFIRM ALL DRILLING DETAILS AGAINST MATERIALS USED
- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

REVISIONS

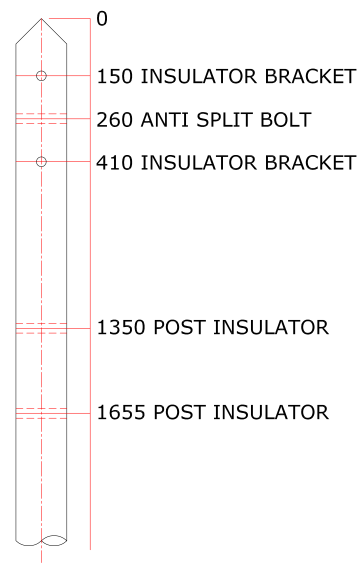
No.	BY	DATE	DESCRIPTION	APP.
R0	AM	13-01-29	NEW DRAWING	DBS

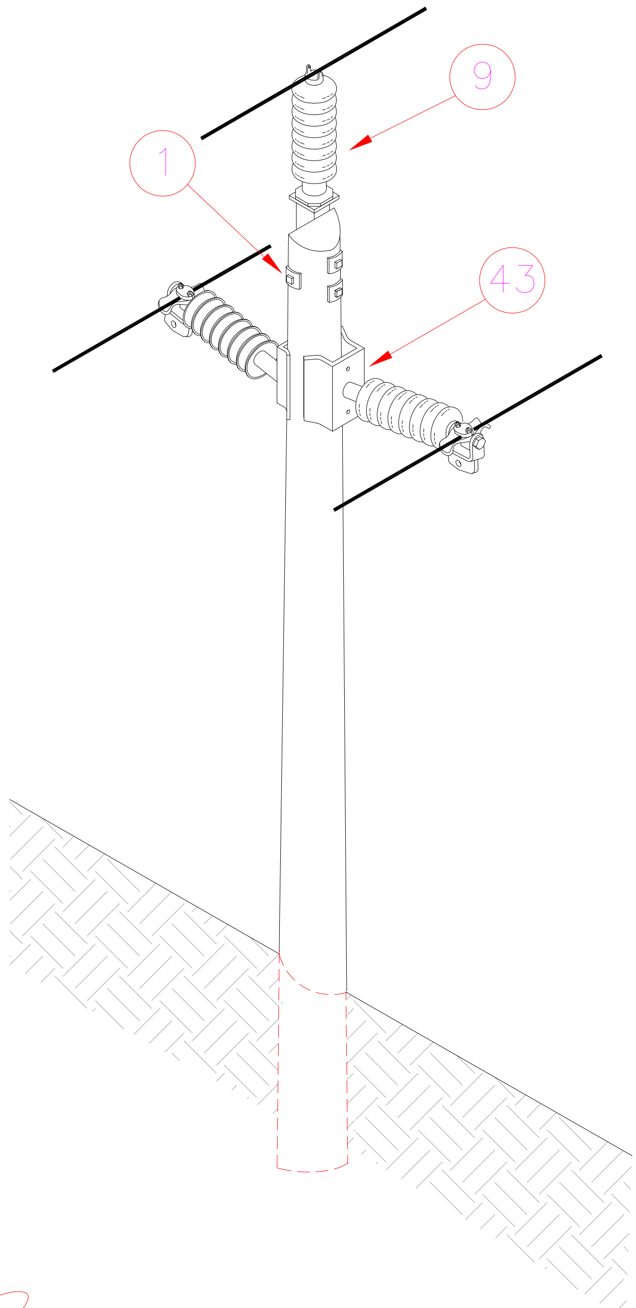
72kV TANGENT H-FRAME
WITH WOOD CROSS BRACING AND STEEL ARM
STRUCTURE TYPE 4123

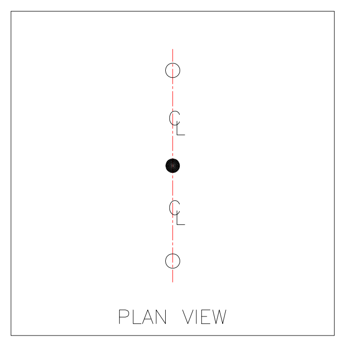
NT ENERGY

DRAWING No.	REV.
T15-SD-4123	R0

ALL HOLES TO BE DRILLED TO 13/16" UNLESS OTHERWISE SPECIFIED.







NOTES:

- ALL DIMENSIONS IN mm UNLESS OTHERWISE SHOWN
- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
- FOR MAX TRANSVERSE AND VERTICAL CAPACITY CONFIRM INSULATOR AND BRACKET STRENGTHS
- DESIGNER TO VERIFY PHASE CLEARANCES FOR MAX SPAN LENGTHS

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

REVISIONS

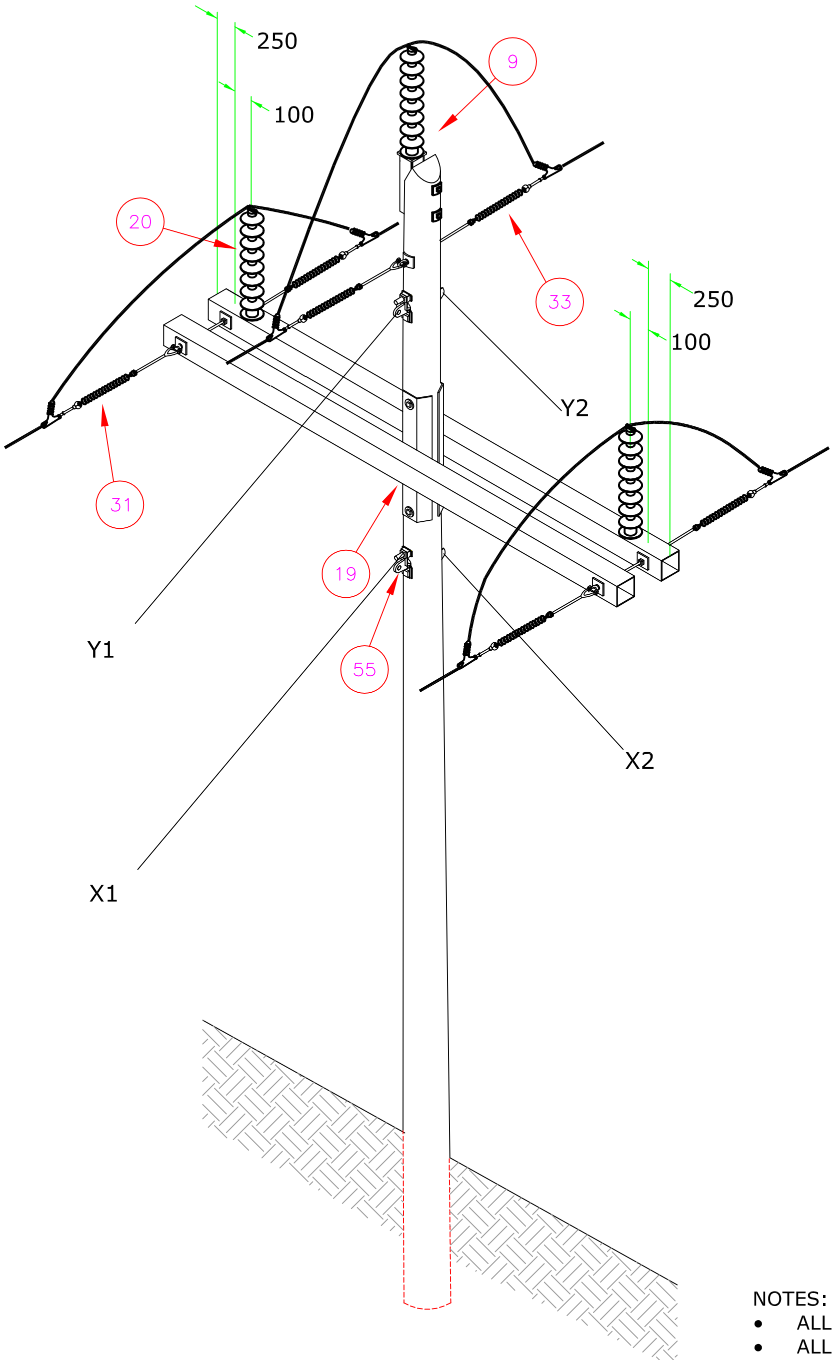
No.	BY	DATE	DESCRIPTION	APP.
R4	AM	12-11-01	REMOVE BONDING AND GROUNDING	DBS
R3	AM	12-06-06	UPDATE STR DWG COMPONENTS	JWT
R2	AM	10-03-08	UPDATE STR DWG	JWT
R1	AM	07-04-11	UPDATE ASS., STR DETAILS, GRND. DRILL	DBS
R0	RDK	02-09	NEW DRAWING	DBS

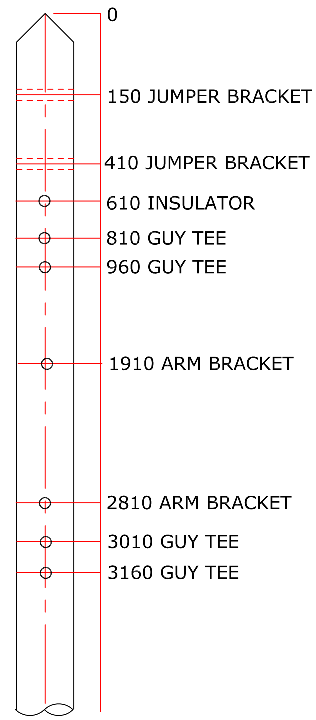
SINGLE POLE 72kV TANGENT
DELTA - HORIZONTAL AND VERTICAL POSTS
STRUCTURE TYPE 4176

