FRONT-END ENGINEERING AND DESIGN: PROJECT TUNDRA CARBON CAPTURE SYSTEM

Final Report

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1 EXECUTIVE SUMMARY

As the next phase of Project Tundra, Minnkota Power Cooperative (MPC) completed a front-end engineering and design (FEED) study to install a post-combustion CO_2 capture system (CCS) at the MPC-operated (Square Butte Electric Cooperative-owned) Milton R. Young Station (MRYS) Unit 2 (MRY2), a 477-MW power plant fueled by North Dakota lignite. The project team completed the FEED with Fluor's Econamine FG Plus℠ (EFG+) technology and is taking the next steps leading up to start of construction. Team members included FEED technical lead Fluor Enterprises (Fluor); owner's engineer and balance of plant (BOP) engineer Burns & McDonnell (BMcD); leading carbon capture consultants (David Greeson Consulting, Hunt International Energy Services); environmental consultants (AECOM, Agora Environmental), other BOP engineering consultants (Golder Associates, Nels); cost-share funding agency, the North Dakota Industrial Commission (NDIC); and the Energy & Environmental Research Center (EERC). Project Tundra's goal is to implement carbon capture, utilization, and storage (CCUS) in North Dakota, while preserving the use of lignite. Future options could lead to revitalizing legacy oil fields and creating a new CO_2 enhanced oil recovery (EOR) industry. The topic of this report is the FEED study for the carbon dioxide capture portion of Project Tundra.

Building on the findings of a pre-FEED study for MRY2, the key deliverables contained in this FEED study are: a) design, costing, and performance data needed to commence project financing activities; b) engineering and material balances required to file for all project permits; and c) a final project schedule.

Based on the results of the previous pre-FEED study, MPC and its team evaluated two options to provide the large amount of steam needed to operate the CCS: 1) installation of new natural gas package boilers and a new pipeline to supply natural gas to the facility and 2) extraction of steam from the existing MRYS steam turbine generator. The FEED study was performed using the package boilers option, as it was deemed to have the lowest technical risk, overall cost, and cost uncertainty. A key feature of the design, however, was the mixing the natural gas boilers' flue gas with the MRY2 flue gas. This increased the size of the CCS system. This design also enabled the tie-in of Unit 1 flue gas for times when Unit 2 is offline.

The CCS was designed to capture a combined 12,978 short tons per day (STPD) of CO_2 from the flue gases produced by the existing MRY Unit 2 along with flue gas produced by the new boiler package within the CCS. The 12,978 STPD CO_2 capture is achieved by normally processing 100% of the total available MRY Unit 2 flue gas (considering full load operation) and 100% of the boiler package flue gas, then removing 90% of the CO_2 available from the processed flue gas streams.

The FEED study was conducted with a +/- 15% cost estimate. Total capital costs, inclusive of owner's costs and contingencies, is summarized below:

- CCS Plant - $745MM
- CCS Balance of Plant - $330MM
- Project Tundra Specific Requirements
    - Earth Works Associated with Carbon Capture - $85MM
    - Impurity Removal Package - $56MM
    - Enclosures / Buildings - $79MM
    - Regional Adjustment for Labor - $87MM

- Owner's Costs - $556MM
- **TOTAL PROJECT CAPEX - $1,938MM**

The total cost of carbon capture, including operating expenses, was estimated as follows:

- $20.57/metric ton based only on operating costs (un-escalated 2021 dollars)
- $78.46/metric ton for the "breakeven CO_2 value" (levelized over life of project)
- $80.60/metric ton for the "breakeven CO_2 emissions penalty" (levelized over life of project)

The above cost estimates exceeded MPC's targets for this project. When comparing the cost of capture against the 45Q tax credit program ($59.93/metric ton, levelized over life of project), there is a shortfall in the available revenue. Based on this, MPC, Fluor and the project team reviewed a number of value engineering or cost-cutting possibilities. Rough order magnitude estimates placed the cost-cutting opportunities at $100-350MM. The choice to supply steam via the natural gas package boilers was based on pre-FEED data and estimates of natural gas transportation costs. The report presented herein is based on the natural gas boilers scenario. However, one key outcome of the presented FEED study is that the natural gas boilers scenario was significantly higher cost than was estimated during the previous pre-FEED study. As such, it is MPC's conclusion that next steps in the project development need to reconsider the scenario where steam is extracted from the MRYS steam turbine generators. While the project team considers this to be a large opportunity for cost-cutting, this report does not contain any detailed technical or cost estimates of the impact of this change. This will need to be examined in future work.

The elimination of new natural gas boilers will free up flue gas-processing capacity over and above the amount produced by Unit 2. Discussions with environmental regulators confirmed that flue gas from Unit 2 can be commingled with a portion of flue gas from Unit 1 during normal operations and then processed together in the CCS. MPC has, therefore, recently decided to utilize the FEED design capacity to process 100% of the flue gas from Unit 2 and a portion of flue gas from Unit 1. Preliminary evaluation of the extraction steam capabilities of the Unit 2 STG indicated that Unit 2 steam extraction alone will not provide enough steam for the CCS at full load during summer periods of high STG condenser backpressure. Preliminary evaluation of the extraction steam capability from Unit 1 indicated that combining extraction steam from both Units 2 and 1 will be able to make up the apparent steam deficit with the added benefit of maintaining operational flexibility for the station.

Elimination of the natural gas boilers has the benefit of 1) allowing the project to reduce the plot plan which has significant capital cost savings, 2) eliminating a new 25-mile natural gas pipeline which has significant operating cost savings and 3) eliminating the price risk and cost of purchasing natural gas.

Following the FEED study and having identified several opportunities to significantly reduce the cost, the next step in this project is to conduct the final engineering work needed to produce Construction Ready Engineering, Schedule and pricing Terms (CREST). The CREST work will include a) detailed steam turbine modeling for steam supply to carbon capture; b) designing the systems, piping, and structures needed for steam integration; c) engineering for the other impacts of a change in steam supply strategy; d) design integration of optimization ideas that are aimed at reducing the projected cost of carbon capture; and e) a more detailed emissions analysis of lignite flue gas. These combined elements will support a possible

start of construction for Project Tundra by the end of 2022. This task is needed to a) more fully determine the extraction steam capabilities from Unit 2 and Unit 1, b) evaluate any structural or mechanical issues that must be addressed in extraction system design, c) evaluate the combining of extraction steam from the two units along with control and monitoring of the steam delivery to the CCS, d) evaluate seasonal steam condensate return conditions and the impact on the STG condensers, and e) identify operational impacts caused by extraction in both the host coal units and the CCS that need to be addressed in detailed design.

2 PROJECT BACKGROUND

As the next phase of Project Tundra[1], Minnkota Power Cooperative (MPC) has completed a front-end engineering and design (FEED) study to install a post-combustion CO_2 capture system (CCS) at the MPC-operated (Square Butte Electric Cooperative-owned) Milton R. Young Station (MRYS) Unit 2 (MRY2), a 477-MW power plant fueled by North Dakota lignite. The project team completed the FEED with Fluor's Econamine FG Plus℠ (EFG+) technology and is taking the next steps leading up to start of construction. Team members included FEED technical lead Fluor Enterprises (Fluor); owner's engineer and balance of plant (BOP) engineer Burns & McDonnell (BMcD); leading carbon capture consultants (David Greeson Consulting, Hunt International Energy Services); environmental consultants (AECOM, Agora Environmental), other BOP engineering consultants (Golder Associates, Nels); cost-share funding agency, the North Dakota Industrial Commission (NDIC); and the Energy & Environmental Research Center (EERC). Project Tundra's goal is to implement carbon capture, utilization, and storage (CCUS) in North Dakota, while preserving the use of lignite. Future options could lead to revitalizing legacy oil fields and creating a new CO_2 enhanced oil recovery (EOR) industry.

The topic of this report is the FEED study for the carbon dioxide capture portion of Project Tundra. Complementary FEED studies were completed on 1) a CO_2 pipeline to safely transport captured CO_2, 2) construction of a nearby saline geologic CO_2 storage facility, and 3) the large recycle and compression facility needed for EOR in a western North Dakota oil field. The CCS, pipeline, and CO_2 storage facility together embody the broader effort known as Project Tundra. Completion of all FEED components of Project Tundra increases the likelihood of commercial implementation.

2.1 MRYS Plant Description

MRYS includes two Babcock & Wilcox (B&W) Carolina-type radiant boilers designed to burn high-moisture, high-slagging/fouling North Dakota lignite. Unit 1 is a cyclone-fired, balanced draft, natural circulation boiler nominally rated at 1,714,000 lb/hr. Unit 2 is a cyclone-fired, balanced-draft, pump-assisted natural circulation boilers nominally rated at 3,050,000 lb/hr. Both are steam–electric generating units and fire North Dakota lignite supplied from the Center Mine, owned and operated by BNI Coal, Ltd.

Unit 1 turbine generator (MRY1) has a nameplate design output capacity rating of 256.2 MW_g (gross)/230 MW_n (net). Unit 1 is owned and operated by MPC and began commercial operation on November 20, 1970. Unit 2 turbine generator (MRY2) has a nameplate design output capacity rating of 488.2 MW_g/ 430MW_n. Unit 2 is owned by Square Butte Electric Cooperative, operated by MPC, and began commercial operation on May 11, 1977. Both units are equipped with separated overfire air (SOFA) and selective noncatalytic reduction (SNCR) systems for NO_x control, a halogen/powdered activated carbon (PAC) system for Hg control, a cold-side dry ESP for particulate control, and a wet lime-based FGD (flue gas desulfurization) unit for SO_2 control. Heat input at maximum capacity for Unit 1 is 2887 MMBtu/hr and 5328 MMBtu/hr for Unit 2. MRY2 is an operational lignite-fired unit with appropriate space, size, scale, and motivated owners that make it an ideal site for a post-combustion CO_2 capture system.

[1] www.ProjectTundraND.com

2.2 Description of Fluor's Econamine FG Plus℠ (EFG+) Technology

Fluor's EFG+ technology (Figure 1) is an advanced amine-based process specialized for removal of CO_2 from low-pressure, oxygen-containing flue gas. The basic plant configuration consists of 1) a two-stage direct contact cooler (DCC) for flue gas cooling and SO_2 removal, 2) an absorber for CO_2 separation, 3) a regenerator for solvent regeneration and the release of pure CO_2, and 4) a compression and dehydration system to supply pipeline-ready CO_2 at the fence line.

The CO_2-absorbing process begins in the DCC to condition the flue gas by cooling and lowering SO_2 to single-digit ppm levels. The blower is used to convey the flue gas flow through the process. The impurity removal package removes the fine aerosol particles that form by combustion of a typical North Dakota lignite. The conditioned flue gas flows up the absorber column, where CO_2 is chemically absorbed into a circulating solvent stream flowing down the column. The CO_2-loaded solvent is then pumped from the bottom of the absorber, through a heat recovery exchanger where it is heated against hot CO_2-lean solvent, and into the top of the regenerator. As the solvent flows down the regenerator, it is contacted by steam, which strips the CO_2 from the solvent, producing an overheated mixture of steam and CO_2. The steam/CO_2 product is cooled, and the steam is condensed and separated from the CO_2 product. Hot CO_2-lean solvent from the bottom of the regenerator is pumped back through the heat recovery exchanger where it is cooled against the cold CO_2-loaded solvent before being returned to the top of the absorber column.

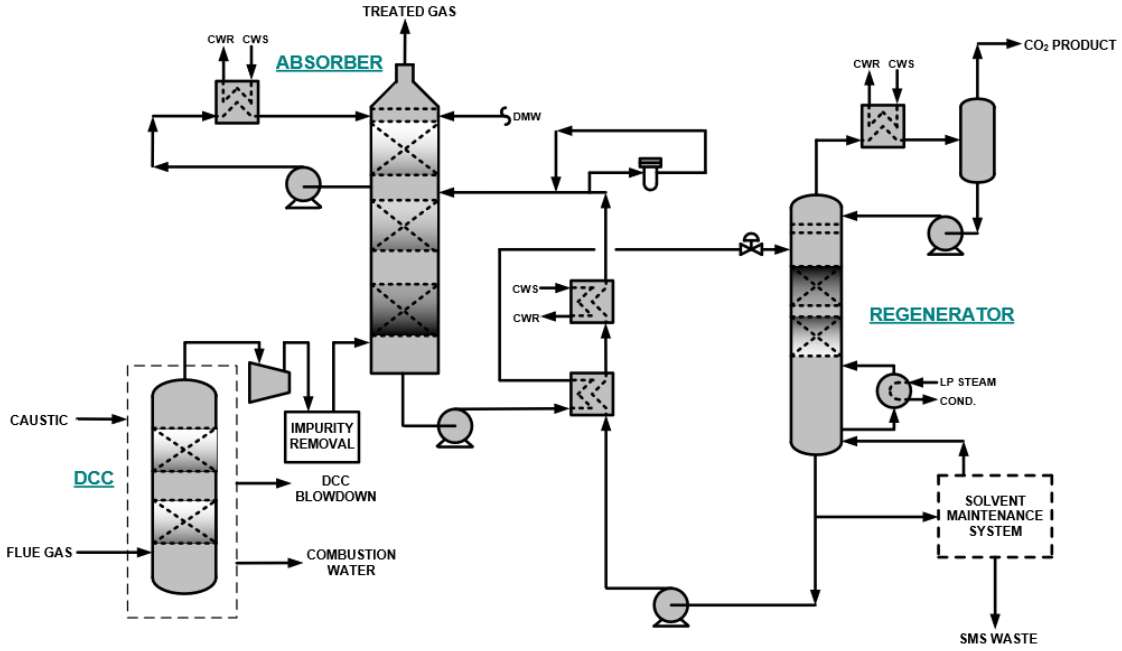


Figure 1. Schematic of Fluor's EFG+ CCS technology.

2.2.1 EFG+ Key Technology Advantages

EFG+ is the only commercial technology available that has extensive operating experience capturing CO_2 from high-oxygen-containing flue gases (up to 15 vol%). Fluor's EFG+ demonstration plant in Wilhelmshaven, Germany, was designed for capture of a nominal 70 tons of CO_2 per day from the flue gas of a coal-fired power plant, which also contained various impurities that are important to consider in the design of a commercial EFG+ plant. Experience gained from the Wilhelmshaven demonstration plant, in

addition to 29 other commercial plants worldwide, has enabled Fluor to make significant improvements to the EFG+ process. The key advantages of EFG+ compared to monoethanolamine (MEA) and other amine-based processes are summarized in the following sections.

Comparison to Conventional MEA. The EFG+ solvent is a proprietary formulation of primary amines; as such, the solvent chemistry is similar to that of a primary amine. However, Fluor has developed multiple process advancements that offer significant improvements over conventional MEA (Table 1).

Table 1. Comparison of the EFG+ Solvent and Process to a Conventional MEA-Based Process

Parameter	Comparison to MEA Process
Regeneration Steam Requirement	30% lower
Electrical Power Requirements	20% lower
Solvent Working Capacity	About 3 times higher
Corrosion Inhibitor	Not required for EFG+; required for MEA
Solvent Consumption	50% lower

Two-Stage DCC. Fluor's patented two-stage DCC treats the flue gas in two sections. In the lower section, the flue gas is cooled, and high-quality combustion knockout water is harvested, which can be reused within the plant with minimal treatment. In the upper section of the DCC, SO_2 is removed to single-digit ppm levels by a circulating scrubbing solution of sodium hydroxide. Fluor's two-stage DCC is beneficial because the knockout water does not get contaminated with SO_2 scrubbing solution.

Absorber Temperature Optimization. The chemical CO_2 absorption process is exothermic (i.e. heat is released as CO_2 is absorbed). While absorption reaction kinetics are favored by the higher temperatures, the solvent CO_2 carrying capacity is reduced. Fluor configures the absorber to remove a portion of the exothermic CO_2 absorption heat at the appropriate location(s) in the column to maximize the solvent carrying capacity while minimizing the impact on the absorption reaction kinetics. This minimizes the solvent circulation rate, and therefore, regeneration energy requirement. Optimizing the absorber temperature profile reduces the net steam demand of the EFG+ process by 3–5%.

Regeneration Heat Integration Configurations. Many EFG+ plants benefit from regeneration heat integration configurations. These configurations serve to: 1) transfer heat from the top of the regenerator column to the bottom, thereby reducing water vapor carryover and lowering both the condenser cooling load and steam demand for the reboiler, and 2) utilize low level heat sources external to the amine system to provide additional heat to the bottom of the regenerator and further reduce the reboiler steam demand. Electrical power is required for some of these integration configurations, so the net benefit depends on the relative costs of steam and electricity. On several recent projects, these configurations reduced the total solvent regeneration energy requirement by 10%. For Project Tundra, these heat integration configurations reduce the operating cost for solvent regeneration by approximately 12% based on relative costs of steam and electricity. Since the heat integration configurations are required to meet the energy consumption in the commercial model, they will be included in the process configuration for Project Tundra.

Minimizing Pressure Drop. A significant energy consumer in any post-combustion CO_2 capture (CCS) process is the blower, which is used to drive the flue gas through the capture process. Fluor works closely

with column internal suppliers to minimize pressure drop by employing advanced designs for internals and packing in the DCC and absorber, thereby reducing the blower power by approximately 65% compared to conventional carbon capture plants.

Solvent Maintenance System (SMS). One of the unique features of EFG+ technology is the new SMS, which removes heat-stable salts (HSS) and other nonvolatile degradation products to maintain solvent hygiene and performance. Unlike traditional batch reclaiming, Fluor's proprietary SMS operates continuously to maintain low levels of HSS and degradation products in the circulating solvent. Consequently, solvent loss, makeup, and waste generation are up to 95% lower than a traditional batch-type reclaiming process, significantly improving economic and environmental profile. Additionally, by maintaining very low concentrations of degradation products and certain metallic contaminants, undesired volatile organic compound (VOC) emissions are also reduced dramatically.

3 PROJECT SCOPE

3.1 Project Summary

The objective of this project was to complete a FEED study on the addition of a post-combustion CCS onto an existing power plant fueled by North Dakota lignite that will demonstrate next-generation CCS feasibility and economics. Building on the findings of a pre-FEED study for MRY2, the key deliverables contained in this FEED study are: a) design, costing, and performance data needed to commence project financing activities; b) engineering and material balances required to file for all project permits; and c) a final project schedule.

MPC has selected Fluor's proprietary EFG+ licensed technology for the FEED with the unit designed to capture a combined 12,978 short tons per day (STPD) of CO_2 from the flue gases produced by the existing MRY Unit 2 along with flue gas produced by the new boiler package within the CCS, which provides the steam necessary for the CCS. The 12,978 STPD CO_2 capture is achieved by normally processing 100% of the total available MRY Unit 2 flue gas (considering full load operation) and 100% of the boiler package flue gas, then removing 90% of the CO_2 available from the processed flue gas streams.

The FEED report presented herein is based on the inclusion of the natural gas boilers. However, a key conclusion of this FEED study is to consider eliminating the new boiler package within the CCS as a cost saving measure. Since the purpose of the boiler package is to produce the steam needed for the CCS solvent regeneration system, elimination of the boiler will require modifications to the existing MRY steam turbine to allow for extraction of the steam at turbine IP/LP crossover. If the boiler is eliminated, the CCS will still target a 12,978 STPD design CO_2 capture capacity by processing 100% of the flue gas from MRY Unit 2 and 34% of the flue gas produced by MRY Unit 1, while maintaining 90% CO_2 removal efficiency from the combined flue gases. The evaluation of the steam extraction option will be done in future work.

The project will compress and transport the captured CO_2 for storage. Fluor's project scope includes the CO_2 capture plant, compression and treating of the CO_2, and the required utility systems to support the new CCS facility.

In addition to Fluor's CCS scope, the balance of plant (BOP) and other FEED study scope is delineated below:

- Water Treatment Process – BMcD
- Water Treatment Makeup Supply – BMcD
- Potable Water Supply – BMcD
- Utility Water Supply – BMcD
- Waste Water Return Piping – BMcD
- Waste Water Class I Disposal Well – Golder Associates
- Natural Gas Tie (From supply to NG Boilers) – BMcD
- Fire Water Supply – BMcD
- Stormwater Management – BMcD
- Cooling Tower Icing Studies – BMcD
- Absorber Tower Icing Studies – Nels
- Air Dispersion Modeling – AECOM
- Emissions Monitoring Plan – Agora Environmental
- 230 kV Power Supply – MPC

3.2 System Boundaries

The CCS block flow diagram (BFD) presented later in Section 6.1 not only describes the interfaces between the various Process Blocks, but it also defines the process and utility streams which originate outside the CCS plant. The utility inputs include high voltage electrical power, fire water, utility water, raw water, RO water, softened water, nitrogen, and natural gas. The flue gas process stream originates at the tie-in point to the power plant exhaust stacks.

4 PROJECT DESIGN BASIS

4.1 Site Characteristics

The project site, as indicated in the yellow outline of Figure 2, exists as undeveloped land adjacent to coal stockpiles. There are existing roads near the project site that provide access points into the unit during construction.

4.2 Site Ambient Conditions

Table 2 provides the relevant site data for the study.

4.3 Fuel Feedstock and Flue Gas Characteristics

4.3.1 Lignite coal

Coal fuel range analyses are based on the coal that is expected to be burned from the Center Mine starting in 2025 through 2030. Table 3 provides the ultimate analysis. Table 4 provides the coal ash analysis.

4.3.2 Natural gas

Natural gas is required in the CCS for firing the new auxiliary boiler to produce steam for solvent regeneration and reclaiming. The natural gas composition is indicated in Table 5.