NT ENERGY

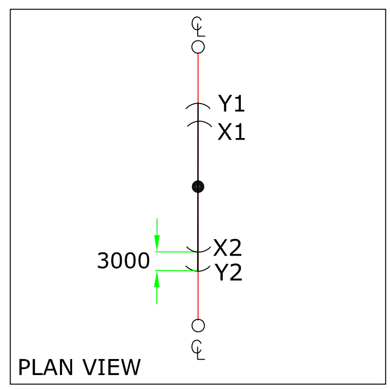
DRAWING No. T15-SD-4176

REV. R4





ALL HOLES DRILLED TO 13/16"



NOTES:

- ALL DIMENSIONS IN mm UNLESS OTHERWISE SHOWN
- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
- DESIGNER TO CONFIRM ALL DRILLING DETAILS AGAINST MATERIALS USED
- ANCHORING REQUIRED TO BE CONFIRMED AND SPECIFIED BY DESIGNER (SEE STRUCTURE LIST)
- ANCHOR KICKS MAY BE REQUIRED, TO BE SPECIFIED BY DESIGNER IN THE STRUCTURE LIST

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

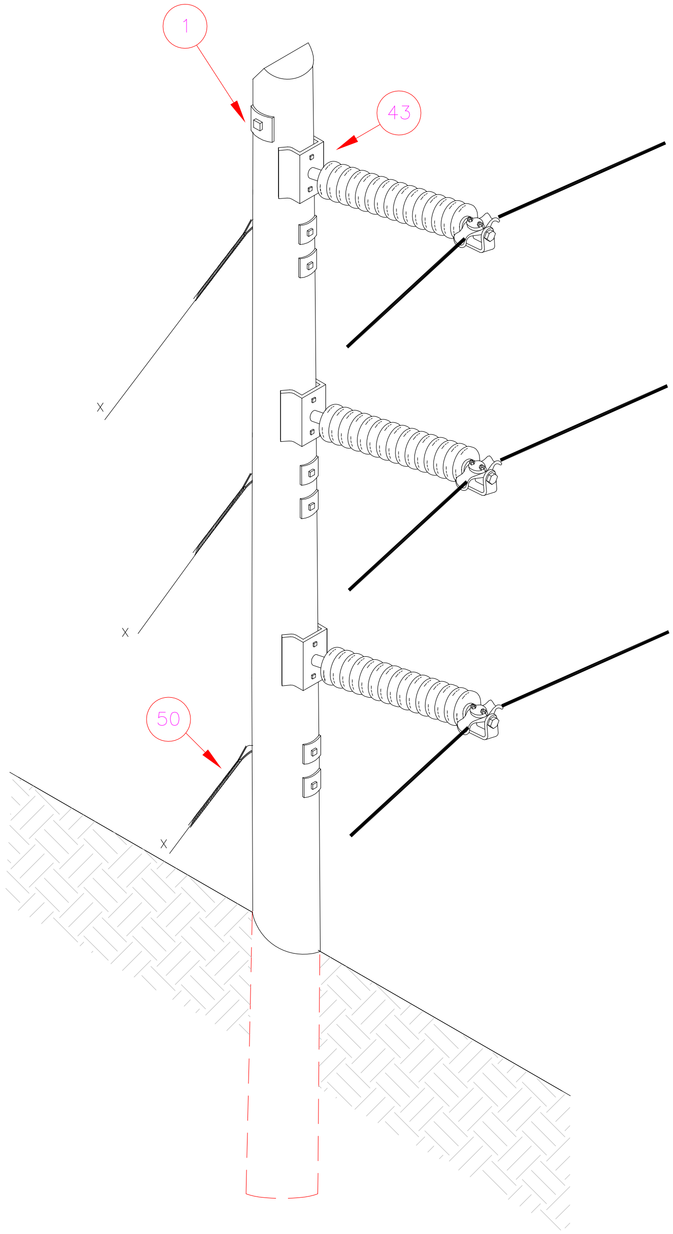
REVISIONS

No.	BY	DATE	DESCRIPTION	APP.
R2	AM	13–01–28	REMOVE GROUNDING, BONDING, DOWNLEAD	DBS
R1	AM	12–06–08	UPDATE DRILLING, PARTS, ADD NOTES	DBS
R0	AM	07–01–04	NEW DRAWING	DBS

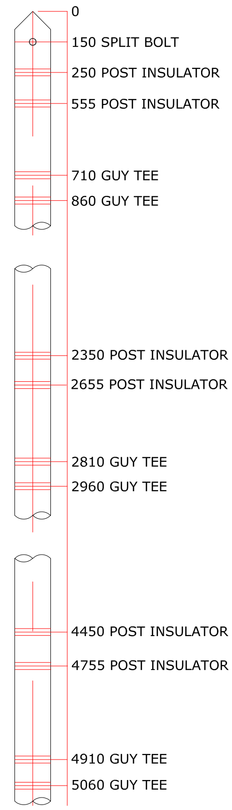
SINGLE POLE 72kV INLINE DDE
WITH STEEL ARMS - DELTA CONFIGURATION
STRUCTURE TYPE 4302

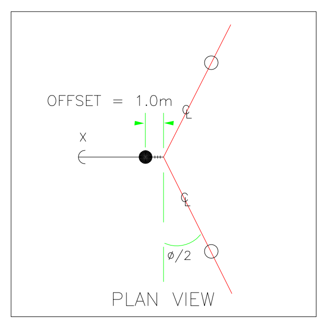
NT ENERGY

DRAWING No.	REV.
T15-SD-4302	R2



ALL HOLES TO BE DRILLED 13/16" UNLESS OTHERWISE NOTED.





DBS ENERGY SERVICES INC.

NOTES:

- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
- FOR MAX TRANSVERSE AND VERTICAL CAPACITY CONFIRM INSULATOR STRENGTHS
- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED

MIDGARD CONSULTING INC

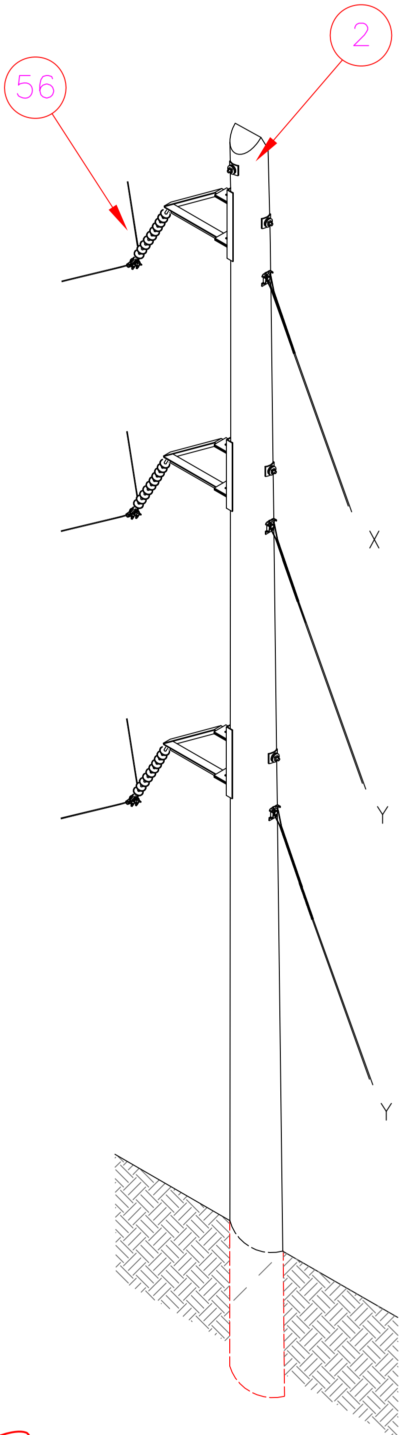
REVISIONS

No.	BY	DATE	DESCRIPTION	APP.
R4	AM	12-11-01	REMOVE BONDING AND GROUNDING	DBS
R3	AM	12-10-05	UPDATE DRILLING DETAILS	DBS
R2	JWT	08-06-23	GUYING ASSEMBLY AND DIMENSIONS	JWT
R1	AM	06-11-02	GRND DETAIL, ASS., DRILL DETAIL, DLEAD	DBS
R0	DBS	06-02-23	NEW DRAWING	DBS

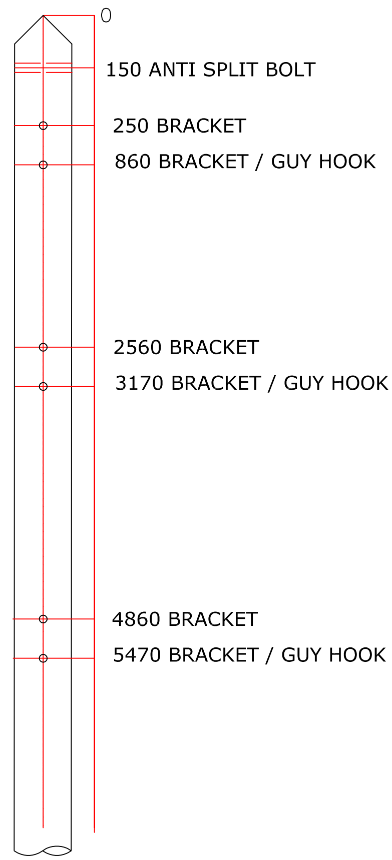
SINGLE POLE 72kV VERTICAL LIGHT ANGLE WITH HORIZONTAL POST INSULATORS FOR TYPICAL DEFLECTION <15°