Figure 2. Project site

Table 2. Site data

Parameter	Value
Atmospheric Pressure (psia)	13.7
Ambient Dry Bulb Temperature	
Maximum (°F)	113
Minimum (°F)	-45
Average (°F)	44
Minimum Design Metal Temperature (°F)	-45
Minimum Design Temperature for Equipment in Enclosures with HVAC (°F)	40
Cooling Tower Design Wet Bulb Temperature (°F)	72.2
Average Relative Humidity	70.9%
Range of Relative Humidity	0 – 100%

Table 3. Ultimate analysis (wt %, as received)

	Min.	Average	Max.
Moisture	34.83	38.86	58.34
Carbon	23.69	41.26	43.35
Hydrogen	6.50	7.13	7.88
Nitrogen	0.45	0.57	1.59
Sulfur	0.32	0.96	2.79
Ash	4.00	6.65	11.94
Oxygen by Difference	2.0	5.3	11.7
Higher Heating Value, Btu/lb	3407	6619	7070

Table 4. Coal ash analysis (wt %)

	Min.	Average	Max.
Silicon as SiO_2	7.81	20.86	39.31
Aluminum as Al_2O_3	5.29	9.88	21.23
Titanium as TiO_2	0.20	0.37	1.13
Iron as Fe_2O_3	4.43	11.16	19.25
Calcium as CaO	14.00	20.96	33.41
Magnesium as MgO	3.22	5.56	9.20
Potassium as K_2O	0.13	0.85	1.99
Sodium as Na_2O	0.60	4.76	11.53
Sulfur as SO_3	12.26	23.49	32.62
Phosphorus as P_2O_5	0.01	0.15	0.59
Strontium as SrO	0.20	0.46	0.68
Barium as BaO	0.03	0.42	1.17
Manganese as MnO_2	0.03	0.09	0.23

Table 5. Natural gas composition

Component	Mole Percent (%)
Nitrogen	2.1584
Carbon Dioxide	0.9269
Methane	81.9635
Ethane	13.848
Propane	0.9044
Normal Butane	0.0246
Iso Butane	0.0158
Pentane	0.0004
Iso Pentane	0.0007
Neo Pentane	0
Hexanes Plus	0
Hydrogen	0.1352
Helium	0.0223

4.3.3 Flue gas

The overall flue gas feed to the CCS will be a combination of the flue gas produced from MRY Unit 2 and the flue gas produced by a new auxiliary boiler that has been included as part of the project to supply steam for the capture plant. MRY Unit 1 will be used as an alternate flue gas source when Unit 2 is out of operation. All (100%) of the available flue gas from MRY Unit 2 (or alternatively Unit 1) and from the auxiliary boiler will be drawn to the CCS for a total CO_2 production rate of 12,978 STPD based on 90% CO_2 recovery. Figure 3 provides the flow scheme of the combined flue gas from each of these sources. Table 6 provides the flue gas specifications for feed to the CCS.

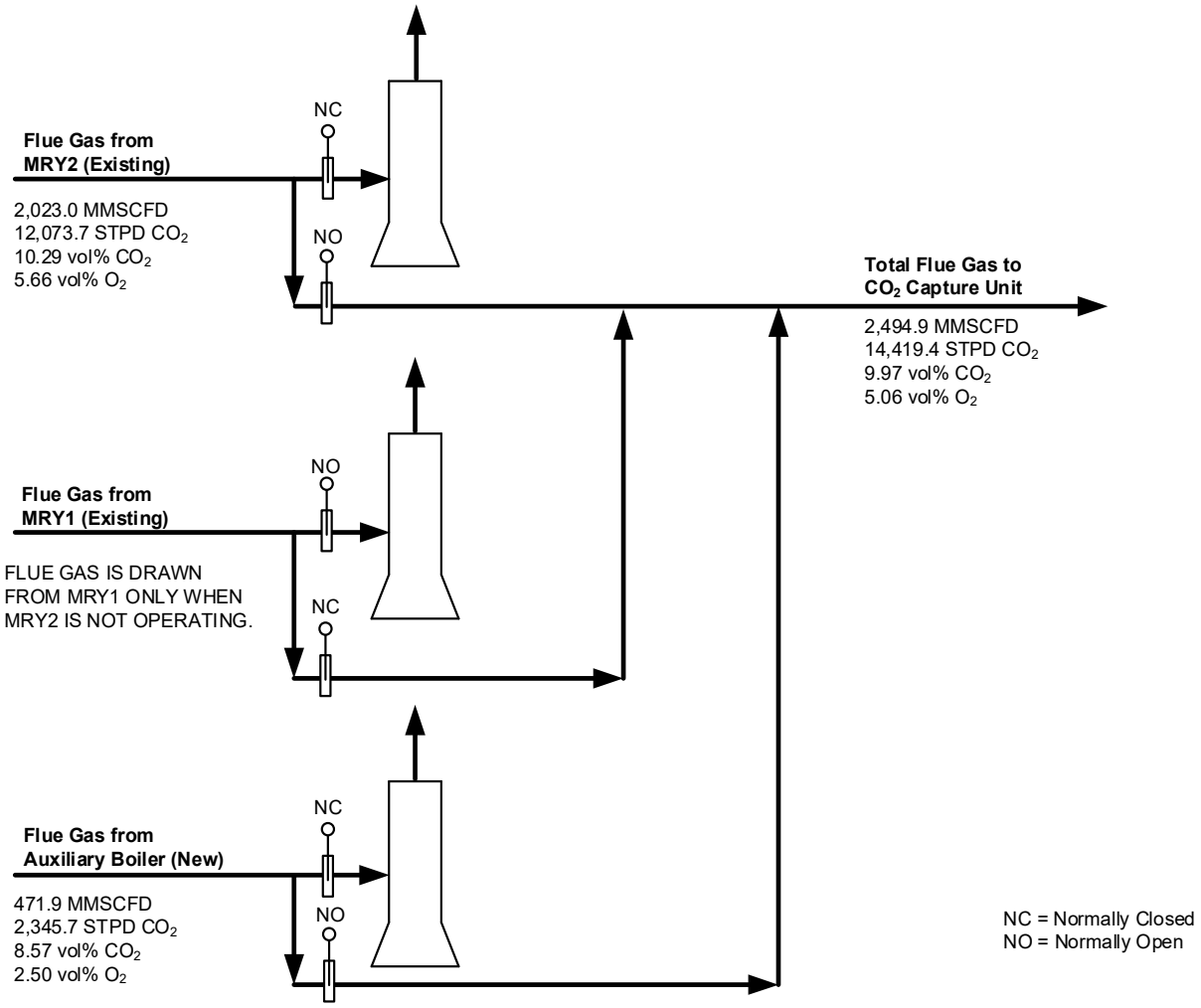


Figure 3. Flow scheme for flue gas feed to the CCS.

Table 6. Flue gas feed design basis

	MRY2 (Note 3)	New Boiler (Note 2)	Total (MRY2 + New Boiler)
Total Flue Gas Available Flow Rate (MMSCFD)	2,023.0	471.9	2,494.9
Total Flue Gas Draw (MMSCFD)	2,023.0	471.9	2,494.9
Percent Flue Gas Draw	100%	100%	-
Temperature (°F)	140.0	295.0	168.6
Pressure (psig)	0 (Note 1)	0	-
Composition (%v/v)			
N_2	61.96	70.56	63.58
CO_2	10.29	8.57	9.97
O_2	5.66	2.50	5.06
H_2O	21.28	17.46	20.56
Ar	0.79	0.85	0.80
SO_2 (ppmv wet)	41.8	0	33.9
NO_x (ppmv wet)	149.4	4.1	121.9
H_2 (ppmv wet)	0	617	117
He (ppmv wet)	0	17	3.2
CO (ppmv wet)	Not Specified	4.9	0.9
NH_3 (ppmv wet)	0.1	4.1	0.9
VOCs (ppmv wet)	Not Specified	4.1	0.8
Particulate Matter (gr/dscf)	0.0056	0.0035	0.0052

Notes:

1) The Blower in the carbon capture unit will hold the flue gas pressure at the duct tie-in point at atmospheric pressure. During normal CCS Plant operation, the dampers to the stack will be fully closed.
2) Boiler flue gas composition and properties to be confirmed with selected Boiler vendor.
3) Flue gas species in trace concentrations may include: SO_3, HF, HCl, HBr, Br_2, Cl_2, NH_3 as $(NH_4)2SO_4$, trace metals (As, Ba, Cd, Cr, Pb, Se), coal ash (Na, Si, Al, Ti, Fe, Ca, Mg, K, P, St, Ba, Mn), Hg^0, and Hg^{2+}.

4.4 Environmental Requirements

4.4.1 Air Emissions

The project owner will be required to obtain an air permit to construct (PTC) based on the emissions from the project. The main emission units in the CCS are the natural gas boilers, the CO_2 absorber, and the cooling tower. Controls to be included with the natural gas boilers are selective catalytic reduction (SCR) for NO_x control and a CATOX system for oxidation of carbon monoxide and VOCs (volatile organic compounds). The Fluor capture process also includes secondary controls: 1) a sodium hydroxide scrubber for SO_2 (to <1 ppm) and 2) an impurity removal package for PM (particulate matter) / aerosols. One component of securing the PTC is air dispersion modeling to examine the impact of the new project emissions on the National Ambient Air Quality Standards. MPC engaged AECOM for this task. Additional PTC information was gathered from Fluor based on the CCS design and performance estimates.

A new emissions monitoring plan will also need to be developed that incorporates a new emission point for the MRYS flue gas (the CCS absorber) as well as comingling of the coal flue gas with the natural gas flue gas. The emissions monitoring plan must consider existing permit limits for the MRY boilers and provide a means to measure the flue gas composition prior to emission. MPC engaged Agora Environmental for this task.

4.4.2 Water Discharge

The project owner will need to obtain a water appropriation permit from the Missouri River to supply the CCS.

MPC has decided to pursue a Class I (non-hazardous) injection well to dispose of the CCS wastewater. A Class I (Underground Injection Control Program) permit is required along with an aquifer exemption (EPA) approval to inject the wastewater into a geologic formation with formation water having total dissolved solids content 3,000 to 10,000 mg/L. MPC engaged Golder Associates to lead the development of information required for the Class I permit, the aquifer exemption request, and the design and costing of the Class I well and associated infrastructure.

Runoff from the new facility is expected to be managed through the existing MRYS North Dakota Pollutant Discharge Elimination System (NDPDES) permit.

4.4.3 Waste Disposal

The current strategy for managing any nonhazardous waste from the CCS is to request to amend the MRYS landfill permit (as necessary) so that the CCS waste can be disposed of in the existing landfill. The specific type/composition and quantity of the waste materials generated by the CCS will be defined through detailed engineering.

The EFG+ solvent can react with an acid or gas stronger than CO_2 to form a heat stable salt (HSS) and other non-volatile degradation byproducts that cannot be regenerated in Fluor's stripper. The solvent maintenance system (SMS) is used to separate these non-regenerable species, producing an effluent that also contains unrecovered solvent and a small amount of water. The SMS effluent will require offsite waste disposal via a third-party contractor.

4.5 Site Specific Design Considerations

General design parameters provided by MPC to the FEED study contractors included:

- A single 100% capacity carbon capture system will be used to remove carbon dioxide from the MRY Unit 2 flue gas and natural gas-fired boiler flue gas. The CCS will be suitable for continuous operation with gas flows as specified.
- The CCS will be designed to maintain, as a minimum, 90% carbon dioxide removal efficiency using an amine-based solvent at the operating conditions as previously described.
- The design of the carbon capture equipment and related systems shall be such that at no time will it limit operation of the MRYS. The carbon capture system design shall take into consideration the

variability of flue gas parameters due to variations in fuel analysis, boiler/turbine operation at higher than anticipated output, variation in excess air, variations in air heater leakage, and variations in flue gas temperature, as well as other parameter variations. The equipment furnished shall meet performance while operating with any range of fuel, MRY Unit 2 load, and makeup water quality range.

- All process piping and equipment will be designed for a 20-year service life.

Major CCS design considerations specific to this study are identified below:

- The EFG+ plant is designed to capture 90% of the CO_2 from the total flue gas feed to the unit.
- The treated flue gas will be vented to atmosphere directly from the EFG+ Plant Absorber.
- The on-stream factor for the plant will be 95% with a turndown to 40%.
- The solvent make-up storage capacity will be a minimum of 30 days.
- The carbon capture unit has a design life of 20 years.
- Proper winterization is required for the cold climate in North Dakota. This includes heated buildings/enclosures, electrical heat tracing, insulation, and a glycol-water heating system.

In addition, other key design considerations are provided as follows.

The project site is located 7 miles southeast of Center, North Dakota, or 40 miles northwest of Bismarck, North Dakota, on North Dakota Highway 25 at 3401 24th Street Southwest, Center, North Dakota, 58530. The project involves the addition of a CCS system to the MRY Generating Station. Unit 2 will provide flue gas to the CCS system (with Unit 1 being used as an alternate flue gas source when Unit 2 is out of operation).

Design of structures and equipment is based on the following published data:

- Design temperatures: maximum dry bulb: 113°F, minimum dry bulb: –45°F, maximum wet bulb: 84°F.

The building code of record is the North Dakota State Building Code, effective January 1, 2020, with reference to the 2018 International Building Code and state amendments.

Wind loading will be in accordance with the 2018 International Building Code (IBC), ASCE 7-16, and the following:

a. Risk category:	II
b. Basic design wind speed, V:	115 mph
c. Exposure category:	C

Seismic loading is in accordance with the 2018 IBC, ASCE 7-16, and the following:

a. Risk category:	III
b. Site class:	D (assumed)

c. Importance factor, Ie: 1.25
d. Spectral response acceleration, S_S (short period): 0.052g
e. Spectral response acceleration, S_l (1-second period): 0.022g
f. Site coefficient, Fa: 1.6
g. Site coefficient, Fv: 2.4
h. Spectral response acceleration, S_{MS} (adjusted for site class): 0.083g
i. Spectral response acceleration, S_{M1} (adjusted for site class): 0.053g
j. Spectral response acceleration, S_{DS} (adjusted for site class): 0.055g
k. Spectral response acceleration, S_{D1} (adjusted for site class): 0.036g
l. Seismic design category: A

Note:

- S_{MS} is the maximum considered earthquake spectral response acceleration for short periods.
- S_{M1} is the maximum considered earthquake spectral response acceleration for a 1-second period.
- S_{DS} and S_{D1} represent the 5% damped design spectral response acceleration at short periods and at a 1-second period, respectively.

Snow loading will be in accordance with the 2018 IBC, ASCE 7-16, and the following:

a. Risk category: III
b. Ground snow load: 35 psf
c. Surface roughness category: C
d. Importance factor, I_s: 1.10

Raw Missouri River water is assumed to have the specifications identified in Table 7, based on the average of 14 tests taken from 2019 from the river north of the MRYS.

Separations Dike water is assumed to have the specifications provided in Table 8, based on 14 tests taken from 2019 at the MRYS separations dike.

Nelson Lake water at MRYS is assumed to have the specifications provided in Table 9, based on 14 tests from 2019 from Nelson Lake at MRYS.

The product CO_2 leaving the CCS boundary will be transported by pipeline to the nearby geologic CO_2 storage injection site and will require the specifications indicated in Table 10.

Table 7. Raw Missouri River water specifications

Parameter	UOM*	Min.	Average	Max.
pH		7.81	8.16	8.36
Specific Conductance	µS/cm	659.3	722.6	861
Turbidity	NTU	2.2	14.3	130.0
Total Alk.	mg/L $CaCO_3$	139	158	180
Pheno Alk.	mg/L $CaCO_3$	<20	<20	<20
Bicarbonate	mg/L $CaCO_3$	132	155	176
Carbonate	mg/L $CaCO_3$	<20	<20	<20
Hydroxide	mg/L $CaCO_3$	<20	<20	<20
Nitrate as N	mg/L	<0.1	<0.1	0.11
Total Hardness as $CaCO_3$	mg/L	211	237	273
Calcium Hardness	mg/L	117	135	155
Mag Hardness	mg/L	93.9	101.7	119.0
Silicates as SiO_2	mg/L	6.78	9.95	26.10
Bromide	mg/L	<0.5	<0.5	<0.5
Sulfate	mg/L	162.0	188.7	257.0
Chloride	mg/L	7.0	8.1	9.1
Nitrate-Nitrite as N	mg/L	<0.1	<0.1	0.13
Nitrite as N	mg/L	<0.1	<0.1	<0.1
Phosphorus as P	mg/L	<0.1	<0.1	0.13
Calcium	mg/L	46.8	53.7	61.9
Magnesium	mg/L	22.8	24.7	28.8
Sodium	mg/L	62.3	73.5	98.4
Potassium	mg/L	3.6	4.3	6.6
Lithium	mg/L	0.039	0.046	0.052
Aluminum	mg/L	0.10	0.48	4.05
Barium	mg/L	<0.1	<0.1	<0.1
Copper	mg/L	<0.05	<0.05	<0.05
Iron	mg/L	<0.1	<0.6	4.81
Manganese	mg/L	<0.05	<0.06	0.18
Molybdenum	mg/L	<0.1	< 0.1	< 0.1
Nickel	mg/L	<0.04	<0.04	< 0.04
Strontium	mg/L	0.48	0.54	0.59
Zinc	mg/L	0.05	0.05	0.05
Boron	mg/L	0.10	0.13	0.15
Cadmium	mg/L	0	0	0
Chromium	mg/L	0.0073	0.0073	0.0073
Lead	mg/L	0.0028	0.0028	0.0028
Vanadium	mg/L	0	0	0

* Unit of measure.

Table 8. MRYS Separations Dike water specifications

Parameter	UOM	Min.	Average	Max.
pH		7.61	8.29	8.77
Specific Conductance	µS/cm	312.3	607.4	811.5
Turbidity	NTU	1.6	6.9	18.0
Total Alk.	mg/L $CaCO_3$	65	123	199
Pheno Alk.	mg/L $CaCO_3$	<20	20	<20
Bicarbonate	mg/L $CaCO_3$	65	116	190
Carbonate	mg/L $CaCO_3$	<20	<20	<20
Hydroxide	mg/L $CaCO_3$	<20	<20	<20
Nitrate as N	mg/L	<0.1	<0.1	0.34
Total Hardness as $CaCO_3$	mg/L	105	234	494
Calcium Hardness	mg/L	55.7	125.8	237.0
Mag Hardness	mg/L	49	108	257
Silicates as SiO_2	mg/L	4.43	7.47	15.60
Bromide	mg/L	<0.5	<0.5	<0.5
Sulfate	mg/L	68.7	186.0	433.0
Chloride	mg/L	2.6	6.4	10.9
Nitrate-Nitrite as N	mg/L	<0.1	<0.1	0.34
Nitrite as N	mg/L	<0.1	<0.1	<0.1
Phosphorus as P	mg/L	<0.1	<0.1	0.3
Calcium	mg/L	22.3	50.4	94.9
Magnesium	mg/L	11.9	26.3	62.4
Sodium	mg/L	19.2	58.7	124.0
Potassium	mg/L	4.2	5.9	8.5
Lithium	mg/L	0.021	0.041	0.063
Aluminum	mg/L	<0.1	<0.2	0.49
Barium	mg/L	<0.1	<0.1	<0.1
Copper	mg/L	<0.05	<0.05	<0.05
Iron	mg/L	<0.1	<0.3	0.84
Manganese	mg/L	<0.05	<0.06	0.12
Molybdenum	mg/L	<0.1	<0.1	<0.1
Nickel	mg/L	<0.04	<0.04	<0.04
Strontium	mg/L	0.22	0.49	0.91
Zinc	mg/L	<0.05	<0.05	<0.05
Boron	mg/L	<0.1	<0.1	0.12
Cadmium	mg/L	<0.0005	<0.0005	<0.0010
Chromium	mg/L	<0.002	<0.002	0.0023
Lead	mg/L	<0.0005	<0.0006	0.0011
Vanadium	mg/L	<0.002	<0.002	0.003

Table 9. Nelson Lake water specifications

Parameter	UOM	Min.	Average	Max.
pH		8.07	8.57	8.91
Specific Conductance	µS/cm	1128	1261	1410
Turbidity	NTU	3.6	11.6	26.0
Total Alk.	mg/L $CaCO_3$	192	232	302
Pheno Alk.	mg/L $CaCO_3$	<20	<24	42
Bicarbonate	mg/L $CaCO_3$	172	201	239
Carbonate	mg/L $CaCO_3$	<20	<36	83
Hydroxide	mg/L $CaCO_3$	<20	<20	<20
Nitrate as N	mg/L	<0.1	<0.23	0.45
Total Hardness as $CaCO_3$	mg/L	302	375	464
Calcium Hardness	mg/L	124	156	204
Mag Hardness	mg/L	178	219	263
Silicates as SiO_2	mg/L	0.45	4.81	11.80
Bromide	mg/L	1.32	1.57	2.29
Sulfate	mg/L	246	416	558
Chloride	mg/L	11.6	14.0	16.0
Nitrate-Nitrite as N	mg/L	0.13	0.30	0.45
Nitrite as N	mg/L	<0.1	<0.1	<0.1
Phosphorus as P	mg/L	<0.1	<0.3	0.68
Calcium	mg/L	49.5	62.5	81.6
Magnesium	mg/L	43.3	53.1	63.8
Sodium	mg/L	135	167	208
Potassium	mg/L	13.4	15.5	17.4
Lithium	mg/L	0.042	0.050	0.065
Aluminum	mg/L	<0.1	<0.2	0.3
Barium	mg/L	<0.1	<0.1	<0.1
Copper	mg/L	<0.1	<0.1	<0.1
Iron	mg/L	<0.1	<0.3	0.39
Manganese	mg/L	<0.05	<0.06	0.08
Molybdenum	mg/L	<0.01	<0.01	<0.01
Nickel	mg/L	<0.04	<0.04	<0.04
Strontium	mg/L	0.76	0.91	1.10
Zinc	mg/L	<0.1	<0.1	<0.1
Boron	mg/L	0.21	0.27	0.34
Cadmium	mg/L	<0.0005	<0.0005	<0.0005
Chromium	mg/L	<0.002	<0.002	<0.002
Lead	mg/L	<0.0005	<0.0006	0.0012
Vanadium	mg/L	0.0028	0.0041	0.0076

Table 10. CO_2 product specifications

Parameter	Value
End Use	Sequestration
CO_2 Capture Capacity, stpd	12,978
Temperature, °F	≤120
Pressure, psig	1675
Composition, % v/v	
CO_2	≥95
H_2O	≤30 lb/MMscf
O_2	≤20 ppmv

4.5.1 Steam Source Selection

Project Tundra's carbon capture system will require large quantities of steam to liberate the CO_2 from the amine-based CO_2 capture solvent in the regeneration system. During pre-FEED studies, conducted under previous and separate efforts, MPC received design details and cost estimates for two potential steam sources: 1) steam extraction from the steam turbine of the existing Unit 2 MRYS host power plant and 2) steam production from auxiliary natural gas package boilers. This is a critical decision in finalizing the design basis for the FEED study. This section briefly describes the specifics of each option along with pros and cons identified by MPC and its team and concludes with MPC's recommendation with reasoning.

4.5.2 Steam Extraction from Unit 2 Steam Turbine

This option would consist of a large steam extraction line that extends from the steam turbine intermediate-pressure to low-pressure crossover to the reboiler at the CCS. The steam from this location must be desuperheated to match the steam requirements of the CCS. This steam would be condensed in the reboiler and then routed back to the power plant by means of a condensate return line. Below is a list of equipment and modifications required for this option followed by a list of pros and cons.

4.5.2.1 Equipment and Modifications

- Steam extraction line
- Steam conditioning system
- Condensate return line
- Steam extraction line drain system
- Significant STG modifications
- Modify condensate system to allow for return of condensate
- Flue gas duct tie in from Unit 2 to the CCS

4.5.2.2 Pros

- Steam extraction requires lower capital cost.
- Lower risks are associated with easements and permits compared with a new natural gas pipeline.
- It will lower the generation output of Unit 2 at times when MPC is potentially long on power and would provide a revenue stream from the sale of steam to the CCS.