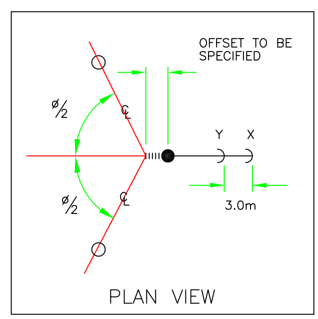
NT ENERGY

DRAWING No.	REV.
T15-SD-4208	R4



ALL HOLES TO BE DRILLED TO 13⁄16" UNLESS OTHERWISE SPECIFIED





NOTES:

- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- DESIGNER TO SPECIFY OFFSET
- DESIGNER TO CHECK FINAL INSULATOR POSITIONS AND CLEARANCES
- DESIGNER TO CONFIRM ALL DRILLING DETAILS AGAINST MATERIALS USED
- ANCHORING REQUIRED TO BE CONFIRMED AND SPECIFIED BY DESIGNER (SEE STRUCTURE LIST)

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

REVISIONS

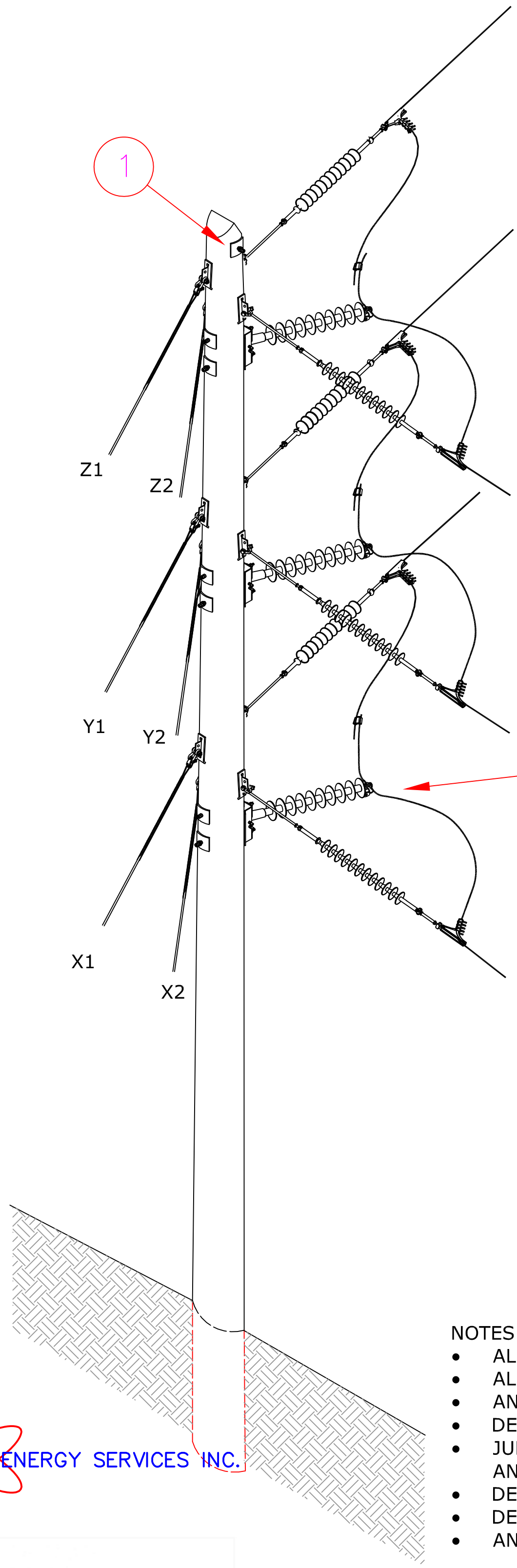
No.	BY	DATE	DESCRIPTION	APP.
R1	AM	13–01–28	REMOVE GROUNDING, BONDING, UPDATE DWG	DBS
R0	AM	06–11–10	NEW DRAWING	DBS

72kV SINGLE POLE VERTICAL MEDIUM ANGLE STRUCTURE TYPICAL 10° - 25° DEFLECTION

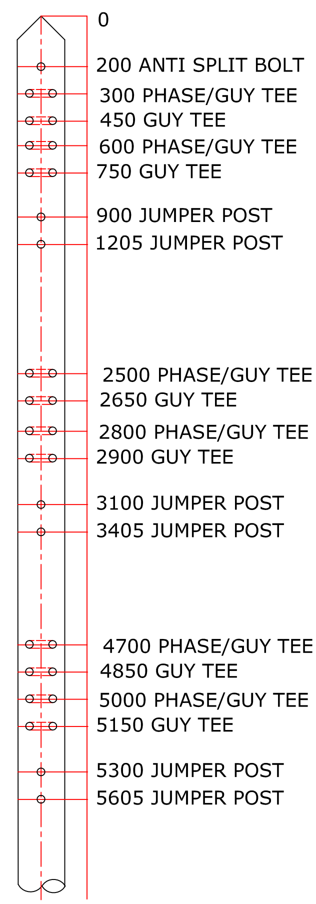
NT ENERGY

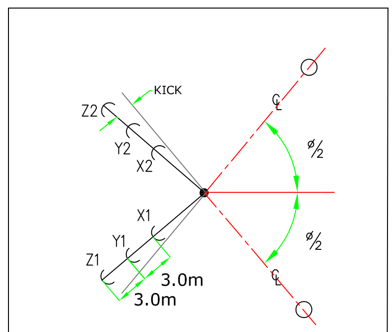
DRAWING No. T15-SD-4210

REV. R1



ALL HOLES TO BE DRILLED TO 13/16" UNLESS OTHERWISE NOTED.





PLAN VIEW

NOTES:

- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- ANCHOR KICKS SHOULD BE USED ON DEFLECTIONS < 60°
- DESIGNER TO SPECIFY ANCHOR KICKS (TO BE SPECIFIED IN STRUCTURE LIST)
- JUMPER POSTS REQUIRED FOR LINE DEFLECTIONS < 60° (NOT REQUIRED FOR 60° AND GREATER DEFLECTIONS)
- DESIGNER TO CHECK PHASE AND GUY CLEARANCES
- DESIGNER TO CONFIRM ALL DRILLING DETAILS AGAINST MATERIALS USED
- ANCHORING REQUIRED TO BE CONFIRMED AND SPECIFIED (SEE STRUCTURE LIST)

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

REVISIONS

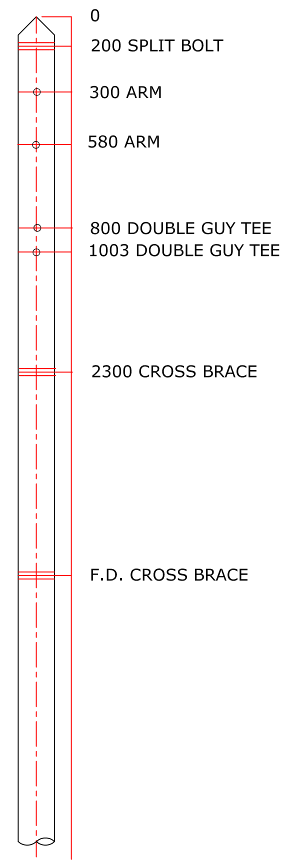
No.	BY	DATE	DESCRIPTION	APP.
R3	AM	13–01–28	REMOVE BONDING, CORRECT DRILLING	DBS
R2	AM	12–10–05	UPDATE DRILL DETAIL	DBS
R1	AM	06–11–02	UPDATE ASS., DRILL DETAIL, PLAN, NOTES	DBS
R0	DBS	06–02–24	NEW DRAWING	DBS

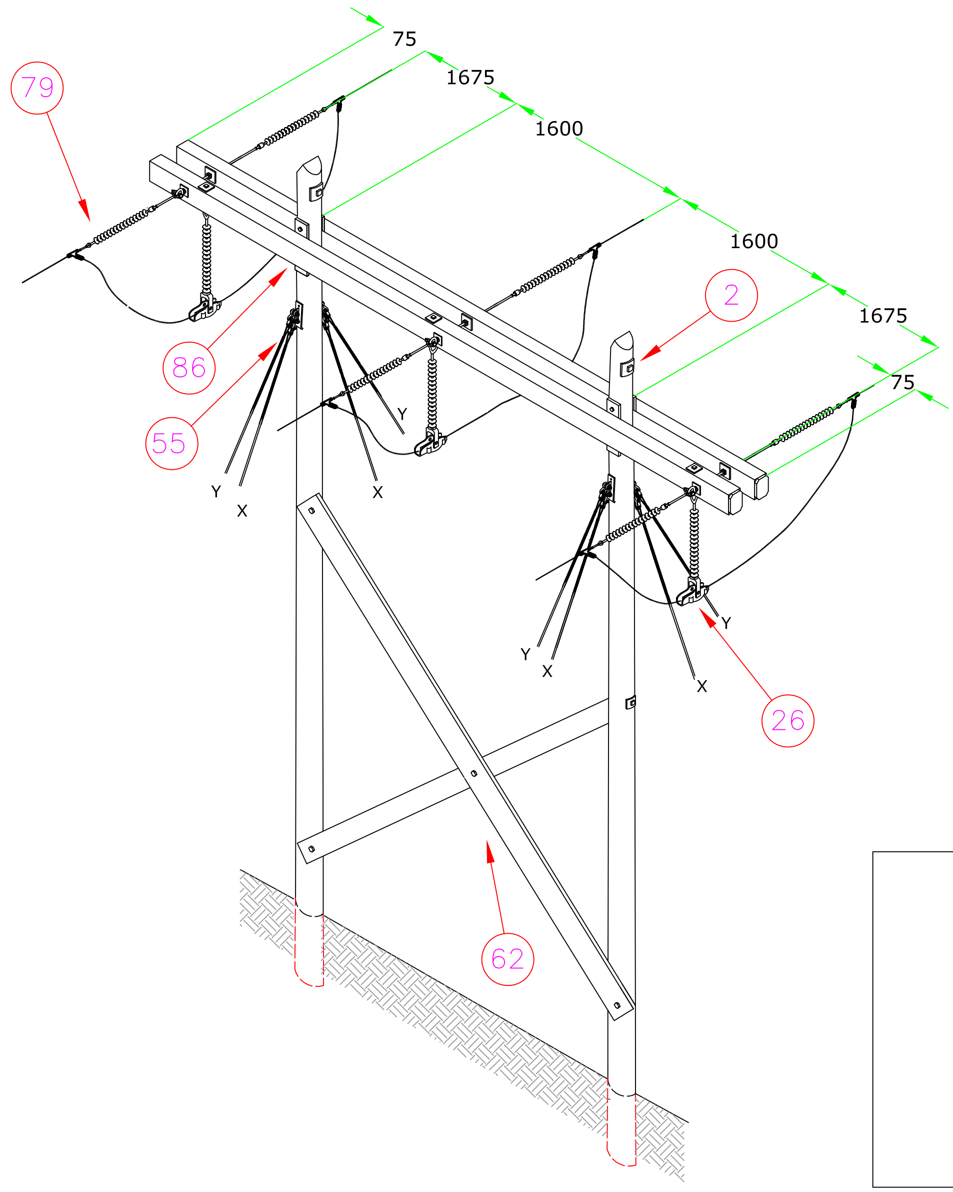
72kV SINGLE POLE VERTICAL DDE
HEAVY DEFLECTION WITH JUMPER POSTS
STRUCTURE TYPE 4310

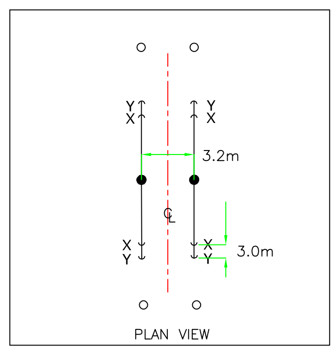
NT ENERGY

DRAWING No.	REV.
T15-SD-4310	R3

ALL HOLES TO BE DRILLED 13/16" UNLESS OTHERWISE NOTED.







NOTES:

- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- FOR MAX STRUCTURAL CAPACITY USE DOUBLE SWAY BRACING FOR POLES OVER 75' TALL
- DESIGNER TO CONFIRM ALL DRILLING DETAILS AGAINST MATERIALS USED
- ANCHORING REQUIRED TO BE CONFIRMED AND SPECIFIED BY DESIGNER (SEE STRUCTURE LIST)

DBS ENERGY SERVICES INC.

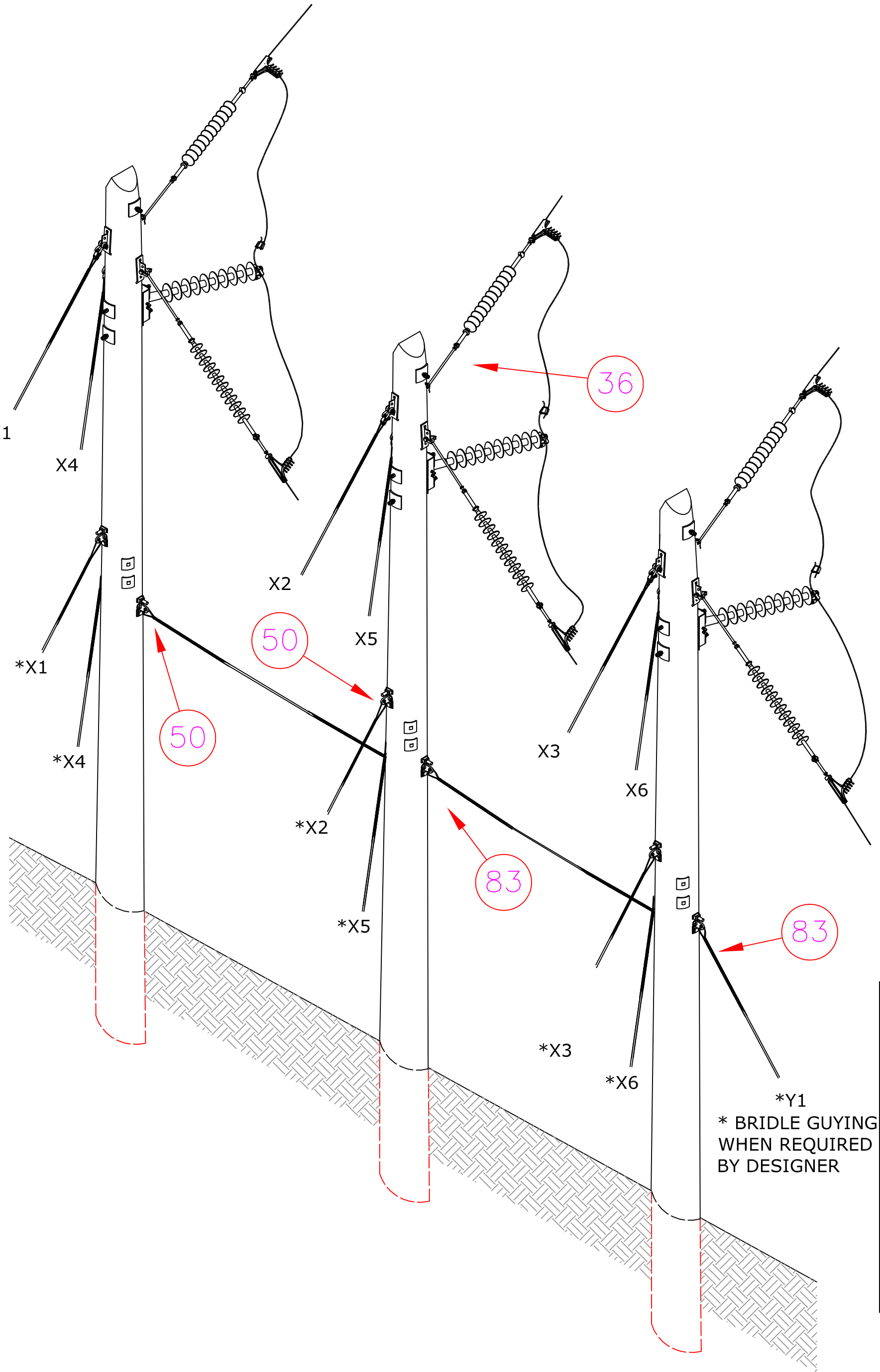
MIDGARD CONSULTING INC

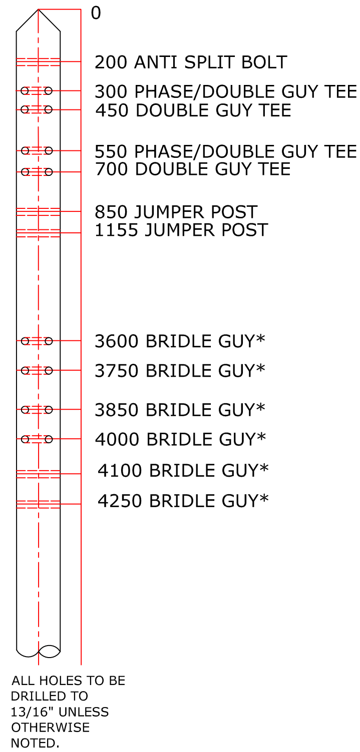
REVISIONS

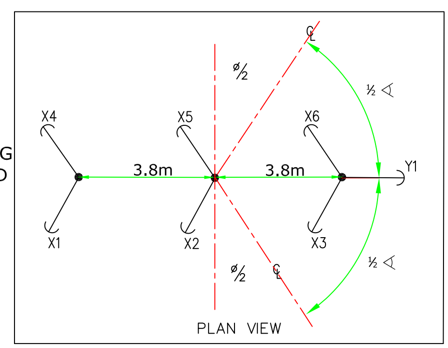
No.	BY	DATE	DESCRIPTION	APP.
R0	AM	13-01-28	NEW DRAWING	DBS

72kV DOUBLE DEADEND H-FRAME
INLINE WITH DOUBLE STEEL ARMS
STRUCTURE TYPE 4326

NT ENERGY	DRAWING No.	REV.
	T15-SD-4326	R0







NOTES:
- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- ANCHOR KICKS MAY BE REQUIRED, TO BE SPECIFIED BY DESIGNER IN STRUCTURE LIST
- JUMPER POSTS REQUIRED FOR LINE DEFLECTIONS < 60° (NOT REQUIRED FOR 60° AND GREATER DEFLECTIONS)
- POLE SPACING MAY BE CHANGED BY DESIGNER TO ADJUST FOR DEFLECTIONS AND PHASE SPACING
- BRIDLE GUYING REQUIREMENT TO BE DETERMINED BY DESIGNER
- DESIGNER TO CHECK GUYING CLEARANCES TO PHASES
- DESIGNER TO CONFIRM ALL DRILLING DETAILS AGAINST MATERIALS USED
- ANCHORING REQUIRED TO BE CONFIRMED AND SPECIFIED BY DESIGNER (SEE STRUCTURE LIST)

DBS ENERGY SERVICES INC.