- It would potentially reduce heat rejection to the cooling water reservoir (Nelson Lake) that would result in cooler temperatures during the summer months and improved power plant efficiency.

4.5.2.3 Cons

- This requires the steam turbine to be successfully modified.
- This will require an approximately 1500-ft-long steam extraction line. With start-up and shutdown every 100 days for boiler-cleaning outages, there is risk associated with energizing and deenergizing a pipeline of that length with steam, especially during extreme cold conditions. In addition, the complexity of the steam drain system may cause issues with water hammering if the drain system is not operating properly.
- This will limit Unit 2 in its ability to load follow because of the requirement to keep the crossover pressures high enough for CCS extraction.
- Steam extraction may limit the ability for MPC to quickly react to maximum generation events because of potential contractual obligations for supplying steam. Response time for the CCS is unknown at this time.
- This will require extensive monitoring of the return condensate to ensure boiler chemistry is maintained. This would also require a currently undefined emergency action plan if the returned condensate from CCS needs to be diverted. Unit 2 condenser makeup valves would be able to make up the amount of condensate that would need to be diverted, but the unit would likely trip in short order because of pH and dissolved oxygen in the feedwater.
- The CCS would likely be limited to electric heat in winter months during Unit 2 or CCS shutdowns.

4.5.3 Auxiliary Natural Gas Package Boilers

The second option of using natural gas boilers would consist of installing a new natural gas pipeline to supply natural gas package boilers to create the steam required for the CCS. In addition, the flue gas produced in the package boilers along with flue gas from Unit 1 (during Unit 2 outages) may, if determined to be feasible, be routed through the CCS, increasing the total annual CO_2 production. Below is a list of equipment and modifications required for this option followed by a list of pros and cons.

4.5.3.1 Equipment and Modifications

- Natural gas pipeline
- Package boilers and associated equipment
- Building to house package boilers
- Demineralized water system with storage
- Larger CCS to handle additional flue gas flow (from boilers)
- Flue gas duct tie-in from Unit 2 to the CCS
- Optional flue gas duct tie-ins from Unit 1 and CCS boilers to the CCS

4.5.3.2 Pros

- Because the steam source for the CCS is independent of whether or not Unit 2 is operating, this option allows for tie-in of Unit 1 to the CCS, which could be used during times when Unit 2 is at reduced load

or when Unit 2 is completely offline. Flue gas from the natural gas boilers can also be routed to the CCS. The combination of these will increase the CCS utilization rate and reduce the overall CO_2 emissions from MRYS.

- This option provides the most operating flexibility for both the CCS and MRYS: allows steam flow to match CCS needs.
- This option is also less intrusive to existing operations and easier to tie in to the existing power plant.
- The natural gas-fired boilers significantly lower the risk as compared to STG modifications.
- This option also would provide an alternative steam heating source when Unit 2 is shutdown.

4.5.3.3 Cons

- One drawback to the natural gas boilers is the requirement for a 15–20-mile-long natural gas pipeline to be built. This exposes the project to permitting and easement risk.
- Another drawback is the requirement for permitting of new natural gas boilers.
- This option will also have a significantly higher capital cost.
- This option requires commingling of flue gas streams, which may require a more complex continuous emission monitor system.
- This option may require Unit 1 to be in service for the term of the tax equity financing.
- Finally, another drawback with this option is exposure of the project to the volatility of the natural gas market.

4.5.4 Steam Source Selected for FEED

Based on the above information and MPC's financial evaluation using its fully developed project financial model, MPC proceeded with the auxiliary natural gas package boiler option to supply steam to the CCS for this FEED study. Below is a summary of the primary reasons for this selection.

- The technical and financial risks associated with utilizing steam extraction from Unit 2 are higher than the risks associated with natural gas boilers. At this time, the definitive answer to the extent of modifications and the cost of the modifications required to allow such a large quantity of steam to be extracted are not fully known. The base case option of installing a new high-pressure/intermediate-pressure turbine is what has been used for the analysis shown above (based on pre-FEED analysis), and the real costs may be higher than the current costs and may include the use of a backpressure control valve on the steam turbine crossover. In general, the costs for natural gas boilers is better understood than the cost for extraction steam.
- The use of natural gas boilers will allow for a wider range of load-following capability of Unit 2. With steam extraction, Unit 2 would be required to operate at near full load conditions regardless of the MISO (Midcontinent Independent System Operator) market or operational need. The use of the natural gas boilers will remove the limitations on the unit and will provide additional flexibility for the CCS.
- MPC will not be selling steam to the CCS and does not run the financial risk of selling steam based on coal cost fluctuations or other operational factors.

- With the natural gas boilers, if Unit 2 is offline (i.e., scheduled or forced outage), the CCS can capture CO_2 from Unit 1 and still generate revenue. In addition, if Unit 2 is forced to operate at partial load because of a fan or scrubber tower being out of service (or market conditions), the CCS can still operate, which may not have been possible with steam extraction.
- The potential to contaminate the boiler water from bad condensate return from the CCS is removed.
- As a whole, the use of natural gas boilers will simplify the contractual obligations between MPC and the owner(s) of the CCS, as fewer services will be supplied by MPC and there is improved flexibility for both systems.
- As identified by the project financial model, the project finances are overall improved.
- Steam extraction from the Unit 2 turbine would reduce the electric output of Unit 2 by about 80 MW, which is currently exported to the grid to serve electric demand. To compensate, that loss in demand would need to be filled by other electric generating units in the MISO market that have an average CO_2 intensity of about 1000 lb/MWh. Unit 2, with the steam boiler option and with routing the boiler flue gas to the CCS, will have a CO_2 intensity of about 250-300 lb/MWh. Thus, the natural gas boiler option will allow Unit 2 to continue to serve electric demand but at a significantly lower overall CO_2 intensity than from the MISO market.

As noted previously, while the FEED study presented herein is based on the natural gas boilers option, a key conclusion of this FEED study is that the gas boilers option was higher cost than expected and that future work should reconsider the steam extraction option as a cost-cutting option.

4.6 Modularization Design Requirements

Modularization of the project was highly investigated to reduce site construction hours and place craft labor in as controlled an environment as possible. Due to limitations in the proximity of water access, the available road system, and obstructions associated with road transport, the module envelope was limited to 80 ft (L) x 18 ft (W) x 13’-9” (H). The conclusion was that modularization was not beneficial due to transportation limitations and schedule risks.

5 BASIC CONTRACTING AND PURCHASING STRATEGY

In accordance with project requirements, Rural Utilities Service (RUS) provisions will be followed. The purchasing strategy for the project would be to open major equipment supply and bulk materials to the world market for such materials unless limited by the RUS provisions.

The basis of Fluor’s execution would be for Fluor to be responsible for the engineering, procurement and construction (EPC) on a self-perform basis using specialty local, regional, and national subcontractors for the installation of the facilities. For example, due to transportation constraints, the large columns and vessels that form the core of the Fluor technology will need to be field fabricated and installed as part of a subcontract package. The subcontractor selection would be based upon the availability of local subcontractors with recent execution experience that is applicable for the planned work.

Prior to commencing Detailed Engineering, Procurement and Construction, all aspects of this initial strategy will be reviewed in light of then current market conditions and modified accordingly.

6 ENGINEERING DESIGN PACKAGES

6.1 Process Engineering

6.1.1 Block Flow Diagram

Figure 4 provides a BFD for the overall EFG+ CCS plant for Project Tundra.

As shown in the BFD, the main CO_2 capture and compression unit of the CCS Plant consists of the following equipment subsystems:

- Flue Gas Cooling & Conditioning
- CO_2 Absorption, Solvent Regeneration & Maintenance
- CO_2 Compression and Drying

The following equipment subsystems are provided to supply the major utilities required by the CO_2 capture and compression process:

- Boiler
- Cooling Tower

6.1.2 Process Flow Diagrams

Process Flow Diagrams (PFDs) associated with the EFG+-based CCS Plant are provided as Attachment 1. There are six (6) PFD drawings covering the following process equipment systems:

- Flue Gas Cooling and Conditioning (Drawing No. M1NN-CCS-DWG-225-02101)
- CO_2 Absorption (Drawing No. M1NN-CCS-DWG-225-02201)
- Solvent Regeneration (Drawing No. M1NN-CCS-DWG-225-02301)
- Solvent Maintenance (Drawing No. M1NN-CCS-DWG-225-02401)
- Chemical Storage and Supply (Drawing No. M1NN-CCS-DWG-225-02501)
- CO_2 Compression (Drawing No. M1NN-CCS-DWG-225-02601)

6.1.3 Utility Flow Diagrams

Utility Flow Diagrams (UFDs) associated with the EFG+-based CCS Plant are provided as Attachment 2. There are five (5) UFD frames covering the following utility equipment systems:

- Cooling Water System (Drawing No. M1NN-CCS-DWG-225-03701)
- Boiler (Drawing No. M1NN-CCS-DWG-225-03702)
- Plant and Instrument Air (Drawing No. M1NN-CCS-DWG-225-03703)
- Miscellaneous Water Services (Drawing No. M1NN-CCS-DWG-225-03704)
- Glycol Water System (Drawing No. M1NN-CCS-DWG-225-03705)

6.1.4 Overall Heat and Material Balance

Figure 5 is an Overall Heat and Material Balance, providing flow rates, temperatures, pressures and compositions for all the process streams to and from the overall CCS plant. Stream numbers correspond to the stream diamonds on the PFDs provided in Attachment 1.

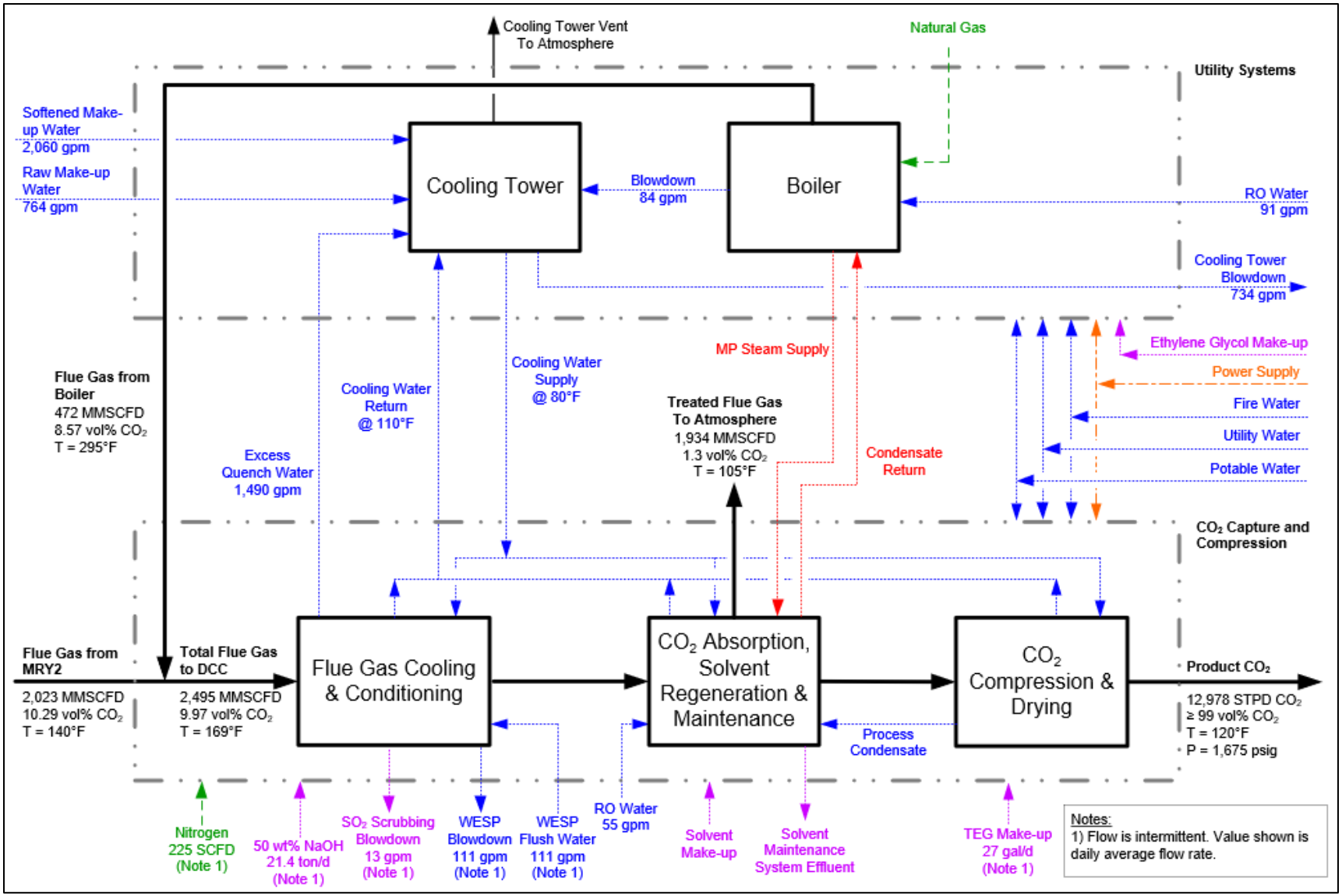


Figure 4. Block flow diagram for the EFG+ CCS plant

Stream Description		MRY2 Flue Gas	Boiler Package Flue Gas	Excess Water to Cooling Tower	SO_2 Scrubbing Solution Blowdown to Battery Limits (Note 1)	20 wt% NaOH to DCC (Note 1)
Stream Number		101	102	107	110	112
Temperature, °F		140	295	138	101	68
Pressure, psia		13.7	13.7	50.0	85.0	13.5
Vapor Fraction		1.0	1.0	0.0	0.0	0.0
Component Flows	MW	mol%	mol%	mol%	mol%	mol%
H_2O	18.02	21.3%	17.5%	100.0%	97.2%	89.7%
CO_2	44.01	10.3%	8.6%	0.0%	0.0%	0.0%
N_2	28.01	62.0%	70.6%	0.0%	0.0%	0.0%
Ar	39.95	0.8%	0.8%	0.0%	0.0%	0.0%
O_2	32.00	5.7%	2.5%	0.0%	0.0%	0.0%
NaOH	40.00	0.0%	0.0%	0.0%	0.0%	10.3%
Sodium Salts	-	0.0%	0.0%	0.0%	2.8%	0.0%
Total Flow, lbmol/hr		222,121	51,817	40,743	353	184
Total Flow, lb/hr		6,186,420	1,441,570	734,050	7,360	3,720
Molecular Weight		27.9	27.8	18.0	20.8	20.2
Density, lb/ft³		0.059	0.047	61.422	72.377	76.1
Liquid Flow, gpm (Actual)		-	-	1490	13	6
Actual Vapor Flow, ACFM		1,735,501	509,898	-	-	-
Vapor Flow, SCFM		1,404,844	327,722	-	-	-

Note 1: Reported flow rate is the average flow rate per operating hour. Peak rates will be higher.

Figure 5. Overall heat and materials balances for the CCS plant

Stream Description		Treated Flue Gas Vent to Atmosphere	Demineralized Water to Absorber	Compressed CO_2 Product to Battery Limits
Stream Number		202	207	606
Temperature, °F		105	Ambient	120
Pressure, psia		13.7	13.9	1,688.7
Vapor Fraction		1.0	0.0	Supercritical
Component Flows	MW	mol%	mol%	mol%
H_2O	18.02	8.0%	100.0%	632 ppmv
CO_2	44.01	1.3%	0.0%	99.9%
N_2	28.01	82.9%	0.0%	163 ppmv
Ar	39.95	1.0%	0.0%	4 ppmv
O_2	32.00	6.8%	0.0%	6 ppmv
NaOH	40.00	0.0%	0.0%	0.0%
Sodium Salts	-	0.0%	0.0%	0.0%
Total Flow, lbmol/hr		212,381	1,522	24,593
Total Flow, lb/hr		5,905,020	27,410	1,081,780
Molecular Weight		27.8	18.0	44.0
Density, lb/ft³		0.063	61.9	36.2
Liquid Flow, gpm (Actual)		-	55	-
Actual Vapor Flow, ACFM		1,564,561	-	-
Vapor Flow, SCFM		1,343,238	-	-

Figure 5 (Continued).

6.1.5 Process Description

This section provides descriptions of each system of the EFG+ CCS Plant designed for Project Tundra. In reading this section, it is recommended to refer to the PFDs and UFDs, provided as Attachment 1 and 2, respectively.

The CCS Plant is designed to recover 12,978 STPD of CO_2 from flue gas produced by the existing MRY Unit 2 and flue gas produced by the new Boiler Package (CCS-PK-702), which is required to produce the necessary steam for the EFG+ unit.

The CCS Plant can also recover CO_2 from the flue gas produced by MRY Unit 1 when MRY Unit 2 is shut down for extended outages.

The EFG+ CCS Plant can be divided into nine primary subsystems or sections:

1. Flue Gas Cooling and Conditioning
2. Flue Gas Blower
3. Flue Gas Particulate Removal
4. CO_2 Absorption
5. Solvent Regeneration
6. Solvent Maintenance
7. Chemical Storage and Supply
8. CO_2 Compression
9. Utility Support Systems

6.1.5.1 Flue Gas Cooling and Conditioning

Refer to drawing number M1NN-CCS-DWG-225-02101 for the PFD showing the Flue Gas Cooling and Conditioning system.

Flue gas produced from MRY2 (or alternatively MRY1 during Unit 2 outages) and flue gas from the Boiler Package are combined and routed to the Direct Contact Cooler (DCC) (CCS-C-101) via the DCC Inlet Ducting System (CCS-DU-101). All (100%) of the available flue gas from both sources will be drawn to the carbon capture unit. Parallel blade guillotine dampers (CCS-DM-101/102/103) are provided on the ducts from each of the flue gas sources to provide double isolation between the flue gas sources and carbon capture plant when the carbon capture plant is not in operation. A seal air system is provided to ensure 100% isolation when the dampers are in the full closed position. During normal operation of the carbon capture unit, the Unit 2 Isolation Damper (CCS-DM-102) and Boiler Package Isolation Damper (CCS-DM-103) will be in the full open position with the respective Unit 2 and Boiler Package stack dampers in the full closed position.

The combined flue gas enters the bottom of the DCC column where it is directly contacted against a circulating water stream. Cold circulating water enters the quench (bottom) section of the DCC where it is heated by the cooling and condensing of water vapor in the flue gas flowing up the column. The water flows down the DCC column and is pumped from the bottom of the column by the DCC Water Pump

(CCS-P-101A/B) through the DCC Water Cooler (CCS-E-101) where it is cooled against cooling water. The cooled water is returned to the top of the DCC. A small portion of the cooled DCC circulating water is periodically routed to the NaOH Dilution Mixer (CCS-MX-501) for dilution of 50 wt% NaOH to 20 wt% NaOH.

A secondary purpose of the DCC circulating water system is to remove particulates from the flue gas, thereby minimizing the potential for contamination of the solvent. To remove the particulates from the system, a continuous slip stream is diverted from the circulating water upstream of the DCC Water Cooler and routed through the DCC Water Filter (CCS-F-101A/B). A portion of the filtered water is returned to the DCC boot on flow control. The remaining water is removed from the circulating water loop and routed to the Cooling Tower to supply a portion of the required make-up water.

To minimize degradation of the EFG+ solvent, most of the SO_2 in the flue gas is removed in the upper section of the DCC. Cooled flue gas from the lower section of the DCC contacts a circulating scrubbing solution containing dilute sodium hydroxide. Scrubbing solution enters the top of the DCC on flow control. Approximately 99% of the SO_2 is absorbed from the flue gas. The cooled and desulfurized flue gas exits the top of the column.

The scrubbing solution is extracted and sent back to the top of the column by the DCC Scrubbing Solution Pump (CCS-P-102A/B). A 20 wt% sodium hydroxide (NaOH) solution supplied by the DCC NaOH Injection Pump (CCS-P-504A/B) is fed to the suction of the DCC Scrubbing Solution Pump in order to maintain the circulating solution pH required to promote SO_2 absorption.

A blowdown is required from this circulating loop to maintain the salt concentration of the circulating scrubbing solution and to remove the absorbed sulfur species. The blowdown stream is sent to the CCS plant battery limit.

6.1.5.2 Flue Gas Blower

Refer to drawing number M1NN-CCS-DWG-225-02201 for the PFD showing the Flue Gas Blower.

The cooled and desulfurized flue gas exiting the top of the DCC column is conveyed through the DCC Outlet Duct (CCS-DU-102) to the Blower (CCS-BL-201).

The Blower, located in the flue gas path between the DCC and Impurity Removal Package (CCS-PK-201), is used to overcome the pressure drop through the DCC, Impurity Removal Package, Absorber and associated ducting. The Blower will hold the flue gas pressure at the MRY/CCS Plant duct tie-in point at atmospheric pressure. The flue gas flow rate through the EFG+ plant is controlled by adjusting the pitch on the Blower's impeller blades.

From the Blower, the flue gas is conveyed through the Blower Outlet Duct (CCS-DU-201) to the Impurity Removal Package.

6.1.5.3 Flue Gas Particulate Removal

Refer to drawing number M1NN-CCS-DWG-225-02201 for the PFD showing the Flue Gas Particulate Removal system.

The Impurity Removal Package (CCS-PK-201) is a packaged unit that removes particulates from the flue gas before it is fed to the Absorber. Particulates must be removed from the flue gas before entering the Absorber as high levels of certain particulates in the flue gas could result in increased solvent emissions. Utility water is supplied to the CCS-PK-201 for periodic flushing. Periodic discharge of flushing water is combined with the DCC scrubbing section blowdown stream and routed to the plant battery limit.

A continuous flow of purge air is required to keep CCS-PK-201 clean and dry and as a flue gas seal. Purge air fans are supplied as part of the CCS-PK-201 package.

6.1.5.4 CO_2 Absorption

Refer to drawing number M1NN-CCS-DWG-225-02201 for the PFD showing the CO_2 absorption system.

Flue gas from the Impurity Removal Package is conveyed through the Absorber Inlet Duct (CCS-DU-202), enters the bottom of the Absorber, and flows upward through the column where it reacts with EFG+ solvent to remove 90% of the carbon dioxide contained in the gas.

From the absorption section, the CO_2-lean flue gas continues to flow up the Absorber column into a wash section. In the wash section of the Absorber, the flue gas is contacted against a circulating water stream that serves to cool and scrub the flue gas as a means to minimize EFG+ solvent emissions by reducing both vapor phase and mechanical carryover of amine. Treated flue gas leaving the Absorber wash system is then vented directly from the top of the Absorber. The Absorber Stack Damper (CCS-DM-201) is provided at the top of the Absorber stack to prevent ingress of rain into the solvent system when the EFG+ unit is shut down. The damper is fully open when the EFG+ unit is in operation and fully closed when the EFG+ unit is shut down.