MIDGARD
CONSULTING INC

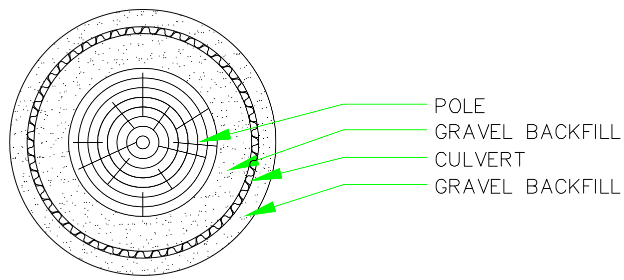
REVISIONS

No.	BY	DATE	DESCRIPTION	APP.
R4	AM	13-01-28	REMOVE GROUNDING, BONDING, UPDATE STR	DBS
R3	AM	10-30-07	ADD JUMPER POST, UPDATE DWG	DBS
R2	AM	06-11-02	GRND DETAIL, DRILL DETAIL, ASSEMBLIES	DBS
R1	DBS	06-04-12	ADDED GROUNDING AND BONDING	DBS
R0	DBS	05-04-11	NEW DRAWING	DBS

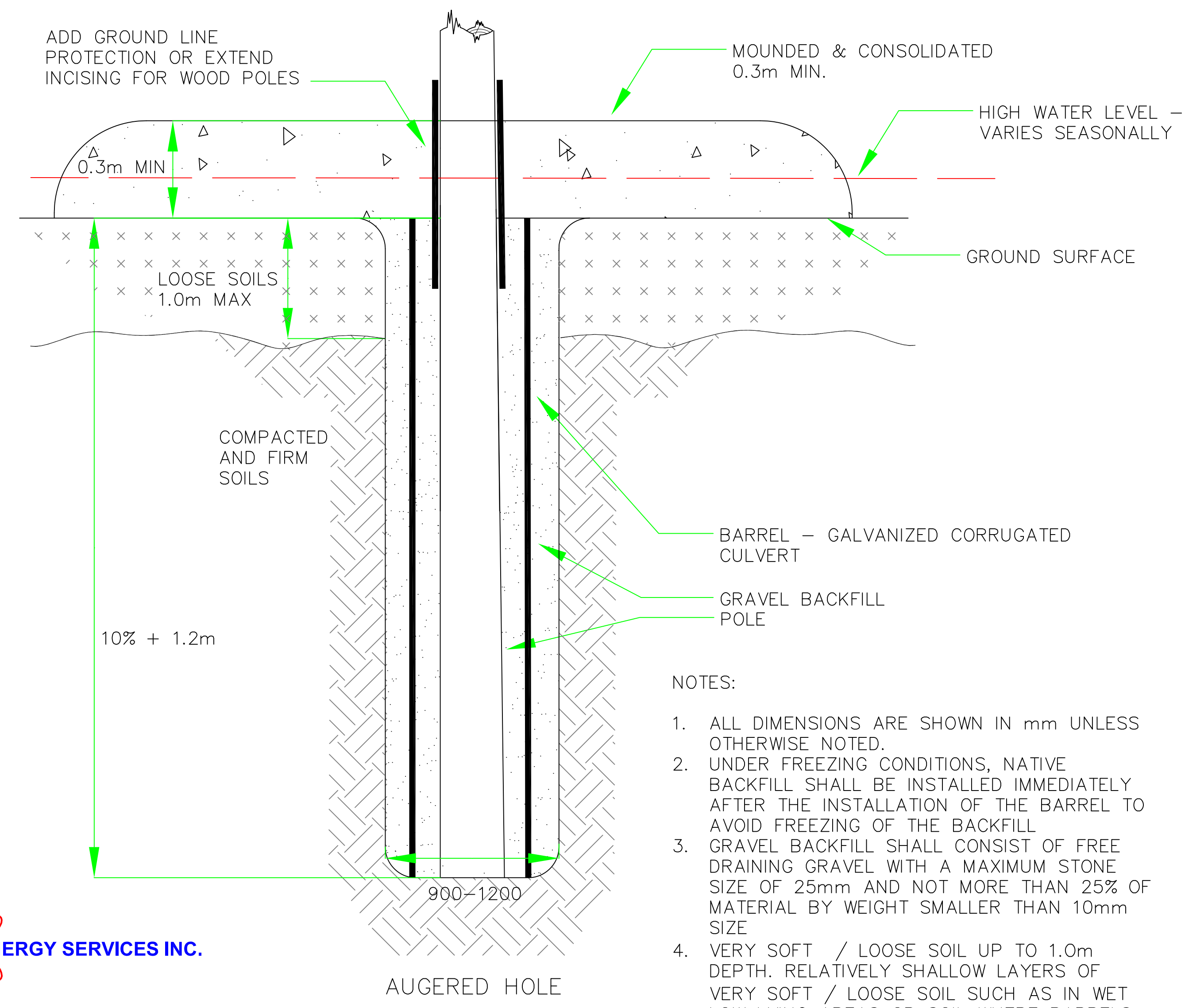
3 POLE DDE WITH DEFLECTION FOR 72kV SUSPENSION WITH JUMPER SUPPORT AND BRIDLE GUYING OPTION STRUCTURE TYPE 4334

NT ENERGY

DRAWING No.	REV.
T15-SD-4334	R4



CROSS SECTION



AUGERED HOLE

NOTES:

1. ALL DIMENSIONS ARE SHOWN IN mm UNLESS OTHERWISE NOTED.
2. UNDER FREEZING CONDITIONS, NATIVE BACKFILL SHALL BE INSTALLED IMMEDIATELY AFTER THE INSTALLATION OF THE BARREL TO AVOID FREEZING OF THE BACKFILL
3. GRAVEL BACKFILL SHALL CONSIST OF FREE DRAINING GRAVEL WITH A MAXIMUM STONE SIZE OF 25mm AND NOT MORE THAN 25% OF MATERIAL BY WEIGHT SMALLER THAN 10mm SIZE
4. VERY SOFT / LOOSE SOIL UP TO 1.0m DEPTH. RELATIVELY SHALLOW LAYERS OF VERY SOFT / LOOSE SOIL SUCH AS IN WET LOW LYING AREAS OR SOIL WHERE BARRELS ARE REQUIRED TO PREVENT CAVING
5. MOUNDED BACKFILL SHALL BE 300mm ABOVE THE GROUND LINE OR HIGHEST WATER LEVEL – WHICH EVER IS THE HIGHER IN ELEVATION

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

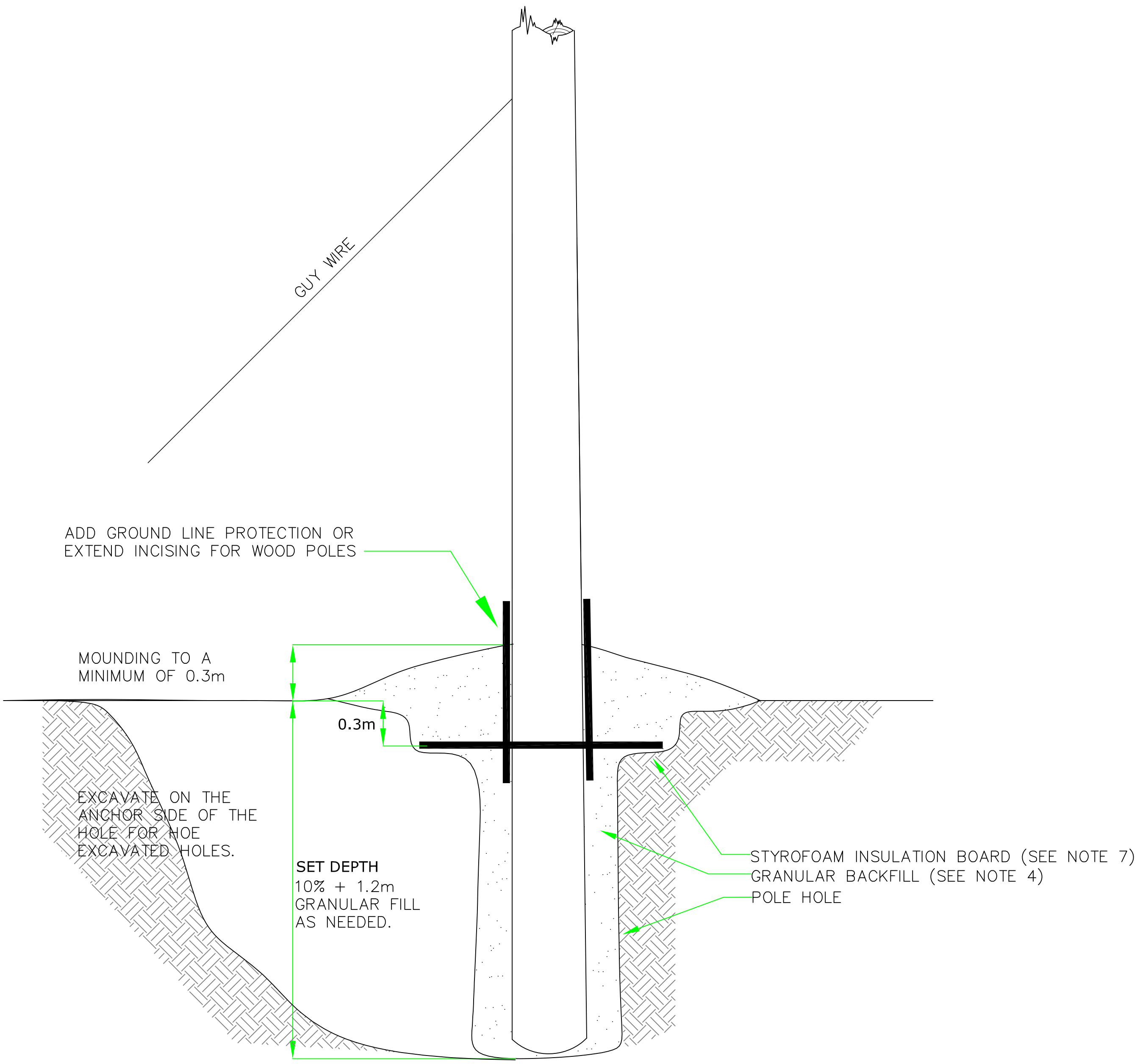
REVISIONS

NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R1	AM	10-10-05	UPDATE FROM DRAFT	DBS
R0	AM	10-04-23	NEW DRAWING	DBS

SHALLOW DEPTH VERY SOFT / LOOSE SOIL
EXTRA EMBEDMENT AND BARREL REQUIREMENTS
DRAWING # 9940

NT ENERGY

DRAWING NUMBER:	REV:
T15-SD-9940	R1



NOTES:

1. ALL DIMENSIONS ARE IN m UNLESS OTHERWISE NOTED
2. ALL BACKFILL SHALL CONSIST OF GRANULAR MINERAL SOILS, SHALL BE PLACED IN MAXIMUM 250mm LIFTS AND COMPACTED BETWEEN LIFTS WITH A MINIMUM OF 2 AGGRESSIVE PASSES OF ACCEPTABLE TAMPING.
3. OTHER POLES SHOULD BE EMBEDDED 10% OF THEIR HEIGHT +1.2m
4. IN AREAS WHERE PERMAFROST ICE LENSES ARE ENCOUNTERED A 50mm THICK SHEET OF STYROFOAM INSULATION BOARD SHOULD BE INSTALLED ACROSS THE EXCAVATED AREA AT THE 0.5m DEPTH TO REDUCE THAWING OF THE PERMAFROST LAYERS

DBS ENERGY SERVICES INC.

MIDGARD
CONSULTING INC

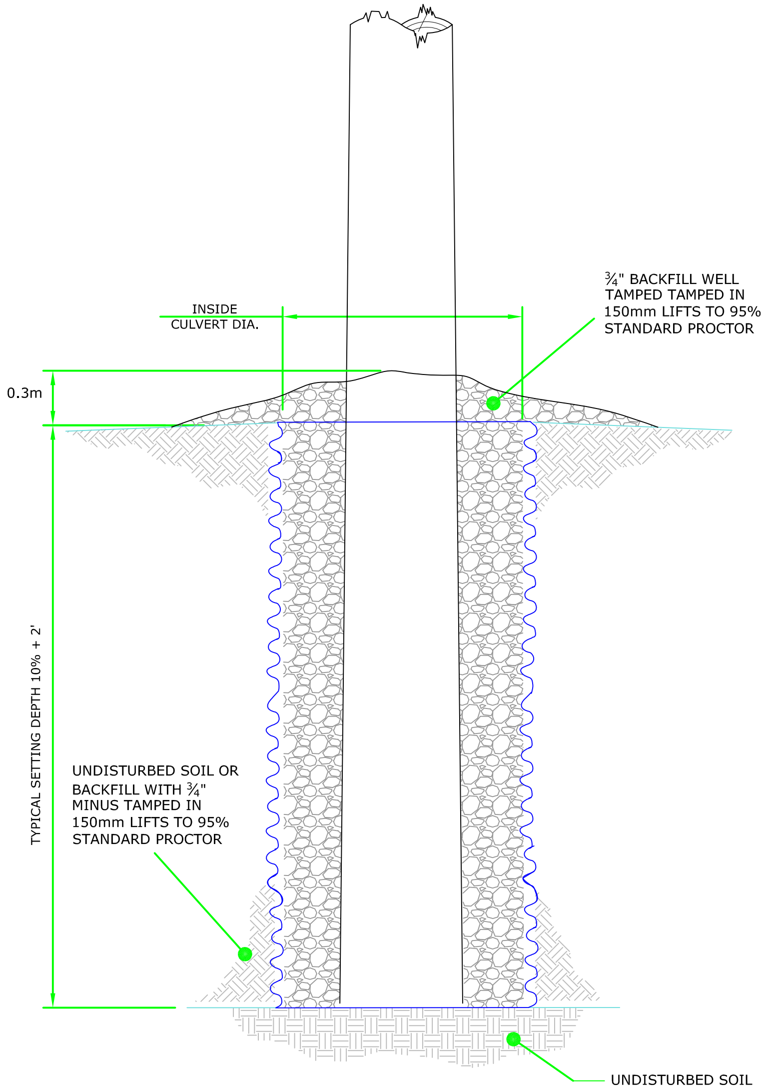
REVISIONS

NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R1	AM	10-10-05	UPDATE FROM DRAFT	DBS
R0	AM	10-04-22	NEW DRAWING	DBS

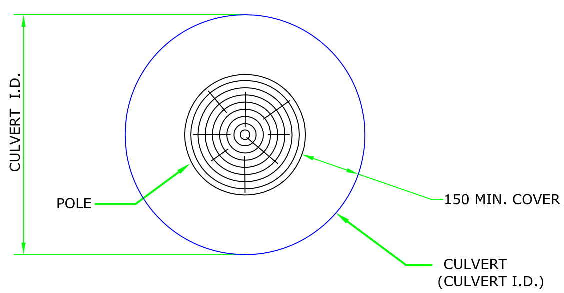
ANCHORED STRUCTURE FOUNDATIONS IN
WET MINERAL SOIL
DRAWING # 9948

NT ENERGY

DRAWING NUMBER:	REV:
T15-SD-9948	R1



TYPICAL CULVERT SET



TOP VIEW DETAIL

NOTES:

1. DEPENDING ON SETTING METHODS AND INSTALLATION; WITH USE OF AN EXCAVATOR, BACKFILL HOLE WITH 150mm LIFTS OF ¾" MINUS TO 95% STANDARD PROCTOR DENSITY. IF THE HOLE IS AUGERED WITH "TEXOMA" OR VACUUM TRUCK, THE CULVERT MAY REQUIRE SHORING OF THE EXCAVATION SITE; AND THEN THE VOIDS TO THE OUTSIDE OF CULVERT SHALL BE UNIFORMLY FILLED WITH FINE, FLOWABLE GROUT MIXTURE WHILE VIBRATING THE CULVERT.
2. BASE OF THE FOUNDATION SHALL BE SET ON UNDISTURBED SOIL; IF NOT POSSIBLE AT THE TIME OF CONSTRUCTION, CONSULTATION WITH THE ENGINEER IS REQUIRED.
3. ANY ADDITIONAL EXCAVATION BACKFILLING REQUIREMENTS SHALL BE DONE USING ¾" MINUS AND BACKFILLED WITH 150mm LIFTS @ 95% S.P.