Since the flue gas is chemically treated against an aqueous amine solution in the Absorber, the flue gas enters the wash section at the top of the Absorber saturated with water vapor. Cooling of the flue gas in the wash system will therefore lead to additional water vapor condensing out of the flue gas. To enhance the performance of the wash system, RO water is continuously fed to the top Absorber wash section. This water, along with any water vapor that is condensed out of the flue gas in the Absorber wash system, is removed from the wash system and diverted to the Absorber amine system as needed to maintain the wash system water balance.

Warm wash water collected at the bottom of the Absorber wash water system is pumped via the Wash Water Pump (CCS-P-202A/B) through the Wash Water Cooler (CCS-E-202), where it is cooled against cooling water, and returned to the top of the Absorber wash system.

CO_2-rich solvent from the bottom of the Absorber is pumped over to the Solvent Regeneration system by the Rich Solvent Pump (CCS-P-203A/B).

6.1.5.5 Solvent Regeneration

Refer to drawing number M1NN-CCS-DWG-225-02301 for the PFD showing the Solvent Regeneration system.

Rich solvent entering the Solvent Regeneration system is first heated against lean solvent in the Solvent Cross Exchanger (CCS-E-301) before being fed to the top of the Stripper (CCS-C-301) below the wash section of the column. Solvent flows down the Stripper counter-current to stripping steam which provides the energy for breaking the bond between the EFG+ solvent and the CO_2, thereby liberating the CO_2 from the solvent. CO_2 and steam travel upward in the column to the wash section of the Stripper located above the rich solvent feed nozzle. In the wash section, condensed water from the Overhead Accumulator (CCS-V-302) contacts the gas. The reflux water partially cools the gas and scrubs entrained solvent and much of the vapor phase solvent out of the overhead gas.

Vapor from the top of the Stripper contains CO_2 saturated with water. The vapor is cooled and most of the water is condensed against cooling water in the Condenser (CCS-E-303). The two-phase mixture from the Condenser enters the Overhead Accumulator where the CO_2 and condensed water are separated. The low-pressure CO_2 product is routed to the CO_2 Compression system.

Stripping steam is provided from the Reboiler (CCS-E-302) by condensing steam provided by the Boiler Package. CO_2-lean solvent collected near the bottom of the Stripper is routed to the Reboiler, where the EFG+ solution is heated to produce a two-phase mixture, with the vapor phase consisting mostly of steam. The two-phase mixture is returned to the bottom of the Stripper to provide the bulk stripping steam for solvent regeneration. Since the Reboiler is a thermosyphon configuration, the solvent-side circulation occurs naturally without pumps.

Steam condensate from the Reboiler is collected in the Reboiler Condensate Drum (CCS-V-303). From the Reboiler Condensate Drum, most of the condensate is pumped back to the Boiler Package via the Reboiler Condensate Pump (CCS-P-303A/B). A slip stream of the pumped condensate is diverted and used to desuperheat steam feeding the Reboiler in the Reboiler Steam Desuperheater (CCS-DS-301).

Lean solvent from the bottom of the Stripper is pumped via the Lean Solvent Pump (CCS-P-301 A/B) through the Solvent Cross Exchanger, where it is initially cooled against rich solvent. The cooled lean solvent from the Solvent Cross Exchanger is then further cooled against cooling water in the Lean Solvent Cooler (CCS-E-203) before being routed back to the Absorber. A slipstream of the cooled lean solvent is diverted to the Lean Solvent Filter (CCS-F-201) that serves to remove any particulates from the circulating solvent stream. The filtered slipstream is returned to the cooled lean solvent stream feeding the Absorber.

6.1.5.6 Solvent Maintenance

Refer to drawing number M1NN-CCS-DWG-225-02401 for the PFD showing the Solvent Maintenance System.

The Solvent Maintenance System (SMS) is a proprietary equipment system for maintaining a high solvent quality. It is designed to remove heat stable salts and other soluble contaminants / degradation products

from the circulating solvent loop. The SMS concentrates these undesirable products into a single concentrated waste stream and routes the waste stream to the Spent Solvent Tank (CCS-TK-401).

Due to the cold ambient conditions at the MPC site, the stored SMS waste can cool and become highly viscous or even freeze. To prevent these conditions the Spent Solvent Tank Heater (CCS-H-401) is provided to heat the solvent using glycol water.

6.1.5.7 Chemical Storage and Supply

Refer to drawing number M1NN-CCS-DWG-225-02501 for the PFD showing the Chemical Storage and Supply system.

Make-up solvent is stored in the Solvent Storage Tank (CCS-TK-501) and is added to the bottom of the Absorber as needed using the Solvent Make-up Pump (CCS-P-501). The amount of solvent make-up per day depends on the plant operating conditions and is determined by regular monitoring of the solvent concentration. The difference between the measured and desired solvent concentration is used to determine how much make-up solvent must be added. The amount of make-up is controlled by the run time of the Solvent Make-up Pump.

Due to the cold ambient conditions at the MPC site, the stored solvent can cool and become highly viscous or even freeze. To prevent these conditions the Solvent Storage Tank Heater (CCS-H-501) is provided to heat the solvent using glycol water.

Nitrogen provided via cylinders is required to blanket the Solvent Storage Tank to protect the solvent against oxidative degradation.

All drains in the solvent system are routed to the Solvent Recovery Tank (CCS-TK-502) through a closed drain system. The tank is heated with the Solvent Recovery Tank Heater (CCS-H-502) to prevent the tank contents from freezing. Glycol water is used as the heating medium.

The recovered solvent is ultimately pumped back to the Absorber boot via the Solvent Recovery Pump (CCS-P-502). The Solvent Recovery Filter (CCS-F-501) is provided to filter particulates out of the solvent before being sent to the Absorber.

The 50 wt% NaOH Storage Tank (CCS-TK-503) is provided to hold an inventory of 50 wt% caustic, which is diluted to 20 wt% and stored in the 20 wt% NaOH Storage Tank (CCS-TK-504) for use in the DCC scrubbing section. A small portion of the cooled DCC water is used to perform the dilution as needed when refilling the 20 wt% NaOH Storage Tank. When the level in the 20 wt% NaOH Storage Tank becomes low, 50 wt% caustic is pumped by the 50 wt% NaOH Pump (CCS-P-503A/B) to the NaOH Dilution Mixer (CCS-MX-501), where the 50 wt% caustic is diluted with DCC water. Ratio control is used to maintain the required flow rate of dilution water in proportion to the amount of 50 wt% NaOH being diluted. The 50 wt% NaOH Storage Tank must be periodically filled by delivery trucks from a local chemical supplier. To prevent freezing of the tank contents, both caustic storage tanks are heated with external electric tracing.

Make-up triethylene glycol (TEG) is stored in the TEG Storage Tank (CCS-TK-505) and is added to the CO_2 Dehydration Package (CCS-PK-601A/B) as needed using the TEG Make-up Pump (CCS-P-505). To prevent freezing of the tank contents, the TEG Storage Tank is heated with external electric tracing.

6.1.5.8 CO_2 Compression

Refer to drawing number M1NN-CCS-DWG-225-02601 for the PFD showing the CO_2 Compression system.

Following CO_2 recovery, the captured CO_2 is compressed and purified to meet the desired product specifications. The CO_2 compression and dehydration section consists of two parallel (2x50%) trains. Low-pressure CO_2 product from the Overhead Accumulator is routed to the CO_2 Product Compressor Suction KO Drum (CCS-V-601A/B), which is provided as a final protection to prevent any liquids from carrying over to the suction of the CO_2 Product Compressor. In addition to the low-pressure CO_2 from the Overhead Accumulator, the CO_2 Product Compressor Suction KO Drum is also fed with TEG off-gas from the CO_2 Dehydration Package and collected condensate from the downstream compressor intercooling stages. Within the KO Drum, any condensed water is separated from the predominantly CO_2 vapor streams and pumped back to the Solvent Regeneration system via the Process Condensate Pump (CCS-P-601A-D).

Overhead vapor from the CO_2 Product Compressor Suction KO Drum is routed to the CO_2 Product Compressor (CCS-K-601A/B), a multi-stage machine that consists of a wet section and a dry section. Both sections of the compressor include intercoolers between each stage. The wet section also includes integrated moisture separators between each stage.

Between the wet and dry sections, partially compressed CO_2 is routed to the CO_2 Dehydration Package (CCS-PK-601A/B), a vendor supplied triethylene glycol (TEG) unit. The TEG unit serves to further reduce the water content in the CO_2 product gas as needed to meet the product specification. Water vapor that is removed from the CO_2 product in the CO_2 Dehydration Package is recycled back to the CO_2 Product Compressor Suction KO Drum as TEG off-gas.

The dehydrated gas from the CO_2 Dehydration Package is returned to the dry section of the CO_2 Product Compressor where it is further compressed to meet the desired product pressure of 1,675 psig. Following the final compression stage, the compressed CO_2 is cooled in the CO_2 Product Compressor Aftercooler (CCS-E-601A/B) to 120°F before being routed to the plant battery limits.

The CO_2 Vent Stack (CCS-VS-601) serves to provide a single emission point for all depressurization and relief lines from the CO_2 compression system. During start-up, the product CO_2 is initially recycled through the anti-surge line while a portion can be vented to atmosphere through the CO_2 Vent Stack to ensure the product specifications are met before sending the CO_2 to the plant battery limits. Upon a trip or shutdown of the CO_2 Product Compressor, the compression system will be automatically depressurized/de-inventoried through blow-off valves provided by the compressor vendor with the CO_2 routed to the CO_2 Vent Stack.

6.1.5.9 Supporting Utility Systems

Refer to the Utility Flow Diagrams provided as Attachment 2.

Utilities required by the EFG+ CCS Plant include: cooling water, steam, instrument air, plant air, nitrogen, make-up water, fire water, utility water, and potable water.

Cooling Water System

A new dedicated cooling tower system is provided to meet all the cooling water demands associated with the EFG+ CCS Plant. The system is equipped with a Cooling Tower (CCS-CT-701), Cooling Tower Basin (CCS-X-701), Cooling Water Pumps (CCS-P-701A-C), and Cooling Tower Chemical Injection Package (CCS-PK-701).

The Cooling Water Pumps draw the cold cooling water from the Cooling Tower Basin and route the cooling water through the various EFG+ CCS Plant users. From the users, the warm cooling water is returned to the top of the Cooling Tower, designed to cool the cooling water from 110°F to 80°F. A continuous blowdown is taken from the discharge of the Cooling Water Pumps to prevent build-up of contaminants in the circulating cooling water loop.

The Cooling Tower Chemical Injection Package (CCS-PK-701) is provided to maintain the quality of the circulating cooling water. This package includes a dosing facility for the following cooling water treatment chemicals:

- Sulfuric acid
- Corrosion inhibitor
- Scale inhibitor
- Dispersant
- Chlorine dioxide
- Non-oxidizing biocide

A portion of the make-up water to the cooling tower system is supplied by the excess DCC quench water and Boiler Package blowdown. The balance of make-up water is provided as softened water from the Water Treatment Unit (outside Fluor's scope) as raw water from Lake Nelson.

Steam System

To meet the EFG+ plant steam demands, a dedicated natural gas fired Boiler Package is provided to produce saturated medium pressure (MP) steam at 165 psig. The Boiler Package consists of three boiler units and includes boiler drums with convection tubes, boiler furnace, burner windbox assembly, burner throat, air blower, economizer, blowdown drums, feed water pumps, deaerator, dampers, and damper control system, and stack. Saturated steam produced from the Boiler Package is routed to the various EFG+ CCS Plant users, and is returned to the Boiler Package deaerator as steam condensate. Blowdown water is routed to the Cooling Tower Basin and make-up water is provided from the RO Unit of the Water Treatment Unit (outside Fluor's scope).

Plant and Instrument Air System

Instrument and plant air requirements for the EFG+ plant shall be met by a dedicated Plant and Instrument Air Package (CCS-PK-703). The Plant and Instrument Air Package consists of 2x100% air compressors with intercoolers and knockout pots, wet air receiver, a dual-bed desiccant dryer, dry air receiver, and associated filters.

Glycol Water System

Due to the cold ambient conditions at the MPC site, most of the equipment within the carbon capture facility is located inside buildings or enclosures. These buildings and enclosures, as well as chemical storage tanks, must be heated during the colder months. To meet this heating demand, a closed loop glycol water system is provided to supply a heating medium of 55 wt% aqueous ethylene glycol solution to the various users within the CCS Plant.

The glycol water system consists of a compression tank, air separator, glycol water circulation pump, glycol water heaters, filter, and drain tank. The Compression Tank (CCS-V-711) is provided to allow for thermal expansion and contraction of the circulating glycol water. The glycol water is pumped by the Glycol Water Circulation Pump (CCS-P-711A/B) through the Glycol Water Heater (CCS-E-711), where the glycol water is heated against hot condensate from the solvent regeneration section of the EFG+ plant. The Glycol Water Electric Heater (CCS-E-712) is provided as a backup heater to provide heat to the glycol water when the Boiler Package is not in operation, during which the normal supply of hot condensate to the main Glycol Water Heater would not be available.

Heated glycol water from the Glycol Water Heater is routed to the various users (i.e. building/enclosure heating units and chemical storage tank heaters) to supply the necessary heat load required for each user. The cooled glycol water return from the various users is then routed to the Air Separator (CCS-V-712) where any entrained air is removed and vented to atmosphere before the glycol water is returned to the circulating pump suction.

A portion of the Glycol Water Circulation Pump discharge is continuously diverted through the Glycol Water Filter (CCS-F-711) and recycled back to the Air Separator.

All drains from the glycol water system are collected in the Glycol Water Drain Tank (CCS-TK-711).

Other Utilities

Other utilities required by the EFG+ plant include nitrogen, make-up water, fire water, utility water, RO water, softened water, and potable water.

Nitrogen is required for blanketing of the Solvent Storage Tank. As this quantity is relatively small, the nitrogen can be provided by cylinders.

Make-up water is provided by MPC to meet the make-up water requirements for the EFG+ unit, cooling tower system, and boiler system. The various types, sources, and uses of make-up water are discussed in previous sections.

Potable water is required for general use at eyewash stations, restrooms, and plant personnel consumption.

6.1.6 List of Major Process Equipment

A process equipment list is included as Attachment 3.

6.1.7 Plot Plan

A Plot Plan is provided as Attachment 4 to indicate how the major equipment in the EFG+ CCS has been arranged. The following narrative is a high-level description outlining the strategy for the plot layout.

Flue gas ducting ties into the existing MRY Unit 1 and Unit 2 stacks located to the northeast of the EFG+ CCS unit plot. To minimize the length and pressure drop associated with the large flue gas duct network, the Direct Contact Cooler (DCC) (C-101) is located on the northeast side of the plot. The Boiler Package (PK-702) is located inside the Boiler Enclosure to the southeast of the DCC column with its stack on the north side of the enclosure. A smaller flue gas duct transfers flue gas from the Boiler Package stack and ties into the larger common flue gas duct to the northeast of the EFG+ CCS plot to ensure adequate straight run is provided to allow for sufficient mixing and distribution into the DCC.

Cooled overhead flue gas from the top of the DCC is routed to the Blower (BL-201), located to the north of the DCC. From the Blower, flue gas is routed through the Impurity Removal Package (PK-201) and ultimately to the Absorber (C-201). The DCC, Blower, Impurity Removal Package, and Absorber are all placed in close proximity to one another to minimize not only the flue gas ducting material cost, but also pressure drop along the flue gas path. This in-turn minimizes the differential head and therefore electrical power associated with the Blower.

The following large circulation pumps are located inside the Process Enclosure just to the south of the DCC and Absorber columns:

- DCC Water Pump (P-101A/B)
- DCC Scrubbing Solution Pump (P-102A/B)
- Absorber Wash Water Pump (P-202A/B)
- Rich Solvent Pump (P-203A/B)
- Lean Solvent Pump (P-301A/B)

These pumps are located in the north side of the Process Enclosure, close to the DCC, Absorber, and Stripper columns, to provide for minimum lengths associated with the large suction lines.

In addition to the large circulation pumps, the following plate and frame exchangers are located inside the Process Enclosure, on the south side of the enclosure:

- DCC Water Cooler (E-101)
- Absorber Wash Water Cooler (E-202)
- Lean Solvent Cooler (E-203)

- Solvent Cross Exchanger (E-301)

The main pipe rack for the CCS plant runs in the east-west direction across the center of the CCS plot and through the middle section of the Process Enclosure.

The Stripper (C-301), Reboiler (E-302), and Reboiler Condensate Drum (V-303) all work together and are therefore all located in one area to the west of the Absorber column. This arrangement provides for a centralized location for the large amine, steam, and condensate lines. The Reboiler Condensate Pump (P-303A/B) is located near the Reboiler Condensate Drum but placed inside the Process Enclosure for winterization purposes.

The large low-pressure CO_2 overhead line from the Stripper is routed to the Condenser (E-303), located on the upper level of the Process Enclosure near the Stripper. The two-phase CO_2-water mixture from the Condenser is routed to the Overhead Accumulator (V-302), located just underneath the Condenser. The Reflux Pump (P-302A/B) is located near the Overhead Accumulator to minimize the pump suction line length.

Most of the equipment associated with the CO_2 Compression system, including the CO_2 Product Compressor (K-601A/B), CO_2 Dehydration Package (PK-601A/B), and CO_2 Product Compressor Aftercooler (E-601A/B), are located inside the Compressor Enclosure on the west side of the plot. The CO_2 Product Compressor Suction KO Drum (V-601A/B) is located outdoors, to the south of the Compressor Enclosure. The Process Condensate Pump (P-601A-D) is located inside the CCS Chemical Transfer Pump Enclosure, close to the Compressor Suction KO Drum to minimize the pump suction line length.

All equipment associated with the glycol water system are located inside the Process Enclosure, at the south side of the enclosure. This location is near the center of the CCS plot and is an optimal location for the glycol water system as glycol water is used to heat buildings/enclosures and tanks throughout the CCS plot.

The chemical storage tanks for EFG+ solvent, sodium hydroxide, and TEG are all located in one area to the west of the Process Enclosure. The associated chemical supply pumps are located inside the CCS Chemical Transfer Pump Enclosure located just west of the tanks. A truck loading/unloading area is provided near the chemical storage and supply area.

The Cooling Tower (CT-701) is located in the southernmost side of the plot as a means to minimize drift and hot air recirculation based on the prevailing wind direction out of the northwest.

6.1.8 Operating and Maintenance Costs

The major operating and maintenance costs associated with the CCS include:

- Utility requirements – for this project, the major utility requirements are natural gas (for generating steam in the new boiler package), electrical power, and raw water make-up.
- Consumables – EFG+ solvent, sodium hydroxide, TEG, and cooling water treatment chemicals.

- Waste Removal – SMS waste effluent removal
- Plant personnel
- Maintenance costs

The EFG+ CCS requires one control room operator and one field operator per shift. Assuming a four shift schedule, a total of 4 control room operators and 4 field operators will be required. Two laboratory technicians are required for the EFG+ CCS. Several maintenance personnel are required for the EFG+ CCS, which can possibly be shared with the power plant. Overall personnel requirements for the CCS are summarized in Table 11.

Table 11. Personnel requirements for the CCS plant

Staff Position	Positions Required
Control Room Operator	4
Field Operator	4
Laboratory Technician	2
Maintenance Supervisor (Note 1)	1
Electrical Technician (Note 1)	1
Mechanical Technician (Note 1)	2
Instrumentation Technician (Note 1)	2
Notes: **1) Maintenance Supervisor and Technicians can be shared with power plant.**	

6.2 Civil Engineering

6.2.1 Soil Load Analysis

A site-specific Geo-technical Investigation, which included field investigation, laboratory testing and engineering analysis, was conducted for the project which provided a report with recommendations for design of foundations and piles along with recommendations for site preparation and grading. Based upon the findings of the soil investigation, generally fill materials consisting of coal, lean clays, landfill debris and Lignite were encountered from the existing grade to a maximum depth of about 12 feet below the existing grade. Below the fill materials, mostly fat clays were encountered to a depth of 120 feet below the existing grade. The geo-technical investigation report provided criteria for supporting lightly loaded structures on shallow foundations (spread footings and structural mats) and supporting heavy loaded structures on deep foundations (piles). It also provided dynamic soil properties for designing of vibrating equipment foundations. For more information, refer to the Geotechnical Investigation Report provided as Attachment 5.

6.2.2 Storm Water Runoff Plan

Storm water runoff and firewater discharge from all proposed areas of the proposed development are collected through swales, ditches and a few catch basins/manholes connected by an underground piping system and conveys the flow to existing drainage system which outfalls to existing detention basin(s).

The storm water drainage conveyance system has been sized to accommodate the largest runoff generated from the following:

- Design rainfall event, 10-year 24-hour storm
- Fire water discharge, estimated to be 1,500 gpm for the proposed development.

Due to the presence of Amine and Glycol in the CCS, the storm water sewer system is considered to be potentially contaminated and therefore detained at source in curbed areas and sumps. The water collected in the curbed areas and sumps will be removed by vacuum truck, as required.

The rainfall event for sizing the drainage conveyance system was based on rainfall information available in the Plant Site Data Sheet provided as Attachment 6.

6.2.3 Geologic Assessment

The Geologic Hazard Study and Seismic Design Information are based on the Site Specific Geo-technical Investigation report. The seismic study indicates that there is a low probability for liquefaction to occur during a major earthquake at the site. Based on the seismic shear wave survey conducted, a Site Class of "D" can be utilized. Based on the hazard report, liquefaction is not expected to occur at the coarse-grained layers encountered at the project site. For more information on the Geological Hazard Study, refer to Appendix I of the Geo-technical Investigation Report, provided as Attachment 5.

6.2.4 Spill Containment Assessment

To minimize the potential for contaminating plant storm water runoff, secondary containment in the form of concrete curbing has been provided for areas where equipment containing Amine and Glycol are located.

Each curbed area will have at least one sump with a drain pipe connected to the storm water drainage system via a normally closed valve. In curbed areas with multiple equipment items; to prevent the spread of a spill from a single equipment item to the entire curbed area, multiple sumps in opposite corners have been placed with a ridge in between them dividing the curbed area into smaller subareas.

After a rain event, the water collected within the curb will be tested for contaminants and if clean, the normally closed valve will be opened releasing the water to the underground storm sewer system. If water collected within the curb is contaminated, or in the event of a spill, the contents will be removed via vacuum truck.

Curbs have been sized to accommodate a 10 year-24 hour storm event.

Where practical, several equipment items with the same service have been placed inside a single curb.

6.3 Structural Engineering

6.3.1 Foundation & Structural Sketches

Preliminary Foundation and Structural Sketches developed for the FEED effort are provided as Attachment 7.