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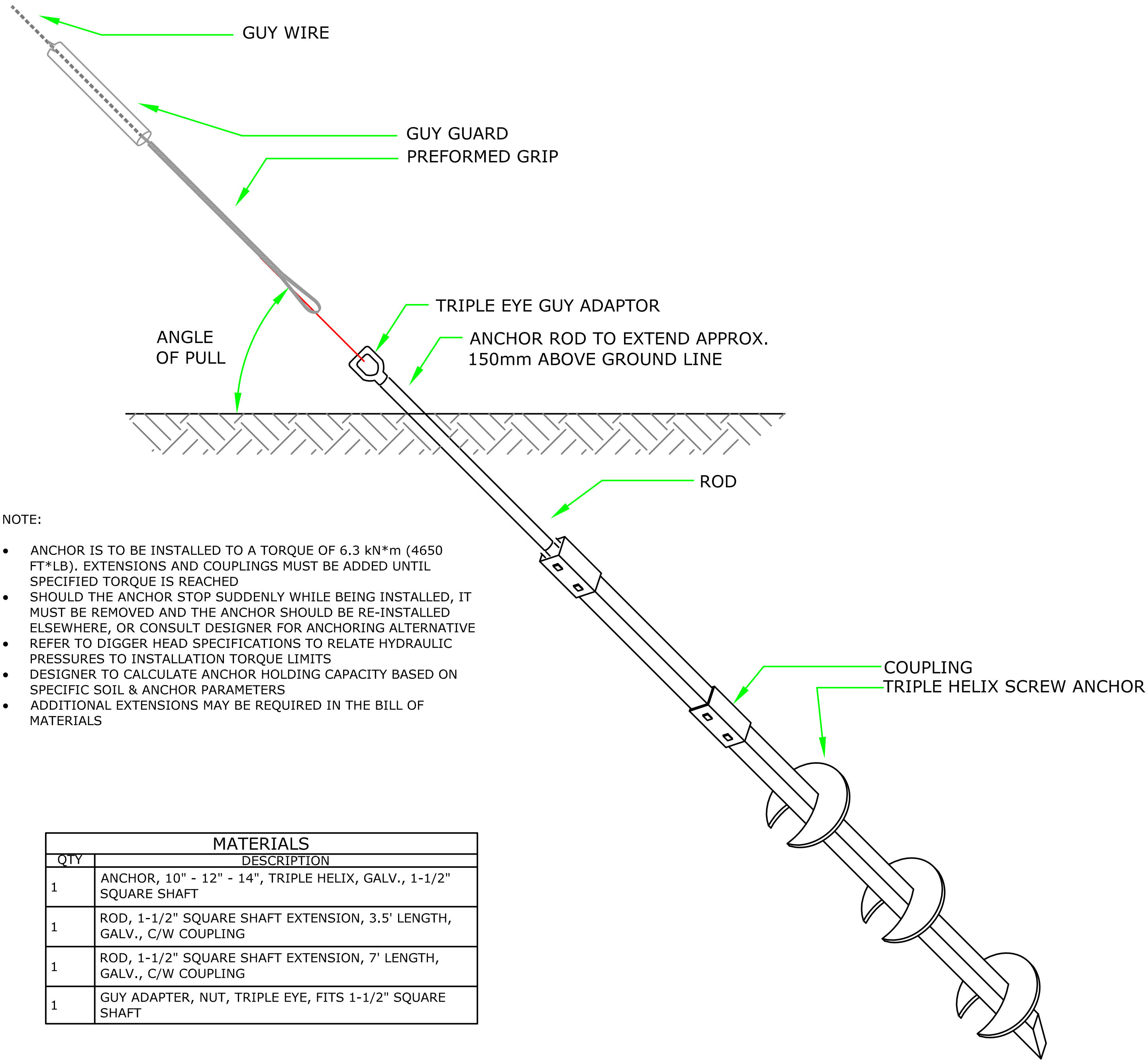
DBS ENERGY SERVICES INC.

REVISIONS

NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R1	AM	13-01-28	UPDATE NOTES AND CULVERT DESCRIPTION	DBS
R0	AM	10-06-21	NEW DRAWING	DBS

TYPICAL CULVERT SET
FOR TX STRUCTURES
STRUCTURE TYPE 9993

	DRAWING NUMBER:	REV:
NT ENERGY	T15-SD-9993	R1



NOTE:

- ANCHOR IS TO BE INSTALLED TO A TORQUE OF 6.3 kN*m (4650 FT*LB). EXTENSIONS AND COUPLINGS MUST BE ADDED UNTIL SPECIFIED TORQUE IS REACHED
- SHOULD THE ANCHOR STOP SUDDENLY WHILE BEING INSTALLED, IT MUST BE REMOVED AND THE ANCHOR SHOULD BE RE-INSTALLED ELSEWHERE, OR CONSULT DESIGNER FOR ANCHORING ALTERNATIVE
- REFER TO DIGGER HEAD SPECIFICATIONS TO RELATE HYDRAULIC PRESSURES TO INSTALLATION TORQUE LIMITS
- DESIGNER TO CALCULATE ANCHOR HOLDING CAPACITY BASED ON SPECIFIC SOIL & ANCHOR PARAMETERS
- ADDITIONAL EXTENSIONS MAY BE REQUIRED IN THE BILL OF MATERIALS

MATERIALS	
QTY	DESCRIPTION
1	ANCHOR, 10" - 12" - 14", TRIPLE HELIX, GALV., 1-1/2" SQUARE SHAFT
1	ROD, 1-1/2" SQUARE SHAFT EXTENSION, 3.5' LENGTH, GALV., C/W COUPLING
1	ROD, 1-1/2" SQUARE SHAFT EXTENSION, 7' LENGTH, GALV., C/W COUPLING
1	GUY ADAPTER, NUT, TRIPLE EYE, FITS 1-1/2" SQUARE SHAFT

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CONSULTING INC

REVISIONS

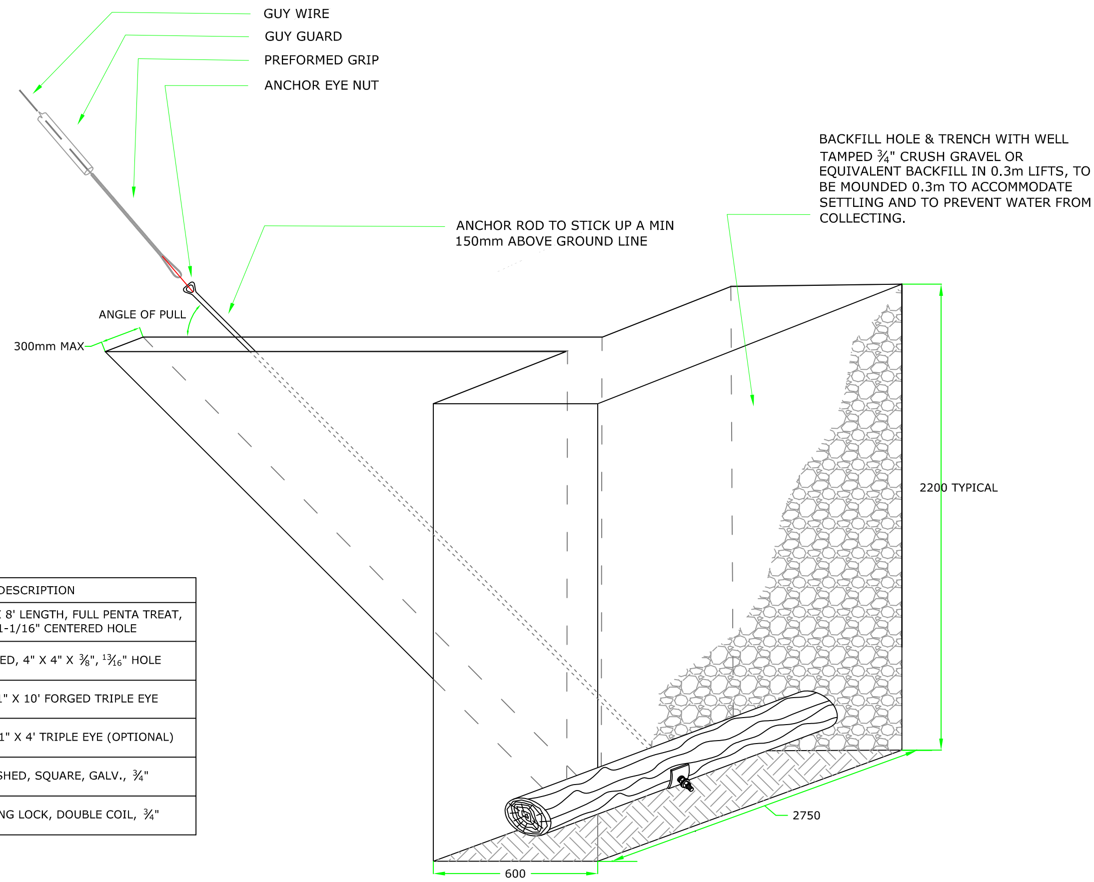
NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R1	AM	06-04-15	UPDATE DRAWING AND BOM	DBS
R0	SDM	06-03-10	NEW DRAWING	DBS

TYPE SS TRIPLE HELIX ANCHOR
ANCHOR DRAWING # 9923

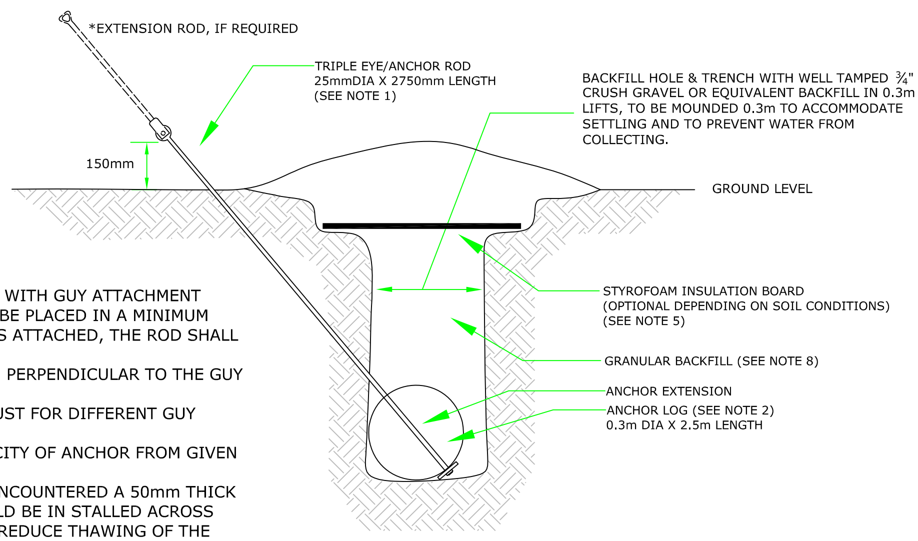
NT ENERGY

DRAWING NUMBER: T15-SD-9923

REV: R1



ITEM	QTY	DESCRIPTION
E090203	1	ANCHOR LOG, 14" X 8' LENGTH, FULL PENTA TREAT, WITH ONE 1-1/16" CENTERED HOLE
E142304	1	WASHER, CURVED, 4" X 4" X ⅜", 13/16" HOLE
E171112	1	ROD ANCHOR, 1" X 10' FORGED TRIPLE EYE
E170707	1	EXTENSION ROD, 1" X 4' TRIPLE EYE (OPTIONAL)
E141106	2	NUT, UNFINISHED, SQUARE, GALV., ¾"
E142603	1	WASHER, SPRING LOCK, DOUBLE COIL, ¾"



NOTE:

1. ANCHOR ROD SHALL BE ALIGNED IN DIRECT LINE WITH GUY ATTACHMENT POINT ON THE POLE. (+/-3 DEGREES) AND SHALL BE PLACED IN A MINIMUM SLOTTED TRENCH. WHERE MORE THAN ONE GUY IS ATTACHED, THE ROD SHALL BE ALIGNED WITH THE CENTER GUY.
2. ANCHOR LOG SHALL BE PLACED HORIZONTAL AND PERPENDICULAR TO THE GUY DIRECTION
3. ADJUST DEPTH BASED ON GUY ANGLE. FIELD ADJUST FOR DIFFERENT GUY ANGLES.
4. DESIGNER IS TO CALCULATE MAX HOLDING CAPACITY OF ANCHOR FROM GIVEN SOIL CONDITIONS & ANCHOR PARAMETERS
5. IN AREAS WHERE PERMAFROST ICE LENSES ARE ENCOUNTERED A 50mm THICK SHEET OF STYROFOAM INSULATION BOARD SHOULD BE IN STALLED ACROSS THE EXCAVATED AREA AT ABOUT 0.5m DEPTH TO REDUCE THAWING OF THE POLE AND ANCHOR AREAS
6. BACKFILL HOLE AND & TRENCH WITH WELL TAMPED, ACCEPTABLE, NATIVE SOIL OR GRAVEL, IN 0.3m LIFTS
7. MOUND BACKFILL A MINIMUM OF 0.3m TO ACCOMMODATE SETTLING AND TO PREVENT WATER FROM COLLECTING
8. ALL BACKFILL SHALL CONSIST OF GRANULAR MINERAL SOILS; SHALL BE PLACED IN 250mm LIFTS AND COMPACTED BETWEEN LIFTS WITH A MINIMUM OF 2 PASSES OF A MECHANICAL TAMPER
9. USE SOIL SAFETY FACTORS OF A MINIMUM 2.0 UNLESS SOIL TESTS ARE AVAILABLE
10. DESIGNER TO CONFIRM SOIL EXPECTATIONS IN FIELD
11. MACHINE DIG HOLE OR DIG BY HAND.

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

REVISIONS

No.	BY	DATE	DESCRIPTION	APP.
R1	AM	10-10-05	UPDATE FROM DRAFT	
R0	AM	10-06-15	NEW DRAWING	DBS

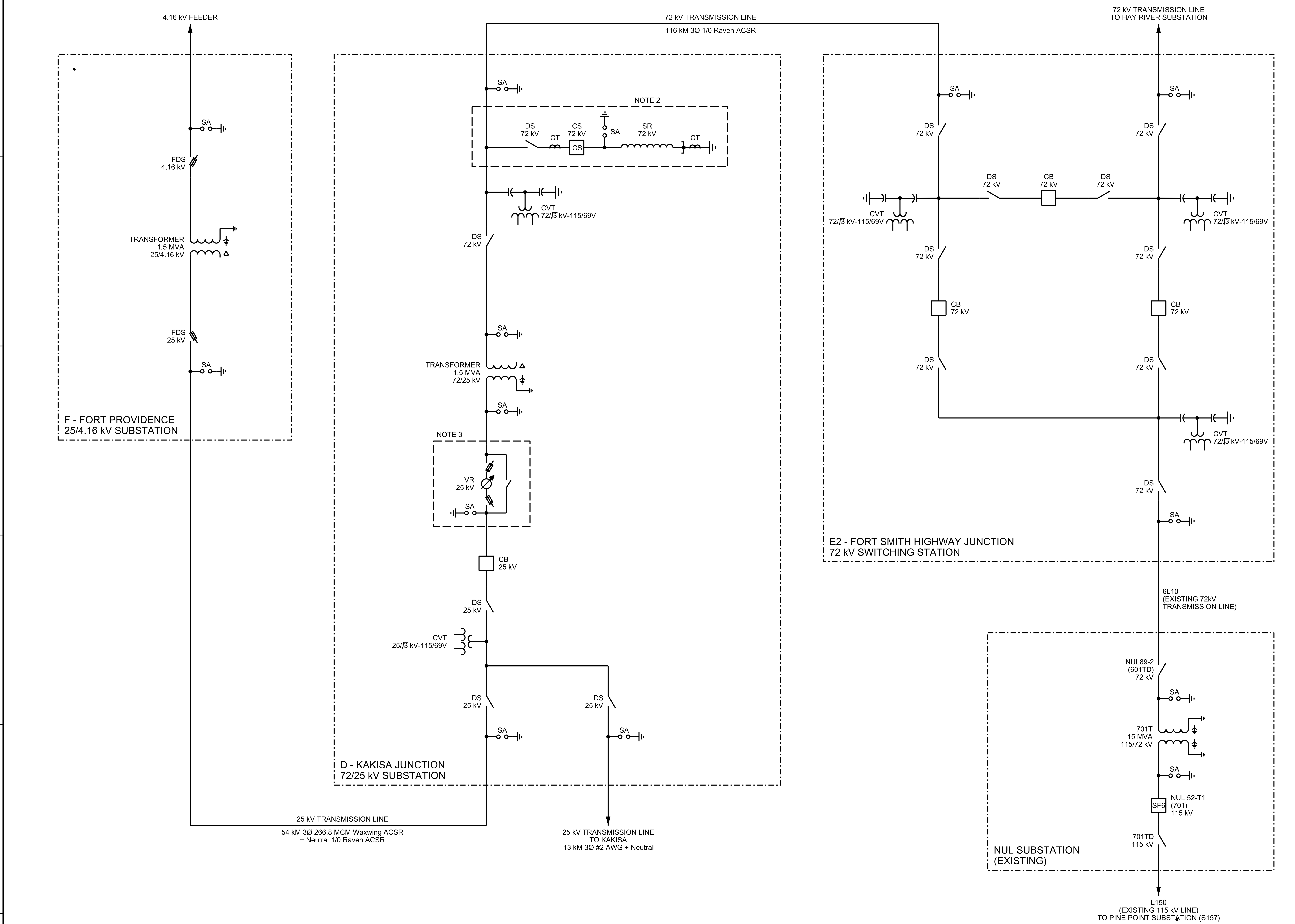
LOG ANCHOR
ANCHOR DRAWING # 9949

NT ENERGY

DRAWING No.	REV.
T15-SD-9949	R1

Appendix C:
Single Line Diagram

DWG. No. H361430-00000-260-288-0001



NOTES:

1. THIS IS A PRELIMINARY DRAWING, SHOULD BE VERIFIED IN DETAIL DESIGN.
2. REACTOR SIZE AND PLACEMENT SHOULD BE VERIFIED BY POWER SYSTEM STUDY.
3. VOLTAGE REGULATOR SIZE AND PLACEMENT SHOULD BE VERIFIED BY POWER SYSTEM STUDY.

LEGEND:

- CIRCUIT BREAKER (CB)
- CIRCUIT SWITCHER (CS)
- FUSIBLE DISCONNECT SWITCH (FDS)
- DISCONNECT SWITCH (DS)
- SURGE ARRESTOR (SA)
- TRANSFORMER
- SHUNT REACTOR (SR)
- CURRENT TRANSFORMER (CT)
- CAPACITIVE VOLTAGE TRANSFORMER (CVT)
- VOLTAGE REGULATOR (VR) AND BY-PASS SWITCH
- VOLTAGE TRANSFORMER (VT)

PRELIMINARY

NOT FOR CONSTRUCTION

APPROVED FOR USE

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	J ZENG	NR	2020-02-19
DESIGNER	J ZENG	NR	2020-02-19
CHECKER	D ZHANG		2020-02-19
DESIGN COORD.			
RESP. ENG.			
LEAD DISC. ENG.	D ZHANG		2020-02-19
ENG. MANAGER			
PROJ. MANAGER	D ALMANZA		2020-02-19

DRAWING APPROVAL STATUS: APPROVED FOR USE

No.	DESCRIPTION	BY	CHK'D	DATE

REVISIONS

DRAWING No.	DRAWING TITLE

REFERENCE DRAWINGS

REG. PROFESSIONAL

GOVERNMENT OF THE NORTHWEST TERRITORIES

FORT PROVIDENCE AND KAKISA TL PROJECT

OVERALL

SINGLE LINE DIAGRAM

SCALE: NTS OR AS NOTED

DWG. No. H361430-00000-260-288-0001

REV C

SHEET SIZE: A1

$USERNAME$ $DATE$ $FILE$ $TIME$