6.3.2 Architectural Design Drawings

Preliminary Structural Drawings that were developed for the FEED effort are provided as Attachment 8. Included in Attachment 8 are sketches for:

- Process Enclosure (M1NN-CCS-DWG-220-00010)
- Compressor Enclosure (M1NN-CCS-DWG-220-00020)
- Boiler Enclosure (M1NN-CCS-DWG-220-00030)
- Multi-Purpose Building (M1NN-CCS-DWG-220-00050)
- Structural Steel – General Notes and Material Criteria (M1NN-CCS-STD-215-00001)

6.3.3 Material Take-Offs

Structural Material Take-offs were generated from a combination of extraction from the 3D model and derived manually from the preliminary sketches developed for Structures, Foundations and Pilings.

Pipe sizes 3" and larger were modeled utilizing S3D software. Material quantities for pipe sizes 3"and larger were extracted from the S3D model. Material quantities for pipe sizes less than 2" were derived manually.

6.4 Mechanical Engineering

Mechanical Engineering developed equipment specifications for various types of equipment used in the CCS plant design, along with data sheets for each equipment item identified in the Process Equipment List (Attachment 4).

6.5 Electrical Engineering

An independent electrical distribution system alternately switched from a 230kV overhead incoming line by MPC will power the CCS Plant. A single radial 230kV feeder will bring power to a single three winding 230/13.8/13.8 kV transformer powering two 13.8kV switchgear busses within a single pre-fabricated substation building located on the southwest corner of the plot. The rest of the CCS Plant electrical distribution will be powered from the 13.8kV busses.

Electrical heat tracing is provided for freeze protection.

6.5.1 Electrical Equipment

An Electrical Equipment List is included as Attachment 9.

6.6 Instrumentation & Controls Engineering

The basic philosophy of the CCS facility is to provide a new dedicated Distributed Control System (DCS) in a new Control Building. Two operator workstations will be provided for that purpose in the Control Room of this building. Communication will be established between the CCS DCS and the existing MRY 1 and MRY 2 DCS.

Components for the new control system such as controllers, power supplies and network cards will be housed in the rack room in the Control Building. Also located within the rack room will be an engineering workstation interface for the new control system.

Remote I/O boxes strategically located within the facility will be the interface point for field instruments to the control system. Remote I/O boxes will have a fiber optic link back to the Power Center equipment room.

6.6.1 Network Architecture Drawing

The conceptual Network Architecture Drawing is provided as Attachment 10.

The DCS I/O will utilize an "electronic marshalling" concept in which the field signals are landed directly on the I/O chassis within the field Remote IO box. The IO device for each signal type will be selectable on a point by point basis thus eliminating the requirement for intermediate marshalling for signal segregation.

6.6.2 Subsystem Interfaces

All subsystems will communicate bi-directionally with the DCS to facilitate the maximum use of the DCS for historization, alarming, and display of information to operators. Subsystem interface to DCS will be Ethernet. Communication protocol will be Ethernet/IP or Modbus TCP.

6.6.3 Instrumentation Cables

Instrumentation cables will be installed in conduit and overhead tray systems. Cable specifications and installation details shall be prepared during detailed design.

Fiber optic cables used between the local areas and RIO to the rack room and will be routed in overhead tray.

6.6.4 Communications Infrastructure

The CCS project is a standalone independent system and will communicate to the existing MRY1/MRY2 plant sites which has an established and adequate communication infrastructure system with sufficient integrity and security to accommodate the communication with the CCS project. MRY1 and MRY2 will need to have a new ELC Controller install in each MRY Relay Room. Besides this addition, there is no other system design changes envisioned for the site due to the demands of the project.

6.7 Fire Protection Engineering

The CCS shall be equipped with a Fire Protection System such that in the event of a major fire, the Fire Protection System will serve to:

- Minimize personnel injury
- Minimize equipment damage
- Avoid escalation of the fire

The Fire Protection System shall protect all structures and equipment that are critical to life safety, as well as enclosures housing critical systems, equipment, or services. A Fire Protection Design Basis has been developed for the Project and is provided as Attachment 11.

6.7.1 Fire Protection System

The fire risk in this new unit is low due to no known flammable hydrocarbons being processed. The remaining fire hazards are:

- A presence of combustibles with high flash points such as lube oil for the CO_2 Product Compressors.
- Natural gas is used as fuel in the steam boiler package.

The facility will be equipped with an underground firewater ring main around the perimeter. The ring main will be connected on two sides to the existing site firewater distribution system. Hydrants along all four sides of the plant are fed from this ring main. Post indicator valves (PIV) will be provided to isolated no more than five hydrants to allow for maintenance and repair while continuing to provide firewater to the remaining hydrants.

An addressable fire alarm panel shall be installed in the Multi-Purpose Building protected with smoke detection and manual fire alarm system designed and installed in accordance with NFPA 72. The building shall be equipped with dry chemical and carbon dioxide fire extinguishers.

CO_2 infrared gas detectors will be located around the new CO_2 Compressor and will be tied into the plant fire and gas detection system. An audible horn and visual strobe unit will be located near the compressor mounted in an unobstructed visible location operated by the fire and gas detection panel.

A complete Firefighting Equipment Specification developed for the Project is provided as Attachment 12.

6.8 Facilities Engineering

The project will require the construction of 4 major facility enclosures/building.

- Process Enclosure
- Compressor Enclosure
- Boiler Enclosure
- Multi-Purpose Building

Preliminary Architectural Drawings for these facilities are provided in Attachment 8. HVAC design for these facilities is provided in Attachment 13.

6.9 Site Security

The site will be secured with controlled access for vehicles, construction personnel, equipment and deliveries, as well as removal of trash and construction debris.

6.10 Logistics

This section describes the Logistics effort for the Project, which involved identifying and evaluating options and limitations for transportation of equipment and materials to the project site, located at the Milton R. Young Station near Center, North Dakota.

The use of rail and in-land water way transportation, in addition to road transport, was evaluated for the project. The project site does not have a rail siding. The nearest available siding is Hensler, ND on a BNSF line. Hensler is an unincorporated rural village in Oliver County, North Dakota and is located approximately 20 miles from the project site. The feasibility of any improvement to the rail siding site should be evaluated to enable flexibility to bring additional equipment into the project site.

Inland barging offers the project the ability to transport modules and oversized equipment from the Port of New Orleans and overseas vendors closer to the site using the Mississippi or Missouri Rivers. These rivers' typical operating windows are April 1st through November 15th. Two ports were identified as good candidates for in-land water way transportation for the project: Sioux City, IA and St Paul, Minnesota.

A physical route study was performed by a third-party contractor, Fracht. The route study focused on five potential routes from various locations to the project site. The origins considered were: Houston, TX; Billings, MT; St. Paul, MN; Sioux City, IA; and Duluth, MN. The route study considered a maximum module envelope of 100' L x 20' W x 13'9" H at 180,000 lbs. For each of the routes, Fracht concluded that transportation of the considered module size to the project site is feasible with relatively low amount of route improvements. No significant grade changes or slopes were identified along the over-road routes.

6.11 Constructability

Due to shipping limitations, the project team understood that execution optimizations would have to occur near site as shipping large modules and preassemblies proved cost prohibitive. To capitalize on improved weather months, assembly-line productivity, and parallel execution, Fluor's construction plan includes the use of nearby preassembly. Employing nearby preassembly allows fabrication and assembly off-site earlier in the project calendar without interfering with earthworks and civil. In addition, nearby preassembly reduces site congestion, resulting in improved productivity and safety performance.

6.11.1 Construction Access

The project has identified four construction access roads and a single dedicated heavy haul road to the project site.

Construction Access Road #1 is located off 24th Avenue Southwest (directly below the Nelson Lake spillway) and will serve as the access / egress point for the Architectural laydown area. This access is approximately 2,000 ft long and 16 ft wide. Required upgrades include a 6 ft width increase and a layer of fresh gravel for the entire length.

Construction Access Road #2 is located approximately 2,000 ft from the southwest corner of the CCS Plant plot area, branching off 24th Avenue Southwest, and 800 ft prior to reaching the MRY front gate.

This primary access road will provide access and egress for all personnel and light haul traffic. In addition, this route will serve as the sole entrance for the Primary Complex that includes craft parking, warehousing, offices, and preassembly shops. Required work includes cutting in approximately 3,300 ft of road, drainage, compaction, and surfacing.

Construction Access Road #3 is directly south of the Construction Entrance #2 and provides parking lot access for personnel. Required work includes cutting in approximately 3,300 ft of road, drainage, compaction, and surfacing of the entire parking lot.

Construction Access Road #4 is located at the very northwest corner of the unit and will serve as the connection point between the CCS Plant plot area and the heavy haul corridor. Required work will include the installation of this road during the early heavy civil portion of the scope.

Figure 6 below shows the four construction access roads for the project site, as well as the various areas for the Primary Temporary Facilities.

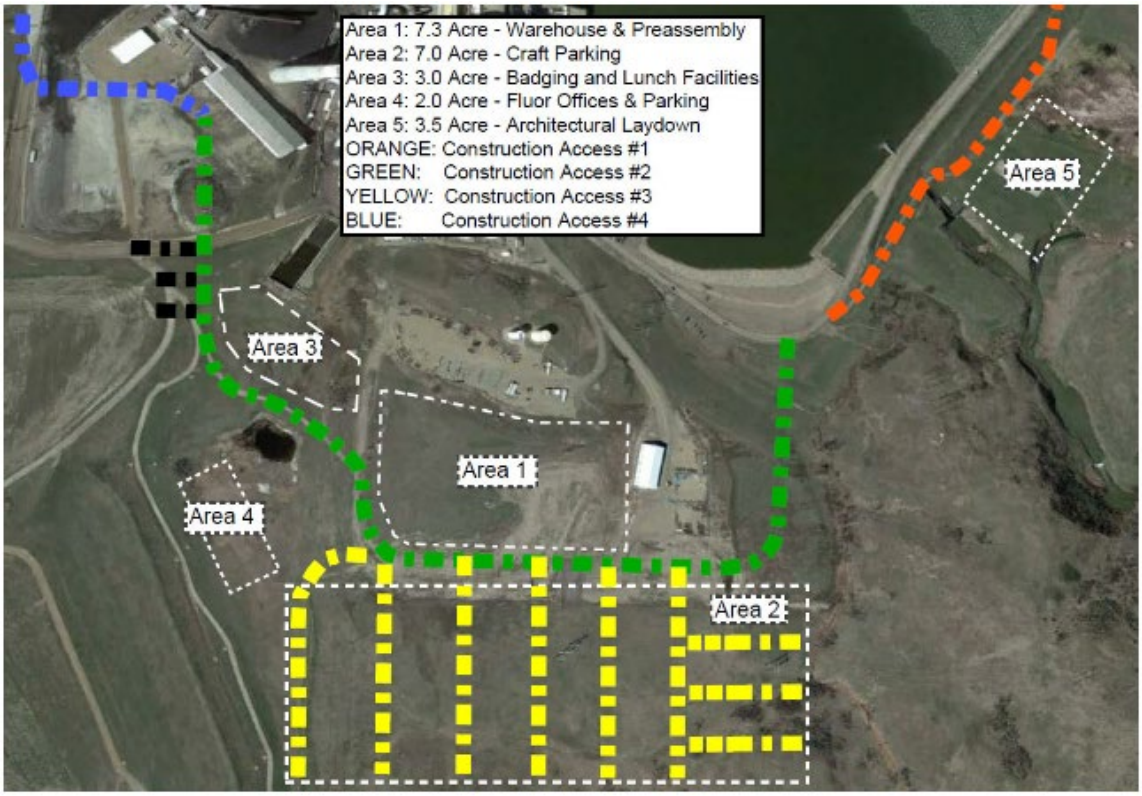


Figure 6. Construction access roads and primary temporary facilities

The project will have a single dedicated heavy haul road connecting access from Hwy 25 (Primary County Road) to the CCS Plant plot area by way of 23rd Avenue and 37th Avenue. This road serves as one of the mines' secondary transport roads, meaning heavy haul upgrades have already been made. The corridor stretches approximately 6 miles from the unit, maintains a 100 to 120 ft gravel top surface, with high-line utility corridor placing overhead utilities at a minimum of 42 ft. Figure 7 shows the heavy haul road to the project site.



Figure 7. Heavy haul road

6.11.2 Laydown Areas

A 7.3-acre plot of land approximately 1100 ft southwest of the CCS Plant plot area will be used for warehousing, prefabrication preassembly and storage, and scaffold laydown. This plot is labeled as Area 1 in Figure 6.

A 3.5-acre plot located approximately 2500 ft west of the plant will be used for architectural laydown. This plot is labeled as Area 5 in Figure 6. Depending on the space requirement of the architectural installation service provider, this area could be sub-developed and provide additional storage for other contractor materials.

In addition, the Off-Site / Secondary Facilities, a 15-acre tract located approximately 6 miles northwest of the CCS Plant plot area, will be used for a concrete batch plant, vessel fabrication, warehousing, material laydown, and preassembly and prefabrication.

6.11.3 Sequencing of Construction Work

Upon completion of civil earthworks, the construction sequence will begin with installation of piling, underground piping, underground electrical, and foundations. As equipment foundations become available, base floor mechanical equipment installations will commence at the northwest corner of the process area working its way to the east. As equipment installation moves east toward the boiler enclosure, structural steel and building enclosure erection will commence. Above grade piping will progress with the setting of process equipment, starting in the northwest corner of the enclosure and working east.

In parallel to the concrete civil work, the Large Field Fabricated Vessels subcontractor will be fabricating vessel can sections for the Absorber, Direct Contact Cooler, and Stripper at the offsite prefabrication / preassembly yard. As cans are completed, they will be stacked two high, loaded onto a SPMT, and transported to the unit for installation. Prior to and during erection, the appropriate nozzles, stiffeners, and piping will be connected to its portion of the vessel. As vessel erection continues vertically, ladders, platforms, and the remaining components will be installed.

6.12 HAZOP

6.12.1 Introduction

The objective of HAZOP is to identify hazards and provide recommendations in case further risk reduction is desired. The P&IDs (Piping and Instrumentation Diagram) subject to HAZOP will go through a client P&ID review prior to the HAZOP. Any comments and updates from the P&ID review will be marked on the P&ID's and are considered as implemented. The HAZOP Study technique defines the method for evaluating the safety and operability of plants and facilities in a systematic way. The HAZOP Study involves a formal team review of P&ID.

In the HAZOP Study, systems are reviewed to ensure these systems are adequately safeguarded. The HAZOP technique is used to assess whether deviations from the design intention could occur and, if so, whether the consequences of such deviations are hazardous.

The HAZOP team needs to be multi-disciplined with authority to make on-the-spot assessment and define recommendations to prevent or mitigate the potential consequences if required. To be effective, the HAZOP Study must involve the Designers of the P&IDs and members with operational experience.

Recommendations from the Project Tundra Project Health, Safety, and Environmental (HSE) studies/workshops were addressed as part of the FEED phase of the project. Open recommendations deferred from the FEED HSE workshops/studies will continue to be tracked during the Detailed Engineering phase of the project.

6.12.2 Scope

The scope of this HAZOP summary includes all of the recommendations generated during HSE workshops conducted by Fluor during the FEED phase of the project. Two levels of Process Hazard Analysis (PHA) were conducted:

- PHA Level I – FEED Hazards Identification Study
- PHA Level II – Hazards and Operability Study

The scope of the HAZOP includes the following Fluor process systems:

- Flue Gas Cooling and Conditioning
- Flue Gas Blower
- Flue Gas Particulate Removal
- CO_2 Absorption

- Solvent Regeneration
- Solvent Maintenance
- Chemical Storage and Supply
- CO_2 Compression
- Utility Support Systems

Upset conditions in the power plant and MPC utility systems were addressed for the interfaces of the HAZOP nodes. For interface points, where the nodes of the HAZOP are connected to Minnkota systems, upset conditions at that point were identified. Causes outside the scope enter at the interface point. The interface points were clearly indicated on the marked-up P&IDs for HAZOP, e.g. the flue gas tie-in points.

6.12.3 HAZOP Team

To perform a quality HAZOP, a knowledgeable, multi-disciplinary team is key. Critical HAZOP participants are outlined below.

HAZOP Facilitator

Fluor assigned the facilitator for the HAZOP. The HAZOP Facilitator is independent from the Process department to avoid bias. The HAZOP Facilitator is responsible for ensuring that a thorough HAZOP study is performed, that the HAZOP study report is satisfactory, and guiding the team to their decision process, based on the Facilitator's experience. However, the Facilitator's involvement does not alter the process engineers' responsibility for safe design and operability of the plant.

HAZOP Scribe

Fluor also assigned the scribe for the HAZOP. It is the scribe's role to document the findings in the HAZOP worksheets.

Process Engineers

The core of the review team consisted of Process Engineers responsible for the design of the unit.

Control Systems Engineer

A Control Systems engineer is required to provide clarification regarding complex control and/or safeguarding loops (Fluor) and interfaces with the existing Distributed Control System (MPC).

Operation Representatives

Operational experience is crucial to the success of the HAZOP. MPC ensured participation of Operations to the HAZOP.

HSE Engineer

MPC's HSE representative participated in the HAZOP. The HSE Representative provides input to the HAZOP and delivers specific knowledge with respect to MPC's Standards and Procedures with respect to safety related subjects.

Other Engineering Disciplines

Other engineering disciplines were consulted on an as-needed basis and remained on call during the HAZOP. For example, where complex rotating equipment is included in a particular P&ID, the Mechanical Equipment Engineer was required to attend.

Subject Matter Experts

Fluor also made available subject matter experts in various technical areas and these individuals were called upon for specific input throughout the HAZOP.

6.12.4 Summary of Findings

A total of 105 recommendations were formulated during the HAZOP review to improve the safety and/or operability of the CCS Plant. This includes four (4) recommendations added during the Hot Glycol HAZOP session conducted on Nov. 24, 2020. Recommendation closure priority (FEED or EPC) and responsibility (Fluor, MPC, EPC Contractor) assignments were specified during the HAZOP workshop.

Of the 105 recommendations, 71 were assigned identified as having a FEED phase closure priority. Responsibility for 66 of the FEED phase items was assigned to Fluor, with two (2) items assigned to MPC.

An EPC phase closure priority was assigned to 34 recommendations. Responsibility for EPC phase recommendations were assigned to MPC and/or the EPC contractor. Several (16) of the recommendations are related to scenarios that need to be reviewed during the Vendor HAZOPs conducted during detailed engineering in EPC.

6.12.5 End of FEED Recommendation Status

There was a total of 130 recommendations from the FEED phase HAZID and HAZOP HSE workshops and studies. The recommendations were assigned to be resolved by either Fluor, MPC or EPC Contractor. Of the 130 recommendations, 80 were closed during the FEED phase. A total of 50 are to be carried forward to the EPC phase of the project. Table 12 provides the individual breakdown of recommendations by study and their status.

Table 12. Breakdown and status of FEED recommendations by study

Workshops/Study	Status		Total
	Defer to EPC	Final (Closed)	
PHA I - HAZID	6	19	25
PHA II - HAZOP	44	61	105
Total	50	80	130

7 BALANCE OF PLANT ENGINEERING (NON-FLUOR SCOPE)

7.1 Burns & McDonnell (BMcD) BOP Scope

As detailed in the previous sections, Fluor's scope was limited to the CCS plant and certain BOP items, including the natural gas boilers and the cooling tower. The remainder of the FEED for Project Tundra

carbon capture retrofit was performed by multiple vendors. This section provides details for the BOP scope performed by BMcD, which included the following:

1. Water treatment facility to supply cooling tower make-up water as well as demineralized water and service water users of the CCS facility.
2. Flue gas interconnection from the existing MRY1 and MRY2 exhaust ducts including tie-in dampers.
3. Delivery of natural gas from the gas metering yard to the gas delivery interface for auxiliary boiler use.
4. Potable water interconnection from the rural water district tie-in point to the interface delivery point to supply Fluor's potable water users.
5. Fire Protection water from the existing MRY facility to the CCS facility.

Key BOP design documents from BMcD are:

- Attachment 17: Level 1 Project Execution Schedule
- Attachment 18: Project Scope of Work Matrix
- Attachment 19: Water Balance Diagram
- Attachment 20: Site and General Arrangement Drawings
- Attachment 21: Piping & Instrumentation Diagrams
- Attachment 22: Major Equipment List
- Attachment 23: Electrical One Line Diagrams

7.1.1 Water Treatment

Water treatment for Project Tundra includes a raw water treatment system and a demineralized water treatment system. The raw water treatment system will supply make-up water to the cooling tower, service water to the CCS facility, and pre-treated feed water to the demineralized water treatment system. The demineralized water treatment system will supply high-purity demineralized water for make-up to the auxiliary boilers for process steam production as well as other demineralized water users in the CCS facility.

The raw water treatment system will be sized for a maximum of 3,100 gallons per minute (gpm) of softened water based on water demands during full load, peak summer ambient conditions and when "fully" softening the cooling tower make-up water to minimize the amount of cooling tower blowdown sent to waste. Fully softening does not mean that 100% of the cooling tower make-up water will be softened, but rather that enough of the make-up water would be softened such that the cooling tower blowdown rate is not set based on scaling potential but to control chlorides to the maximum limit of 100 mg/L set by Fluor. The demineralized water treatment system is sized for the continuous production of up to 120 gpm of demineralized water.

7.1.1.1 Raw Water

Raw water will be delivered to the raw water treatment system from the existing Lake Nelson Intake Building. New Lake Water Intake Pumps will be supplied from the existing enclosure. BMcD was not able to visit the site to review constructability of removing the existing pumps, and installation of the new

pumps, but based on MPC provided drawings of the intake structure and existing pump curves, the pumps can be replaced with minimal impact to existing pump design such as the pump base plate and pump can.

7.1.1.2 Raw Water Treatment

The raw water treatment system will be designed to soften the raw water and remove suspended solids such that it is suitable for use as cooling tower make-up water as well as for make-up to the demineralized water treatment system. The raw water will first be fed into an equalization tank to store water and provide a controlled feed stream to the treatment process. Two (2) x 100% feed pumps will route water from the equalization tank to two (2), in series reaction tanks where the following chemicals will be injected: hydrated lime, soda ash, sodium hypochlorite, and coagulant. Polymer will also be injected into the overflow pipe from the second reaction tank before the water enters a one (1) x 100% high rate solids recirculating style clarifier, where with the assistance of polymer and coagulant the suspended and precipitated solids will settle out the bottom of the clarifier as underflow while the permeate will overflow from the top. The sludge underflow will be recirculated using a set of two (2) x 100% sludge recirculation pumps and/or routed to a solids handling system using two (2) x 100% sludge blowdown pumps. The solids handling system will consist of a sludge storage tank, two (2) x 50% filter press feed pumps, and two (2) x 50% plate and frame filter presses. The permeate from the clarifier will flow into two (2) x 50% gravity sand filters for polishing removal of suspended solids. Filtrate from the sand filters will route into a Clearwell Sump from where the water will be sent to three different locations. First, the majority will be sent directly to the cooling tower basin to serve as make-up for evaporative and blowdown losses. The second use of the treated raw water will be to produce service water. The third use will be to supply make-up water to the demineralized water treatment system. A set of three (3) x 50% submersible pumps will send water to the cooling tower basin and another set of three (3) x 50% submersible pumps will send water both to service water users in the CCS facility as well as provide make-up to the demineralized water treatment system.

7.1.1.3 Demineralized Water Treatment

The demineralized water treatment system will be designed to produce high purity water for make-up to auxiliary boilers for process steam production as well as other demineralized water users in the CCS facility. The demineralized water treatment system will consist of two (2) x 100% UF skids, cartridge filters, two (2) x 100% two-pass RO skids, and miscellaneous equipment such as tanks, pumps, and chemical skids. The water produced by the demineralized water treatment system will be of the quality listed in Table 13.

Table 13. Demineralized water quality

Parameter	Demineralized Water
Specific Conductivity at 25°C, µS/cm	150
Total Iron, mg/L	0.01
Total Copper, mg/L	0.01
Silica, mg/L	8.0
TDS, mg/L	0.5

7.1.2 Natural Gas

Natural gas will be supplied to the Fluor provided auxiliary boilers located in the Auxiliary Boiler Enclosure from the natural gas metering yard located on the south side of the CCS facility. MPC and a commercial natural gas transmission company evaluated the routing and estimated cost of a new natural gas line to supply the plant. The interconnecting delivery pipeline from the metering yard to the CCS Auxiliary Boiler Enclosure includes pressure control to maintain minimum pressure delivery to the auxiliary boilers. It is assumed that the natural gas is adequate for supply to the auxiliary boilers and requires no further conditioning.

7.1.3 Potable Water

Potable water will be supplied to the site from the Southwest Water Authority (SWA) on the northeast side of the MRYS property as indicated in Figure 8. A potable water line will be routed from the SWA delivery point to the process building. Fluor's scope will include booster pumps to provide additional pressure for delivery to service users.



Figure 8. SWA potable water tie-in location

7.1.4 Flue Gas

The MRY facilities Unit 1 and Unit 2 will deliver flue gas from the existing power generation operations to the CCS facility. The CCS facility will be designed for 100% flue gas operation from MRY2. While MRY2 is not operating, MRY1 will deliver the flue gas to the CCS facility for CO_2 gas separation. The existing flue gas ductwork will include dampers to allow for continued power generation operation without

the CCS facility operation, or in the case of MRY1, when MRY2's flue gas is being transferred to the CCS facility. Alloy guillotine dampers will be installed in the existing transition ductwork to the MRY1 and MRY2 stacks, as well as transition ductwork to the CCS facility.

The tie-in will require the removal of existing fiber reinforced plastic (FRP) ductwork and replacement with an FRP reducing tee from the existing ductwork. Seal air blowers are included to provide seal air for the damper that is closed, to pressurize the upstream side of the damper against the damper seal gasket to provide an airtight seal.

7.1.5 Fire Protection

7.1.5.1 Water Treatment Building

The fire protection design for the Water Treatment Building, per National Fire Protection Association (NFPA) standards, does not require the use of water suppression inside of the building based on chemical storage quantities and occupancy classification. The main process area of the building will require linear type heat detectors, pull stations, horn and strobe, and portable fire extinguishers. The electrical room located on the second floor of the building will require photoelectric smoke detectors instead of the linear type heat detectors due to the classification of equipment located within this room.

The building will have a local fire alarm control panel for monitoring and control of the local detection systems. The local panel will be connected to Fluor's fire protection system for indication of system activation in the main fire control panel located in the CCS control room.

7.1.5.2 Existing Facility Interconnection

MPC performed a flow analysis of the existing MRY facility fire water pumps and system to supply the CCS facility with fire water for both hydrant supply and building and equipment suppression. Based on the results of this flow analysis test, the existing pumps are capable of providing sufficient flow, but would require a booster pump to provide adequate pressure as requested by Fluor in the interface table supplied in Attachment 20. Booster pumps have been located on the east side of the CCS facility, with BMcD's scope including a tie-in to the existing MRY underground yard distribution fire water piping, and delivering water to the specified location in Attachment 20.

7.1.6 Compressed Air

The compressed air system distributes air throughout the water treatment system for instrument use and to support maintenance needs. The system is provided clean, dry 'Instrument Air' from Fluor's compressed air system to a new dry instrument air receiver located in the Water Treatment Building. From the air receiver instrument air is routed for use to actuate control valves and automated valves related to the water treatment system, and also to supply air to the core blow and air blow of the filter presses. The system also provides non-essential 'Service Air' for maintenance related activities such as cleaning and for operating pneumatic tools.

7.1.7 Electrical Design

The Water Treatment Building and system electrical system will be powered from the CCS Facility auxiliary power system by two 13.8kV switchgear breakers which will feed two 13.8kV-480V transformers.

The transformers feed a dual main, mechanically interlocked, 480V Motor Control Center which provides power to the water treatment loads. New cable tray and conduit will be installed throughout the water treatment building to facilitate cable routing. No new underground raceway is required or included. Grounding, lighting, and receptacles are included.

The new Lake Nelson intake pumps will be located in the MRY2 Screen House and powered from existing spare switchgear breakers located in the MRY2 Electrical Building. New cable tray will be provided from the MRY2 Electrical Building, through MRY2, to near the MRY1/2 Auxiliary Transformer. Existing spare duct bank conduits will be used to route the cable from the MRY1/2 Auxiliary Transformer to the MRY2 Screen House.

The new dampers (2) located at the MRY1 and MRY2 tie-in ducts will be powered from the existing MRY1/2 480V auxiliary power systems. New conduit and cable tray will be installed as necessary to route from the power sources to the dampers. New lighting is included on the new damper access platforms.

7.2 Environmental

7.2.1 Air Dispersion Modeling Results

As noted in Section 4.4.1, air dispersion modeling is a required component of the air permit that is needed prior to the CCS construction. This section provides a summary of the modeling results performed by AECOM.

Table 14 provides the results of the NAAQS assessment. As noted in the table, none of the standards are exceeded for the project.

Table 14. Results of NAAQS assessment for CCS project emissions.

Pollutant	Averaging Period	Rank of Model Impacts	Maximum AERMOD Design Concentration ($\mu g/m^3$)	Ambient Background Concentration ($\mu g/m^3$)[8]	Total Concentration ($\mu g/m^3$)	USEPA NAAQS/North Dakota AAQS ($\mu g/m^3$)	% of Standard
NO_2	1-hr[1]	98th	28.04	35.00	63.04	188.0	34%
	Annual[2]	H1H	0.78	5.00	5.78	100.0	6%
PM_{10}	24-hr[7]	H6H	14.62	30.00	44.62	150.0	30%
$PM_{2.5}$	24-hr[3]	98th	9.18	13.70	22.88	35.0	65%
	Annual[4]	H1H	0.98	4.75	5.73	12.0	48%
SO_2	1-hr[5]	99th	73.23	13.00	86.23	196.5	44%
	3-hr[6]	H2H	73.65	11.00	84.65	1,300.0	7%
	24-hr[6]	H2H	28.83	9.00	37.83	365.0	10%
	Annual[2]	H1H	2.06	3.00	5.06	80.0	6%
CO	1-hr[6]	H2H	22.60	1149.00	1171.60	40,000.0	3%
	8-hr[6]	H2H	15.05	1149.00	1164.05	10,000.0	12%

7.2.2 Emissions Monitoring Plan

MPC contracted Agora Environmental to develop an emissions monitoring plan that accounts for the CCS operation. The introduction of the CCS will require significant changes to ensure that the MRYS and CCS emissions are properly monitored and reported. As illustrated by the simplified configuration diagram in Figure 9, all the flue gas from Unit 2 will typically be exhausted to the CCS. However, there may be periods when the flue gas will be exhausted through the existing Unit 2 stack or transitional periods when a portion of the Unit 2 flue gas is exhausted through the existing stack while some of the gas is treated by the CCS. MPC may also send the flue gas from Unit 1 to the CCS when Unit 2 is not in service.

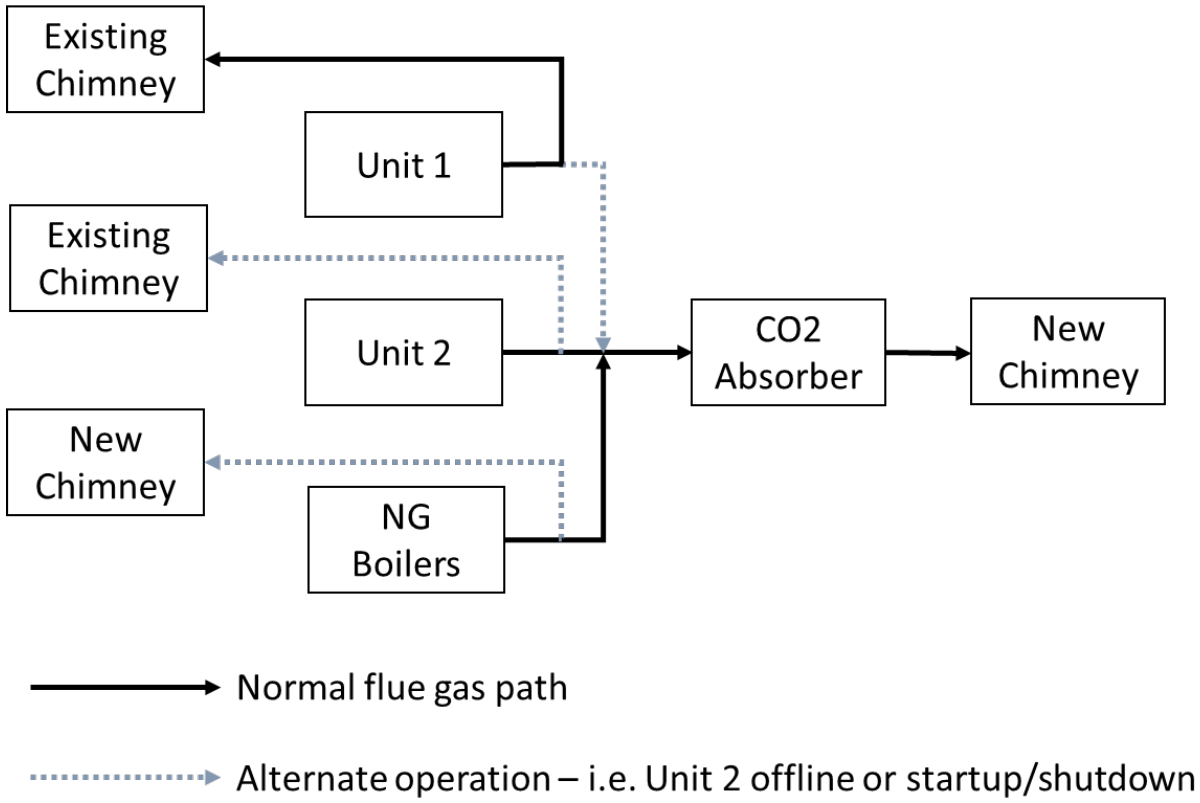


Figure 9. Simplified configuration/operation scenario of the flue gas flow paths from MRYS during CCS operation.

In addition to addressing the potential different operating scenarios and the issue of attributing the emissions measured at the different stacks for the purposes of demonstrating compliance with the existing limits on Units 1 and 2, another fundamental issue that must be addressed is how to calculate the heat input and lb/MMBtu values for any emissions measured at the new CO_2 absorber stack. Typically, when CO_2 concentrations are measured, lb/MMBtu emission rates and CEMS-based heat input values are determined using a F_c-factor representing the ratio of the volume of CO_2 generated to the calorific value of the fuel combusted in units of scf CO_2/MMBtu. For a given fuel, F_c-factors tend to be relatively consistent, and the regulatory agency provides default F_c-factors for various fuels in Table 1 of 40 CFR Part 75, Appendix F as well as Reference Method 19 in 40 CFR Part 60, Appendix A. However, the CO_2 removal by the CCS invalidates the assumptions underpinning the standard F_c-Factor approach. Since the F_c-factor is based on

the volume of CO_2 generated by combustion, the standard F_c-factor approach cannot be applied to measurements at the CCS stack.

In consideration of the above, Agora developed the continuous emissions monitors systems (CEMS) locations shown in Figure 10.

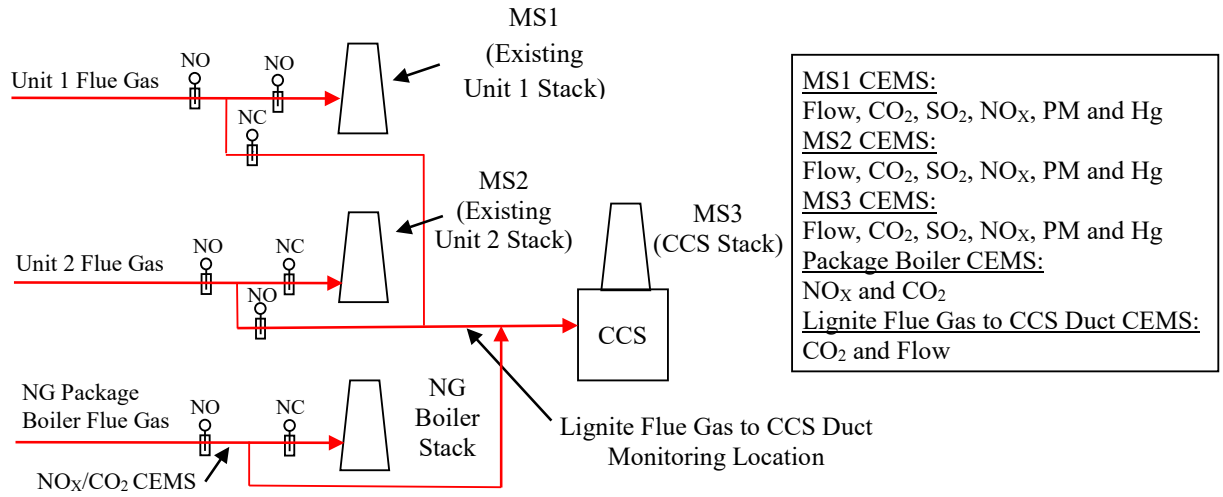


Figure 10. Planned new CEMS locations

Existing Unit 1 and 2 Stack CEMS. The CEMS equipment on Units 1 and 2 stacks will remain unchanged and will be used to measure emissions when the flue gas (or a portion of the flue gas) from the respective unit is exhausted through each of the stacks. On each stack, the emissions will be monitored by a volumetric flow monitor and CO_2, SO_2, and NO_X concentration analyzers. A particulate matter (PM) CEMS and a mercury (Hg) sorbent trap monitoring system (STMS) will also be maintained on each of the existing unit stacks. Not shown in Figure 10 are the CO_2 and SO_2 CEMS located on the inlet and outlet of the flue gas desulfurization (FGD) systems in Unit 2 and the CO_2 and SO_2 CEMS located on the inlet of the flue gas desulfurization (FGD) systems in Unit 1.

Natural Gas-Fired Package Boiler CEMS. The flue gas from three natural gas-fired package boilers used to provide steam for the CCS will typically be exhausted through the CCS stack but may also be diverted to a separate common stand-alone stack. All three package boilers will be affected under Subpart Db of 40 CFR Part 60, which requires the NO_X lb/MMBtu emissions to be monitored by a CEMS. Since the package boilers are identical and will each be subject to the same emission limit, MPC proposes to install NO_X and diluent (CO_2 or O_2) analyzers in the common exhaust duct from the boilers prior to point where the duct branches to the CCS stack or the stand-alone stack so that compliance with the standard can be determined on a continuous basis regardless of whether the flue gas is treated by the CCS or vented to the stand-alone stack. The heat input to the natural gas fired boilers will be measured based on the fuel flow and gas heating value, and those values will also be used to determine the CO_2 emissions for the package boilers.

Lignite Flue Gas to CCS Inlet Duct CEMS. To address the issue of being unable to use a Fc-Factor to calculate heat input or lb/MMBtu values directly based on concentration measurements at the CCS stack, the heat input that is associated with the lignite flue gas being exhausted to the CCS will be determined

using volumetric flow and CO_2 concentration measurements in the duct upstream of the CCS. The flue gas measurements at the duct CEMS location will reflect the flue gas prior to any CO_2 removal, so the standard F_C-Factor can be used in conjunction with the CO_2 and flow to calculate a heat input value associated with the lignite flue gas to the CCS. However, since the CEMS will be located upstream of the introduction of any flue gas from the package boilers, the total heat input associated with the CCS flue gas will be the heat input calculated based on the duct CEMS measurements plus the package boiler heat input.

CCS Stack CEMS. Minnkota Power will measure flue gas emissions from the CCS stack using CEMS including SO_2, CO_2, NO_X, and flow monitors. The plant will also install and maintain a Hg STMS to measure the mercury concentration and will use PM continuous parametric monitoring system (CPMS) and periodic performance testing to demonstrate compliance with the MATS particulate emission standard.

In addition to the above conceptual description of the monitoring strategy, Agora developed a detailed list of the emissions monitoring calculations that will be required to meet the applicable regulations for the MRYS and CCS facilities.

7.3 Golder BOP Scope

Golder Associates was contracted to complete the FEED-level design of a Class I (non-hazardous) wastewater injection well and associated infrastructure and associated cost estimate. Additionally, Golder developed the information necessary for Minnkota to separately prepare the Class I permit application and the aquifer exemption request that will be required prior to construction and injection, respectively. This section of the report contains a summary of the work performed and the major deliverables. Attachment 24 contains the full detail, including engineering drawings.

7.3.1 Class I Well Operating Philosophy

MPC plans to discharge excess process water from the Project Tundra CCS system, which includes cooling tower blowdown, reverse osmosis reject, water treatment softening sludge, impurity removal package discharge, and polishing scrubber blowdown, to their existing flue gas desulfurization (FGD) scrubber blowdown vaults. FGD blowdown from the Unit 1 and Unit 2 scrubber absorber towers is delivered to the scrubber blowdown vaults and then sluiced to Scrubber Pond Cell 4, which is a composite-lined impoundment with a capacity of 307 million gallons below the permitted maximum elevation (2093' msl). Additional inflow to the FGD scrubber system includes makeup water from Nelson Lake, runoff, leachate from the closed scrubber pond cells (i.e., Cells 1, 2, and 3), and other site process waters. Free water in Scrubber Pond Cell 4 (Cells 5 and 6 will be used in the future) is siphoned back to the scrubbers for use in the scrubbing process and sluicing FGD solids. The proposed injectate will be sourced from the Unit 2 Pond Return Tank, which receives water siphoned from Scrubber Pond Cell 4. Given the known chemistry of water in the FGD scrubber system and the anticipated chemistry of the wastewaters from the CCS system, the proposed injectate is anticipated to be non-hazardous; however, because the CCS system is not operational at this time, the exact the chemistry is unknown.

Based on the expected flow rate of the CCS water effluent (up to ~950 gpm), Golder designed two wells. MPC initially plans to construct only one well; if the injection capacity of that well is sufficient to handle the full volume of CCS water effluent, then the second well will not be constructed. This phased approach

is necessary due to uncertainty in the amount of fluid that can be injected into the subsurface formation planned for the project, the Inyan Kara formation from 3,667 to 3,838 ft below ground surface (bgs). The Class I well and the construction/operating strategy were informed by the significant site-specific geologic information that MPC collected on the Inyan Kara formation as a part of MPC's separate efforts to characterize potential zones for CO_2 geologic storage.

7.3.2 Class I Well Design and Construction

This section describes procedures for the design and construction of the injection wells and includes details on the casing and cementing program, logging procedures, drilling and testing program, and proposed annulus fluid. Well design and construction procedures follow the requirements of 40 CFR § 146.12 (USEPA n.d.) and NDAC Article 33.1-25 (North Dakota Legislative Council 1978) for Class I non-hazardous injection wells.

The well designs assume an injection tubing diameter of 7 inches. A perforated casing completion with 0.52-inch entrance diameter and 24-inch penetrations at a rate of 4 to 12 perforations per foot within the identified Inyan Kara sandstone layers will be used (perforation rate to be determined after borehole drilling). The tubular sizes and hole diameters are provided in Table 15.

Table 15. Class I injection well tubular and hole sizing

Component	7-inch Injection Tubing	
	Tubular	Hole Diameter
Injection Tubing	7-inch OD Long Thread Coupling	-
Production Casing	9.625-inch OD Long Thread Coupling	12.25-inch hole (1.3125-inch annulus)
Surface Casing	13.375-inch OD Buttress Thread Coupling	17.5-inch hole (2.0625-inch annulus)
Conductor Casing	20-inch OD Buttress Thread Coupling or Welded	26-inch hole (3-inch annulus)

The following provides the general procedures for the construction of each Class I injection well:

1) Install a 20-inch-diameter conductor casing cemented at an estimated depth of 80 feet in nominal 26-inch-diameter hole.
2) Drill 17.5-inch-diameter hole to approximately 1,260 ft bgs (100 feet below the bottom of the uppermost source of drinking water (USDW)). Run deviation surveys every 250 feet.
3) Conduct open-hole testing (wireline geophysical logs).
4) Run 13.375-inch-diameter surface casing to approximately 1,260 ft bgs (100 feet below the bottom of the USDW).
5) Grout surface casing annulus to ground surface using approximately 12 to 15 pounds (lbs) of Haliburton VariCem cement (or equivalent) per gallon of fresh water to ensure adequate sealing of the annular space.

6) Run cement bond log.

7) Drill 12.25-inch-diameter hole to approximately 3,940 ft bgs (approximately 50 feet below injection zone). Run deviation surveys every 1,000 feet.

8) Conduct open-hole testing (wireline geophysical logs and DST).

9) Run 9.625-inch-diameter production casing to approximately 3,888 ft bgs (approximately 50 feet below bottom of injection interval). Grout annulus to ground surface using approximately 12 to 15 lbs of Haliburton ElastiCem (or equivalent) cement per gallon of fresh water to ensure adequate sealing of the annular space.

10) Run cement bond log.

11) Perform pressure test on well casing.

12) Perforate production casing in the injection interval (approximately 3,667 to 3,838 ft bgs) with 0.52-inch entrance diameter and 24-inch penetrations at a rate of 4 to 12 shots per foot within the identified sandstone layers (perforation rate to be determined after borehole drilling).

13) Perform physical/chemical development of the well.

14) Install 7-inch-diameter injection tubing and packer to approximately 3,617 ft bgs (approximately 50 feet above injection zone). PermaPak single-bore packer (or equivalent) constructed to match production casing and injection tubing.

15) Place annular fluid.

16) Complete well surface features

Following construction, a series of well logs, mechanical integrity tests and formation tests are required prior to being allowed to commence injection operations.

7.3.3 Surface Infrastructure

The proposed injection well locations and the locations and alignment of injection well supply piping and associated structures are shown in Attachment 24. Figure 11 provides the preliminary layout.

Surface infrastructure will include the following:

- A connection pipeline from the existing Unit 2 Pond Return Water Tank to the injection piping, within the Lime Prep Building near the south end of the power block. Also housed within the Lime Prep Building will be a supply pump, potential pre-injection water treatment system, and an injection well screen filter for removal of suspended solids.
- One high-pressure injection well pump (with variable frequency drive) and flow meter will be housed in a separate building near each Class I injection wellhead.
- The first well will be housed in a building on the well pad that will accommodate the injection wellhead, the injection well annulus pressurization equipment, and instrumentation and controls to ensure that the well is operated within the permit limitations for injection pressure and annulus pressure.

- If required, the second well will be housed in a separate building approximately 0.5 miles south of the first well that will also accommodate an injection wellhead, injection well annulus pressurization equipment, and instrumentation and controls to ensure that the well is operated within the permit limitations for injection pressure and annulus pressure.

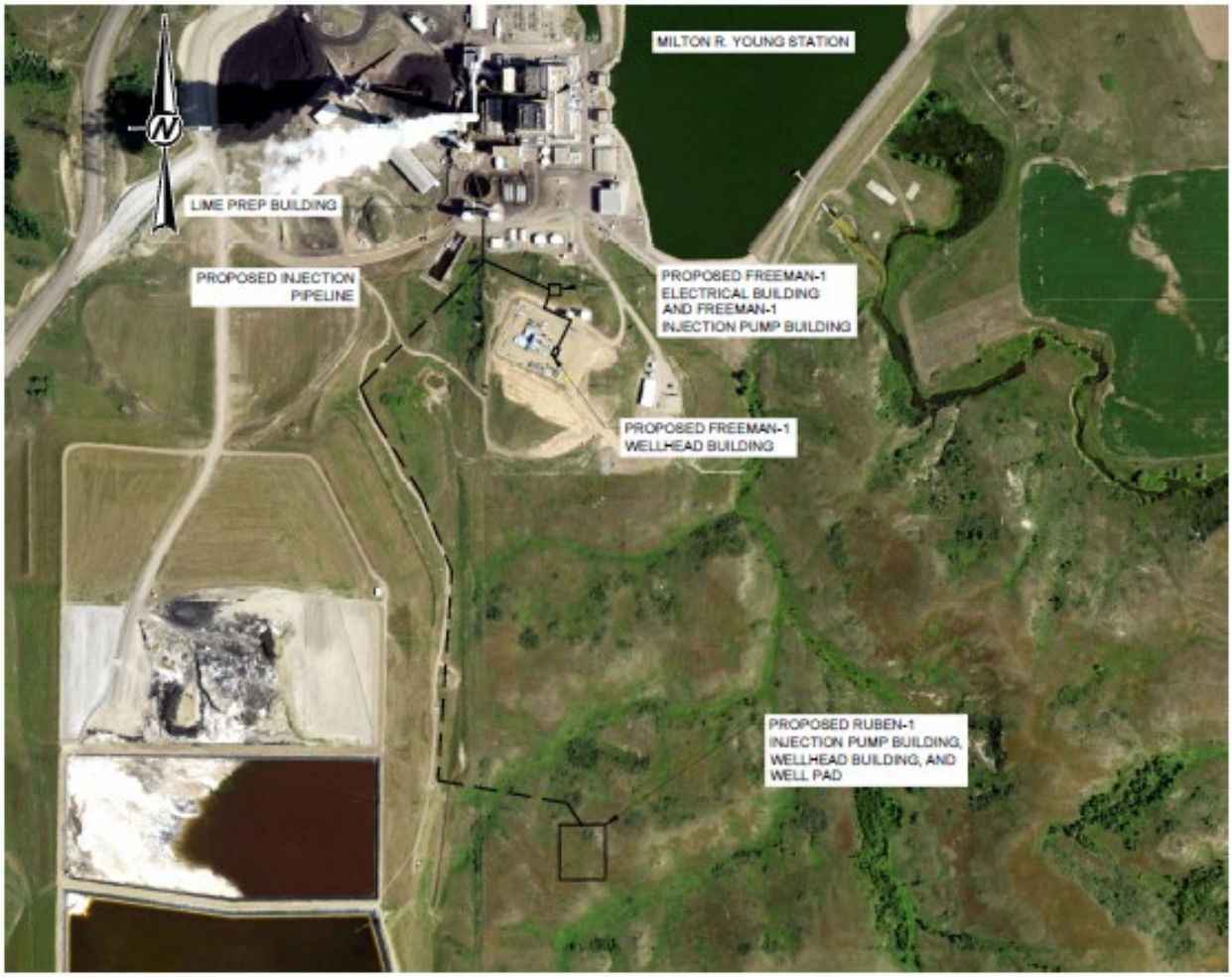


Figure 11. Locations of the two Class I wells designed by Golder: Well 1 (FREEMAN-1) to be located on existing well pad just south of the MRY. Well 2 (RUBEN-1) to be located 0.5 miles south of Well 1.

8 PROJECT COST ESTIMATE

8.1 Overview – CCS Plant (Fluor's Scope)

After the development of the scope of facilities was completed, a Capital Cost Estimate was performed. This estimate has an accuracy range of plus or minus fifteen percent (15%). The estimate is based on a mixture of vendor/contractor bids for the major equipment items and services contracts and Fluor in-house pricing for the bulk material items, engineering/design and construction services. A Basis of Estimate was developed to provide definition around the content of the estimate and is included as Attachment 14. Major estimate clarifications are provided below.

General Clarifications:

- Project execution basis is assumed to be on a lump sum engineering, procurement and construction basis with performance guarantees and liquidated damages.
- Forward escalation has been included from 2020 to project completion. This is valued at $76.6 MM.
- The project construction execution is based on the use of open shop labor. Per diem and incentives for labor attraction and retention are included.
- Pre-commissioning, Commissioning, Start-up and the Performance Testing were included.
- Contingency has been included at $106.5 MM.
- Licensor Fee is excluded.

The estimate has been broken into the following items with the total installed costs of each system as follows:

- CO_2 Capture Plant - $745 MM
- Balance of Plant / Utilities - $330 MM
- Project Tundra Specific Requirements
    - Earth Works Associated with Carbon Capture - $85 MM
    - Impurity Removal Package - $56 MM
    - Enclosures/ Buildings - $79 MM
    - Regional Adjustment for Labor - $87 MM

Summing all cost components results in a combined total installed cost of $1,382 MM. Please also see the Basis of Estimate and the Estimate Summaries provided as Attachments 14 and 15.

8.2 CCS Plant (Fluor's Scope)

For an in-depth description of the facilities included within this portion of the Capital Cost Estimate please refer to the Process Description provided in Section 6.1.5 of this report. The estimated total plant capital cost (excluding Owner's costs) for the CO_2 Capture facility is approximately $745 MM.

8.3 Balance of Plant (Fluor's Scope)

All the required utilities and buildings to support the CO_2 Capture Plant are included as part of the project. These include the following:

- Cooling Tower
- Boilers for steam production
- Multi-Purpose Building
- Substation

The combined total installed cost for these utility systems and buildings is $330 MM.

8.4 Balance of Plant (Burns & McDonnell Scope)

8.4.1 Summary

The estimated cost for the base scope of work, inclusive of Owner's costs, contingency, and escalation is $73.3 million. The cost estimate is classified as AACE Level 3.

8.4.2 Cost Estimate Basis

The cost estimate prepared by BMcD includes all engineering, design, equipment, materials, construction, commissioning, and startup activities to construct the Plant in accordance with this document. The purpose of the cost estimate basis is to generally describe the scope of the cost estimate, and the methodology for estimating the costs.

The following describes the methodology used in the development of the cost estimate:

- Estimate assumes an EPC contract philosophy including EPC procurement of all equipment and materials.
- Estimates are based on the assumptions and project scope described in this Report.
- Major Engineered Equipment: Budgetary quotes and in-house information from similar projects were utilized. BMcD solicited budgetary quotes from acceptable vendors for the following equipment supply packages and furnish and erection packages:
    - 5.2970 Field Erected Tanks
    - 5.3210 Raw Water Softening Treatment
    - 5.4560 Dampers (Furnish and Erection)
    - 5.8360 Fire Protection (Furnish and Erection)
- Construction Estimates: Construction commodities were estimated using recent pricing from similar projects, and budgetary vendor quotes. Quantify take-offs were performed for each discipline specific to this project.
- Labor Rates: Labor rates and productivity factors were provided by historical in-house data based on recently performed projects in the area.
- Project Indirects: Estimates are based on Burns & McDonnell's experience as an Owner's Engineer and executing EPC projects of similar scope.

8.4.3 Engineered Equipment

The equipment supply includes the procurement of all major equipment by the EPC. Refer to the Major Equipment List included in Attachment 22 for a listing of anticipated equipment and material supply contracts. The equipment supply cost includes the supply of specified equipment as well as the transportation cost to the site, technical field advisers, and training.

Equipment installation includes the receiving, initial inspection, and erection of all equipment, as well as the installation of vendor pipe supplied with the equipment. Productivity factors for the equipment

installation were derived from Burns & McDonnell past project information and construction rates for the project area.

8.4.3.1 Site Development / Foundations

The site civil, foundations, and site development scope is not included in this estimate. Foundation quantities necessary for the installation of equipment and materials associated with scope as defined in this Report have been developed by BMcD, but the construction costs associated with this scope will be included in the Fluor developed FEED estimate. Fluor will be responsible for not only the construction of the civil grading and site foundations, but will also be responsible for the following, but not limited to, construction laydown, trailer, and parking areas, on-site storm water management, and site finishes.

8.4.4 Structural Steel

Steel is included to support new equipment, enclosures, above grade branch lines of piping and cable tray within the water treatment area. Cable routed outside of the water treatment system footprint will be supported by Fluor's steel and cable tray.

Structural steel erection has been included for the erection of the new MRY1 and MRY2 flue gas isolation dampers and ductwork necessary for the tie-in to the new CCS facility.

Miscellaneous steel such as platforms, grating, handrail, stairs and ladders are included for structure access that is not otherwise provided as part of the equipment contracts.

The structural productivity rates, wage rates, and material pricing were based on BMcD previous project history for construction in the area.

8.4.5 Architectural

The architectural scope of work includes the supply and installation of pre-engineered buildings, roofing and siding of a custom engineered stick-built building. This also includes the supply and installation of primary and secondary framing, interior walls, plumbing, building insulation, windows, doors, flashing, gutters, and building finishes.

8.4.6 Paintings and Coatings

The painting scope includes field touch up painting of factory coated equipment to repair damage during construction as well as costs. The painting of the building steel is included in the architectural scope. Outdoor structural steel is hot-dip galvanized, not painted. Indoor structural steel is finished painted, if required. Pipe priming is assumed to be applied in the shop and estimated as material cost, with underground steel piping being coated for corrosion resistance.

8.4.7 Piping

The piping scope of work includes above and below ground piping supply and installation. Vendor supplied pipe is included in the equipment installation cost. The piping scope covers purchase of pipe, fittings, flanges, valves, specials, bolt-up kits, cathodic protection, supports, and pre-fabricated pipe. The piping scope of work does not include trenches (civil scope), freeze protection (electrical scope), insulation

(insulation scope); touch up painting (painting) or pipe labeling (painting). The piping scope of work does include applicable non-destructive evaluation (NDE), pre and post weld heat treatment (PWHT), and hydro testing if applicable.

The piping estimate was based on a takeoff from the general arrangement with P&IDs. Using these quantities, pricing for bulk material, valves, pipe fabrication was based on BMcD recent project pricing and budgetary quotes. The labor estimate was based on rates in the area.

8.4.8 Insulation

The insulation scope of work includes the installation of thermal, personnel protection, and freeze protection insulation. The insulation scope does not include any equipment insulation.

8.4.9 Electrical

The electrical scope includes installation of equipment in the Water Treatment Building, supply and installation of the below grade raceway (duct bank and buried conduit), cable tray and all required supports within the Water Treatment Building footprint, medium and low voltage cable systems, control, instrumentation and communications cable, lighting and convenience power, lightning protection and grounding systems, and freeze protection. Cable installation includes terminations, wire labels, cable tags, connectors, continuity testing, and Hi-Pot testing. Equipment includes the, Motor Control Centers (MCCs) and Switchgear, transformers, heat tracing, communications systems, and lightning protection.

The electrical estimate was completed using take off quantities that were derived from a combination of: historical equipment pricing, one-line drawings and the equipment layout.

8.4.10 Instrumentation & Controls

The instrumentation scope of work includes a mix of electrical and mechanical installation costs, including installation of balance of plant instrumentation and associated mechanical tubing required for proper installation. The instrumentation estimate was completed based on installation rates in conjunction with instrument take off quantities, historical instrument pricing, and system controller locations.

8.4.11 Demolition

The demolition scope of work includes the removal of the Lake Nelson Intake Pumps in the existing Lake Nelson Intake Pump Enclosure located at the MRY facility. Disposal cost of the pumps is not included.

8.4.12 Indirects

The following methods were used for indirects:

- The Construction Management (CM), Startup Management, and Construction Indirects were estimated based on the project field staffing plan, the project execution schedule, and project historical indirect costs. Also included are the CM staff expenses including travel, living expenses, and site offices.
- It is assumed builders risk insurance is provided by Owner.

- Detailed design and field engineering hours based on the project schedule, number of procurement packages, and project execution schedule.
- Start-up management and technicians based on project start-up execution.
- Escalation based on project schedule, including escalation of procured equipment costs.

8.4.13 Taxes

Sales and use tax are not included in the estimate.

8.4.14 Construction Labor Basis

The estimate was developed based on labor rates from RSMEANS as well as previous project history for construction in the area.

8.4.14.1 Labor Wage Rate & Expenses

Wage rates were taken from building trade contracts from previous work experience in the area. The wages range from $91 - $172 / hour inclusive of the following costs:

- Wages, Fringes, General Liability, Workers Compensation Insurance, and Overtime
- Small tools and consumables
- Temporary facilities
- Subcontractor Supervision
- Scaffolding
- Construction Equipment
- Per Diem
- Safety Incentives
- Subcontractor Performance Bond, Overhead Fee and Profit

8.4.14.2 Work Hours

The estimate assumes shifts are 50-hour work weeks with anything over 40 hours as premium time at 1.5 times the base wage rate to attract labor.

8.4.14.3 Labor Housing

The estimate is based on housing being available in the Project area (trailer parks, campgrounds, local housing, and local hotels).

8.4.14.4 Labor Per Diem

Craft per diem is include in the Labor Wage Rates and Expenses cost.

8.4.14.5 Retention Plan

Subcontracts will manage the labor turnover. No funds were added to the estimate for excessive labor turnover rate.

8.4.14.6 Escalation

Escalation was included at the following rates:

- Engineered Equipment – 3% per annum
- Construction Labor and Subcontracts – 4% per annum
- Materials - 3% per annum
- Indirects – 3% per annum

Escalation was included from March of 2021 to the point of construction for construction labor and equipment. Material was escalated to a point of approximately 6 months on average before the start of construction for each phase (civil, structural, mechanical, electrical, I&C).

8.4.15 Contingency

Project contingency is a means to quantify the unknown project risks and the level of confidence and accuracy of the estimate according to AACE guidelines for this level of project development. An amount of contingency is generally included to cover this inherent variance in final vs estimated project costs, assuming the project design basis remains constant. The quality and quantity of project specific equipment and material bids utilized, the detail of commodity take-offs, the degree of known labor installation efficiencies, etc., are all examples of factors that will influence the estimating uncertainty range. A Project contingency of 10% on total Direct and Indirect Cost is included in the base estimate.

MPC elected to use 13% for Owner's Costs contingency and 25% for EPC contingency (1) in part because of the level of execution planning called for in the scope of work for both Owner's Costs and EPC, but (2) primarily because of the supply chain and cost escalation issues that were beginning to appear in the market as the FEED study was concluding.

8.5 Owner's Costs

Owner's costs include all those expenses borne by the project owner that are not captured in Fluor's scope and cost estimate. Owner's costs do, however, include the BMcD costs ($73.3 MM) previously summarized in Section 8.4.1. Based on detailed analysis by MPC and its consulting team, Table 16 breaks down the estimated owner's costs.

Table 16. Estimated Owner's Costs (Non-Fluor Scope)

Cost Item	Amount	Notes
Project Management / Construction Management & Owner's Engineer	$19,938,000	Based on 42-month schedule
Operations & Startup	$7,095,659	Based on 42-month schedule
Spare Parts	$10,365,000	
RUS / American Vessels	$1,000,000	
License Fee	$10,000,000	
Insurance	$6,640,000	

Warranty and Upgrade	$500,000	
Water Supply and Treatment	$36,687,569	
Wastewater	$5,000,000	
Drainage	$300,000	
Power Supply	$4,932,774	
Controls & Internet	$250,300	
Services	$24,131,000	
LNTP Activities	$8,696,000	
Owner Facilities	$2,208,800	
Miscellaneous	$35,555,000	
Base Total Owner's Cost	$173,300,102	
Contingency on Owner's Cost	$22,574,054	13%
EPC Contingency	$356,250,997	25%
Escalation (Owner's Cost Only)	$4,159,202	Based on 40% of OC @ 2% for 3 years
TOTAL Owner's Cost	**$556,284,355**	

8.6 Operating Expenses

Total auxiliary load for the capture system is provided in Table 17.

Table 17. Total thermal and electrical auxiliary loads

Source	Auxiliary Load	Unit
Thermal	37,124	MMBtu/day (natural gas input)
Blower	7.8	MW_e
Capture Plant	14	MW_e
Compression	44.4	MW_e
Cooling Tower	8.2	MW_e
Flue Gas Conditioning	5.5	MW_e
Misc.	0.4	MW_e
Natural Gas Boilers	3	MW_e
Total Electrical Load	83.3	MW_e

Operating expenses (OPEX) per ton of CO_2 captured were broken down into categories, as shown in Table 18 (2021 dollars).

The variable costs (VAR) consist of the EFG+ Solvent, Caustic Soda for the SO_2 scrubber, TEG for the dehydration system, disposal costs for the reclaimed solvent, water treatment chemicals, cooling tower chemicals, water make-up costs, water disposal costs, and miscellaneous annual testing for the CCS plant. These costs were estimated using annual consumption rates provided by Fluor and BMcD.

Labor costs were estimated using current MPC operator costs and assuming one control room operator per shift, one assistant control room operator per shift. In addition, there were several day-shift only employees for maintenance and management support for the CCS plant.

MPC services costs included raw water treatment, waste water disposal, security for the site post construction, and other capital and operating modifications to existing infrastructure required for the addition of the CCS plant.

Power costs were based on typical power purchase agreement terms for firm retail service with a capacity credit for the value of a limited number of hours per year when the CCS load could be curtailed by MPC during grid emergencies.

The natural gas line item was calculated assuming a cost of $2.85 per MMBTU and the heat rate for the package boilers.

The remaining expenses of G&A, misc, and insurance were estimates from MPC based on the overall project size.

Table 18. Estimated project OPEX per short ton CO_2 captured

Cost Category	Amount (2021)
VAR	$4.02
Labor	$0.54
MPC Services	$1.79
Power	$4.46
Natural Gas	$7.7
MPC G&A	$0.06
Misc.	$0.05
Insurance	$0.04
Total per ton CO_2 captured	$18.66

8.7 Summary of Total Project Costs

Total estimated capital costs are provided below:

- CCS Plant - $745MM (provided by Fluor)
- CCS BOP - $330MM (provided by Fluor)
- Project Tundra Specific Requirements (provided by Fluor)
    - Earth Works Associated with Carbon Capture - $85MM
    - Impurity Removal Package - $56MM
    - Enclosures / Buildings - $79MM
    - Regional Adjustment for Labor - $87MM
- Owner's Costs - $556MM (provided by BMcD, MPC & Golder)
- **TOTAL PROJECT CAPEX - $1,938MM**

Based on the above CAPEX estimate and the OPEX estimate provide in Section 8.6, the cost of CO_2 capture was calculated:

- $20.57/metric ton based only on operating costs (un-escalated 2021 dollars)
- $78.46/metric ton for the "breakeven CO_2 value" (levelized over life of project)
- $80.60/metric ton for the "breakeven CO_2 emissions penalty" (levelized over life of project)

The calculation methods are summarized below.

Following the guidelines in NETL's Cost Estimation Methodology for NETL Assessments of Power Plant Performance (February 2021), the Tundra capital cost estimate breaks down in the following categories:

Bare Erected Cost (BEC)	Equipment, Materials, Direct and Indirect Labor, Site Prep, Roads, Davis-Bacon	$821,450,052
Engineering, Procurement, and Construction Cost (EPCC)	BEC, Engineering and Design, Permits, Construction Management	$1,148,531,062
Total Plant Cost (TPC)	BEC, EPCC, Design Margin, Escalation, Contingency, Fee	$1,476,597,448
Total Overnight Cost (TOC)	BEC, EPCC, TPC, Owner's Costs	$1,939,295,272
Total As-Spent Capital (TASC)	BEC, EPCC, TPC, TOC, Escalation	$2,020,026,601

For the purposes of the FEED study, the construction period for Tundra was assumed to be October 2022 through June 2026 – approximately 44 months including start up, commissioning, and testing. The cash flow over that period was estimated to be typical of a large capital-intensive construction project peaking in months 27 through 36 leading up to mechanical completion in month 41. Figure 12 shows both monthly and cumulative capital expenditure at the TASC level.

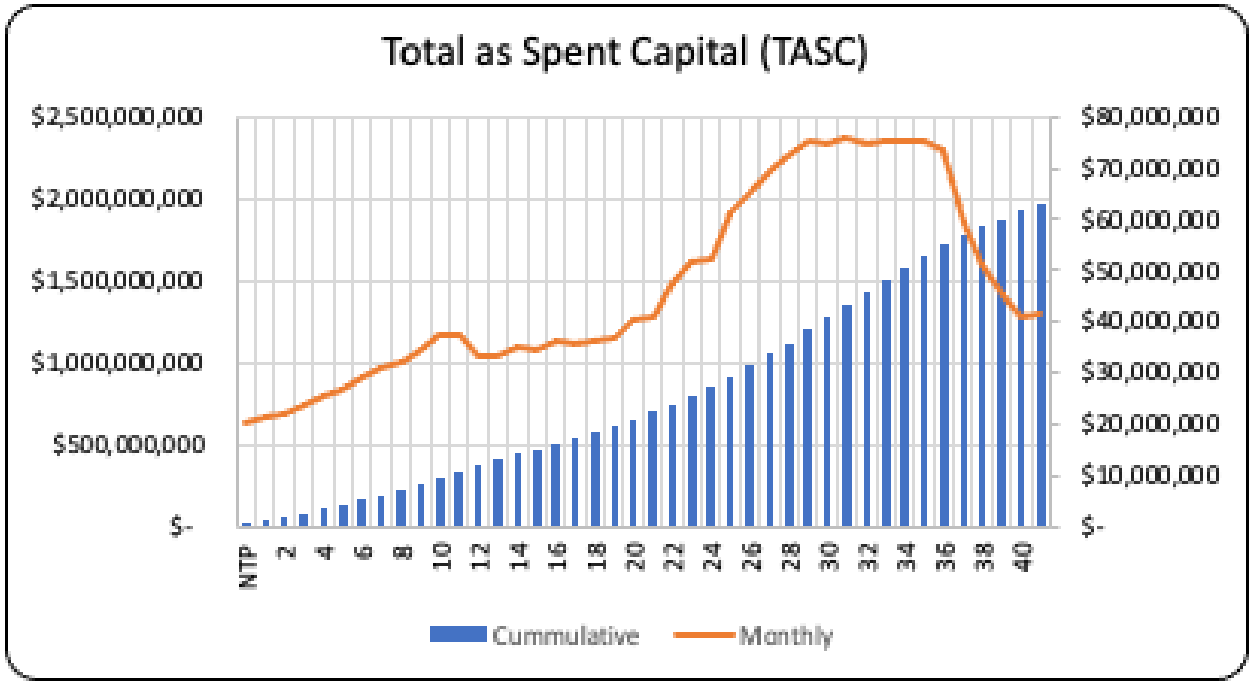


Figure 12. Monthly and cumulative total as spent capital

Using the TASC for capital and $20.57 per metric ton for O&M, the "Breakeven CO_2 Value" for project Tundra is $78.46 per metric ton of CO_2 captured, compressed, and dehydrated at the fence line. The "Breakeven CO_2 Emissions Penalty" is $80.60 per metric ton since the levelized cost of CO_2 transport and

storage for Tundra is $2.14 per metric ton. Compared to the levelized estimated 45Q tax credits of $59.93 per ton (assuming 45Q at $50/ton in 2026) that leaves a $20.67/ton shortfall for breakeven if the owners of Tundra are able to "self-monetize" the tax credits and avoid paying fees to tax equity providers for the monetization service. It should be noted that the Breakeven CO_2 Value and the Breakeven CO_2 Emissions Penalty calculations assumed that since steam, electricity, and other commodities provided to Tundra by the host power plant are paid for by Tundra at full market value, there is no economic impact to the host power plant, and therefore the term "$LCOE_{non\ CCS}$" used in NETL's Cost Estimate guidance is equal to zero.

9 ESTIMATED PROJECT SCHEDULE

9.1 Fluor's Scope

The project generated a Level 1 (Management Summary) Engineering, Procurement, Construction and Commissioning (EPCC) schedule to support the execution of the project going forward. For the phases mentioned (EPCC) the total duration is 47 months. Based upon the current execution approach, time has been allowed prior to the start of Detailed Engineering for Fluor to improve the Capital Cost Estimate accuracy, and for MPC to obtain project financing. Procurement of all equipment and materials including long lead and critical equipment, occurs after project award. There has also been time allotted after the commissioning of the facility to startup the plant and conduct the performance testing of the facility. This entire sequence of activities is depicted in Attachment 16.

9.2 BMcD's Scope

The project schedule is designed to integrate into the CCS plant schedule. The design and procurement durations are indicative to support civil and structural foundations that will be designed by BMcD, but Fluor will perform the construction under their civil/foundations subcontract. Start-up and commissioning will be performed to support the CCS start-up and commissioning process. The schedule reflects an EPC contracting approach. The dates listed in the schedule provided in this report are consistent with initial MPC schedule targets. If start of construction date ultimately is delayed, this schedule will need to be delayed accordingly. Attachment 17 includes the Level 1 schedule for the water treatment plant.

9.2.1 EPC Project Execution

9.2.1.1 Engineering & Procurement

An engineering timeframe has been included in the project schedule that supports issuing construction documents that are 100% complete at construction contract award to minimize rework and revisions in the field. Procurement packages, primarily those with equipment critical to the water treatment building, are being issued to support the underground design package that will be executed by Fluor and its sub-contractors.

Critical path for the Project will be through the design and award of the Unit 2 flue gas damper to erect and install the flue gas damper system during the Fall 2022 Unit 2 outage. The flue gas dampers will be designed to allow for continuous operation of the MRY station while construction of the CCS facility commences.

9.2.1.2 Construction

Construction is planned to begin in November of 2022 with the performance of the construction facilities, site prep, and underground design packages from Fluor. To support a target completion date of the water treatment scope of the Project by November of 2023, completion of the underground installation will need to be completed by April of 2023.

The Water Treatment building will be designed and erected for panel and siding leaveouts to provide adequate access for piping and equipment installation. Building cranes and hoists have been provided to assist in constructability of internal components within the building.

The damper supplier will be responsible for the supply and erection of the Unit 1 and Unit 2 dampers. The supplier will require two mobilizations for the erection of the dampers to align with Unit 1 and 2 outages at the MRY facility. Erection for the dampers will be performed on the ground prior to the outage window, with only the tie-in to be completed during the outage windows.

Schedule margin has been included to compensate for project delays and possible differences in quoted equipment supply.

9.2.1.3 Start-up and Commissioning

Preliminary startup and commissioning activities will be performed using construction power fed from the existing substation. The Plant electrical and mechanical systems will be commissioned in a sequence to support providing utility service to the CCS facility for start-up and commissioning activities, and sequencing to not interrupt operation of the MRY operational units.

10 RECOMMENDATIONS AND FUTURE WORK

The FEED study performed by Fluor from April 2020 through December 2021 identified several potential project cost reduction opportunities. One such opportunity is to change the CCS steam supply from new natural gas boilers to steam extraction from the existing Unit 2 and Unit 1 lignite-fired generating units. The base case design of the Project Tundra CCS is sized to process 100% of the flue gas from Unit 2 in addition to the flue gas from new natural gas-fired boilers and results in a design capacity of 12,978 short tons of CO_2 per day. The elimination of new natural gas boilers will free up flue gas-processing capacity over and above the amount produced by Unit 2. Discussions with environmental regulators have confirmed that flue gas from Unit 2 can be commingled with a portion of flue gas from Unit 1 during normal operations and then processed together in the CCS. MPC has, therefore, recently decided to utilize the current design capacity to process 100% of the flue gas from Unit 2 and a portion of flue gas from Unit 1. Preliminary evaluation of the extraction steam capabilities of the Unit 2 STG indicated that Unit 2 steam extraction alone will not provide enough steam for the CCS at full load during summer periods of high STG condenser backpressure.

Preliminary evaluation of the extraction steam capability from Unit 1 indicated that combining extraction steam from both Units 2 and 1 will be able to make up the apparent steam deficit with the added benefit of maintaining operational flexibility for the station.

Elimination of the natural gas boilers has the benefit of 1) allowing the project to reduce the plot plan which has significant capital cost savings, 2) eliminating a new 25-mile natural gas pipeline which has significant operating cost savings and 3) eliminating the price risk and cost of purchasing natural gas.

The next step in this project is to conduct the final body of the study and engineering work needed to produce Construction Ready Engineering, Schedule and pricing Terms (CREST). The CREST work will include a) detailed steam turbine modeling for steam supply to carbon capture; b) designing the systems, piping, and structures needed for steam integration; c) engineering for the other impacts of a change in steam supply strategy; d) design integration of optimization ideas that are aimed at reducing the projected cost of carbon capture; and e) a more detailed emissions analysis of lignite flue gas. These combined elements will support a possible start of construction for Project Tundra by the end of 2022. This task is needed to a) more fully determine the extraction steam capabilities from Unit 2 and Unit 1, b) evaluate any structural or mechanical issues that must be addressed in extraction system design, c) evaluate the combining of extraction steam from the two units along with control and monitoring of the steam delivery to the CCS, d) evaluate seasonal steam condensate return conditions and the impact on the STG condensers, and e) identify operational impacts caused by extraction in both the host coal units and the CCS that need to be addressed in detailed design. Major tasks for the CREST study were identified as follows.

10.1 Steam Extraction Studies, Steam Supply to CCS Design, Impact of Steam Extraction on Existing MRY Facilities and Operations

The subtasks associated with this effort are as follows.

10.1.1 Siemens Unit 2 Steam Turbine Thermal Modeling and Evaluation of Modifications Required

Preliminary evaluation of the extraction steam capabilities for Unit 2 identified no fatal flaws. Further study is required, however, to first confirm preliminary results and then to develop design parameters that would allow safe and efficient steam extraction from the Siemens STG associated with Unit 2. These evaluations are required to ensure that sufficient steam is available at the required temperature and pressure for use in the CCS while also ensuring operational integrity of the Unit 2 Siemens STG.

10.1.2 General Electric Unit 1 Steam Turbine Thermal Modeling and Evaluation of Modifications Required

As noted above, the extraction steam capacity on Unit 2 alone identified a potential shortfall in steam to process 12,978 short tons of CO_2 per day. After evaluating alternative steam source possibilities, it was decided to investigate the use of Unit 1 extraction steam to make up for the shortfall in steam when processing flue gas at the full capability of the CCS. Preliminary evaluation of the extraction steam capabilities of Unit 1 identified no fatal flaws; however, further study is required to 1) confirm preliminary results and 2) develop design parameters that would allow safe and efficient use of extraction steam from the GE STG associated with Unit 1. These evaluations are required to ensure that sufficient steam is available at the required temperature and pressure for use in the CCS while also ensuring operational integrity of the Unit 1 GE STG.

10.1.3 Evaluation of Unit 2 and Unit 1 Commercial Operation and Environmental Impacts Resulting from the Use of Extraction Steam for CCS Operation

The implementation of steam extraction from Unit 2 and Unit 1 will have commercial operation implications for the MRY facility. As part of the economic evaluation of the use of steam extraction, the impact to commercial operation of MRY must be determined and quantified. It must also be verified that there are no potential impacts on MRY's existing permits and operating authorization. The thermal modeling described in the STG evaluation tasks above will provide the information needed to then detail the performance impacts of extraction on the MW output and operating characteristics of MRY. The commercial operation impacts must be evaluated (along with confirmation of no permit impacts) in order to provide a full understanding of the cost and the value of extraction steam.

10.2 Impurity Removal Package Pilot Testing

During the FEED study and other prior NDIC-funded research, MRY flue gas characterization was performed that provided flue gas particulate count and speciation data that were used by Fluor to estimate emission rates for the CCS system. Based on the data gathered during those short investigations, Fluor indicated that because of remaining uncertainty regarding the amount of particulate in the flue gas, a Impurity Removal Package would likely be required to ensure that CCS emissions would be at acceptable levels. The flue gas quality uncertainty can be eliminated and, therefore, a potential large capital and operating cost reduction realized, if more structured and engineered pilot testing of a small-scale Impurity Removal Package on actual MRY flue gas was conducted. Such a pilot-scale test would allow engineers to determine if the Impurity Removal Package is really needed and, if so, the design requirements for particulate removal, overall system sizing, and utility consumption.

This task is intended to repeat the flue gas characterization testing with a fully manned test station to ensure continuous and accurate data collection from a pilot-scale Impurity Removal Package and associated pilot-scale flue gas pretreatment system. The results of the pilot testing will be used to determine whether an Impurity Removal Package is needed and, if so, develop specifications for a full-scale Impurity Removal Package system for the project.

Three potential vendors for Impurity Removal Package have been identified that can build and supply a unit at the scale required for Project Tundra. After a technology review conducted with Fluor during the FEED, two candidate vendors were recommended for this pilot testing task.

10.3 Evaluation of Existing Water Supply, Disposal, and Treatment Equipment and Integration of Additional Water Treatment Capacity into MRY to Support CCS

One of the FEED study deliverables was to identify the boundary between the CCS equipment and systems that will be supplied by MRYS. Water supply and water treatment were identified as best provided by MRYS as a part of the owner's scope. A new water supply and treatment system was designed by MPC based on preliminary water requirements information provided by Fluor. As the FEED design progressed to completion, refined water supply requirements were developed by Fluor and resulted in somewhat reduced water supply requirements that impact the amount of water needed and a smaller treatment system design. After the conclusion of the FEED, MPC conducted a preliminary assessment of MRYS's existing water supply and treatment system and determined that rather than building a new treatment system,

modification to the existing water plant system is feasible and has the potential to provide significant project cost savings. Elimination of a new and separate water treatment system eliminates the water treatment building from the plot plan and allows for a significant reduction in project plot area, elimination of a whole building enclosure, and an opportunity for additional reduction in water treatment cost.

This task is intended to perform a detailed evaluation of the existing water supply and treatment system, identify modifications to existing equipment, integrate additional water treatment equipment into existing systems, and provide cost estimates for same.

10.4 Evaluation of Value Engineering and Cost Reduction Opportunities Identified in FEED Study

The FEED study performed by Fluor from April 2020 through December 2021 identified over 70 potential value engineering and cost reduction opportunities in addition to the steam extraction opportunity described above. The potential cost reduction items identified can reduce the CCS portion of the project cost by an estimated $100 MM to possibly $350 MM. The value of the identified cost reduction items is based on a rough order magnitude (ROM) estimating approach. In order to properly evaluate the technical, operational, and commercial impacts of these identified cost reduction items, the Project Tundra team will need to perform additional design, engineering, and evaluations of any operational impacts.

This task will evaluate the feasibility of value engineering and potential cost reduction opportunities, modify the current CCS design, estimate the actual cost reduction potential of each opportunity, and incorporate into the final project design any item that improves the economics of Project Tundra.

10.5 Analysis of the Potential Impacts of Ductwork Pressure Transients When Treating Flue Gas from Multiple Lignite-Fired Boilers under Various Operating Scenarios

As described above, flue gas from both Unit 2 and Unit 1 will be mixed prior to introduction into the CCS for processing. In the base case (with extraction steam) the CCS design capacity will be used to process 100% of the flue gas from Unit 2 and a portion of flue gas from Unit 1. Although the ability to mix the flue gases from both Unit 2 and Unit 1 will require additional emission monitoring equipment for proper accounting, it will provide the opportunity for greater flexibility in MRY operations. If either Unit 2 or Unit 1 needs to reduce output, the ability to deliver more flue gas from the other unit will maximize the quantity of CO_2 captured and sequestered each year.

The flue gas systems in the MRY facility and the CCS include several large horsepower fans that have the potential to damage the flue gas ductwork during transient conditions. This will require the design of protection systems that will prevent overpressure or underpressure in the ductwork system. The ductwork protection system will need to coordinate the operation of all fans and ductwork dampers as well as any protection devices in both the CCS as well as those in the MRY units.

The first step in this task will be to create a computer model of the ductwork, damper, and fans in the entire system to evaluate many possible operating and upset condition scenarios. The model will allow evaluation of ductwork pressure transients when treating flue gas from single or multiple lignite-fired boilers under many possible operating scenarios. In this task, the Project Tundra team will also identify ductwork

protection requirements, create specifications, write a detailed protection system description, and produce cost estimates which can then be used by multiple project design disciplines.

10.6 Absorber, Absorber Stack Damper, CO_2 Vent System and Cooling Tower Icing Studies, and Evaluation of Heat Tracing Requirements and Cold-Weather Protection Requirements

The location of MRYS provides unique and severe seasonal variations in weather that must be addressed in the detailed design of the CCS. The use of a wet polishing scrubber (DCC) in the CCS means the absorber flow stream will be saturated with water as it exits the top of the absorber through the vent. Also, the CCS design includes a wet cooling tower for cooling of CCS process streams. The cooling tower air discharge is also typically saturated with water. These wet flow streams present significant design challenges to allow for safe operation in cold weather while providing adequate and efficient cooling in the summertime.

In cold weather, these wet flow streams will condense water vapor that has the potential to form ice on the vent stack and on cold structures adjacent to the cooling tower. This potential for icing has significant structural consequences that must be addressed in design. In addition, there are safety of personnel and safety of operations concerns because of the potential for large quantities of ice to build up and fall from height, potentially injuring personnel and damaging equipment. Icing mitigation strategies and protection requirements must be addressed before detailed design of the facility can commence. An icing model for the absorber and absorber stack damper were developed during the FEED that identified several areas of concern. With the changes in orientation and location of the buildings and the large CCS vessels because of the elimination of the natural gas boilers and the water treatment building, this model needs to be updated with information from the new plot plan described above and reevaluated to determine the icing potential of the cooling tower, absorber stack, absorber stack damper, surrounding equipment, personnel access areas, and adjacent buildings. One common icing mitigation strategy is the use of electrical or steam heat tracing to mitigate or prevent damaging levels of ice formation. Icing mitigation in other areas of the CCS facility and adjacent interconnecting facilities must also be evaluated to ensure safety of personnel and equipment. Anywhere in the plant where there is a potential for damaging or unsafe levels of icing, the use of heat tracing must be evaluated.

This task will model, evaluate, and develop detailed requirements and cost estimates for cold-weather operation of the absorber, absorber stack damper, CO_2 vent system, cooling tower, and other areas of the CCS and evaluate mitigation strategies, including heat tracing and other options.

10.7 Gaseous Dispersion Modeling to Support Revisions in Permitting Parameters and Evaluation of Safety of Operations due to Change in Steam Supply Source

The change in steam supply to the CCS from natural gas boilers to steam extraction from the MRY STGs likewise removes the flue gas emissions from the natural gas boilers that would have been processed together in the CCS. The extraction steam supply decision has, therefore, altered the expected characteristics of the flue gas which is now different from what was assumed in the FEED study. Further, the extraction decision has led to elimination of some buildings and rearrangement of many of the large structures. These changes require that the gaseous dispersion modeling needed for permitting of the CCS be revised and rerun using the new locations and conditions. Dispersion modeling also needs to be redone

to evaluate safety of operations associated with upset conditions where high-pressure CO_2 must be vented for safety.

This task will develop and evaluate gaseous dispersion models for the new flue gas and CO_2 emission points at various operating conditions.

10.8 Development of Project Contract Attachments to Define Construction Scope of Work, Project Specifications, Guarantees, and Testing Requirements

With the completion of the FEED, there is a well-developed and near final set of design and specifications for Project Tundra. In order to move into the construction phase, those designs and specifications are needed to develop project-specific documents that describe in detail what the EPC contractor (Fluor) will build and how it will build it, including the following documents: scope of work, project specifications, operations manuals, milestone schedules, subcontractor documents, guarantees, performance standards, and testing requirements.

This task will develop project-specific documents that conform to and describe the specific project requirements that will form the basis of a "ready for execution" construction agreement.

10.9 Evaluation of Existing Structural Components for Impacts Related to Project Implementation

The FEED study identified routes for flue gas ductwork, piping, and electrical that made use of existing structures for support of BOP services to interconnect the MRY facility to the CCS.

It is envisioned that building structural steel (internal and external) will be used to the greatest extent possible to support STG extraction piping, return condensate, electrical and instrumentation wires and associated equipment, flue gas ductwork, and other miscellaneous equipment needed to interconnect MRY systems with the CCS. In some instances, existing structural steel must be relocated to accommodate rerouting of heavy haul roads for coal and ash trucks because of the location of CCS facilities. This task will evaluate existing structural steel for strength to bear new loads and forces and relocation to accommodate new traffic routes and then produce preliminary designs, modification plans, specifications, and cost estimates for use and/or relocation of existing structural elements for Project Tundra.

ATTACHMENT 1 – PROCESS FLOW DIAGRAMS

CCS-DM-101 UNIT 1 ISOLATION DAMPER | CCS-DM-102 UNIT 2 ISOLATION DAMPER | CCS-DM-103 BOILER PACKAGE ISOLATION DAMPER | CCS-DU-101 DCC INLET DUCTING SYSTEM | CCS-P-102A/B DCC SCRUBBING SOLUTION PUMP | CCS-C-101 DIRECT CONTACT COOLER | CCS-DU-102 DCC OUTLET DUCT | CCS-P-101A/B DCC WATER PUMP | CCS-F-101A/B DCC WATER FILTER | CCS-E-101 DCC WATER COOLER

B.L.

BLOWDOWN
OSBL
INTERMITTENT
110

BLOWDOWN
M1NN-CCS-DWG-225-02201
FROM IMPURITY REMOVAL PACKAGE (CCS-PK-201)
INTERMITTENT

20 WT% NaOH
M1NN-CCS-DWG-225-02501
FROM DCC NaOH INJECTION PUMP (CCS-P-504A/B)
112
INTERMITTENT

FLUE GAS
M1NN-CCS-DWG-225-03702
FROM BOILER PACKAGE (CCS-PK-702)
102

CCS-DM-103

FLUE GAS
OSBL
FROM MRY UNIT 1
NNF

CCS-DM-101

FLUE GAS
OSBL
FROM MRY UNIT 2
101

CCS-DM-102

CCS-DU-101

CCS-P-102A/B

CCS-C-101

CCS-DU-102

FLUE GAS
M1NN-CCS-DWG-225-02201
TO BLOWER (CCS-BL-201)

DCC WATER
M1NN-CCS-DWG-225-02501
TO NaOH DILUTION MIXER (CCS-MX-501)
INTERMITTENT

CCS-E-101
CWS
CWR

CCS-P-101A/B

CCS-F-101A/B

DCC EXCESS WATER
M1NN-CCS-DWG-225-03701
TO COOLING TOWER BASIN (CCS-X-701)
1007

NOTES:

1. ABBREVIATIONS:
   - BL : BATTERY LIMITS
   - CWR : COOLING WATER RETURN
   - CWS : COOLING WATER SUPPLY
   - OSBL : OUTSIDE BATTERY LIMITS
   - NNF : NORMAL NO FLOW

LEGEND:

◇ STREAM NUMBER

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REFERENCE DWG NUMBER	REFERENCE DRAWINGS
0	N/A	ISSUED FOR REPORT	MI	KA	SR								

FLUOR®
CONTRACT M1NN

CONTRACT	M1NN	
DESIGNED BY	M. ITO	
CHECKED BY	K. AFSHAR	
SUPERVISOR	S. REDDY	APP DATE
LEAD ENGR/SPEC.	K. AFSHAR	APP DATE
FLUOR	R. GRAEBE	APP DATE
CLIENT	D. WOLF	APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA
CARBON CAPTURE AND SEQUESTRATION

PROCESS FLOW DIAGRAM
ECONAMINE FG PLUS℠ PROCESS
FLUE GAS COOLING AND CONDITIONING

SCALE	DRAWING NUMBER	REV
NONE	M1NN-CCS-DWG-225-02101	0

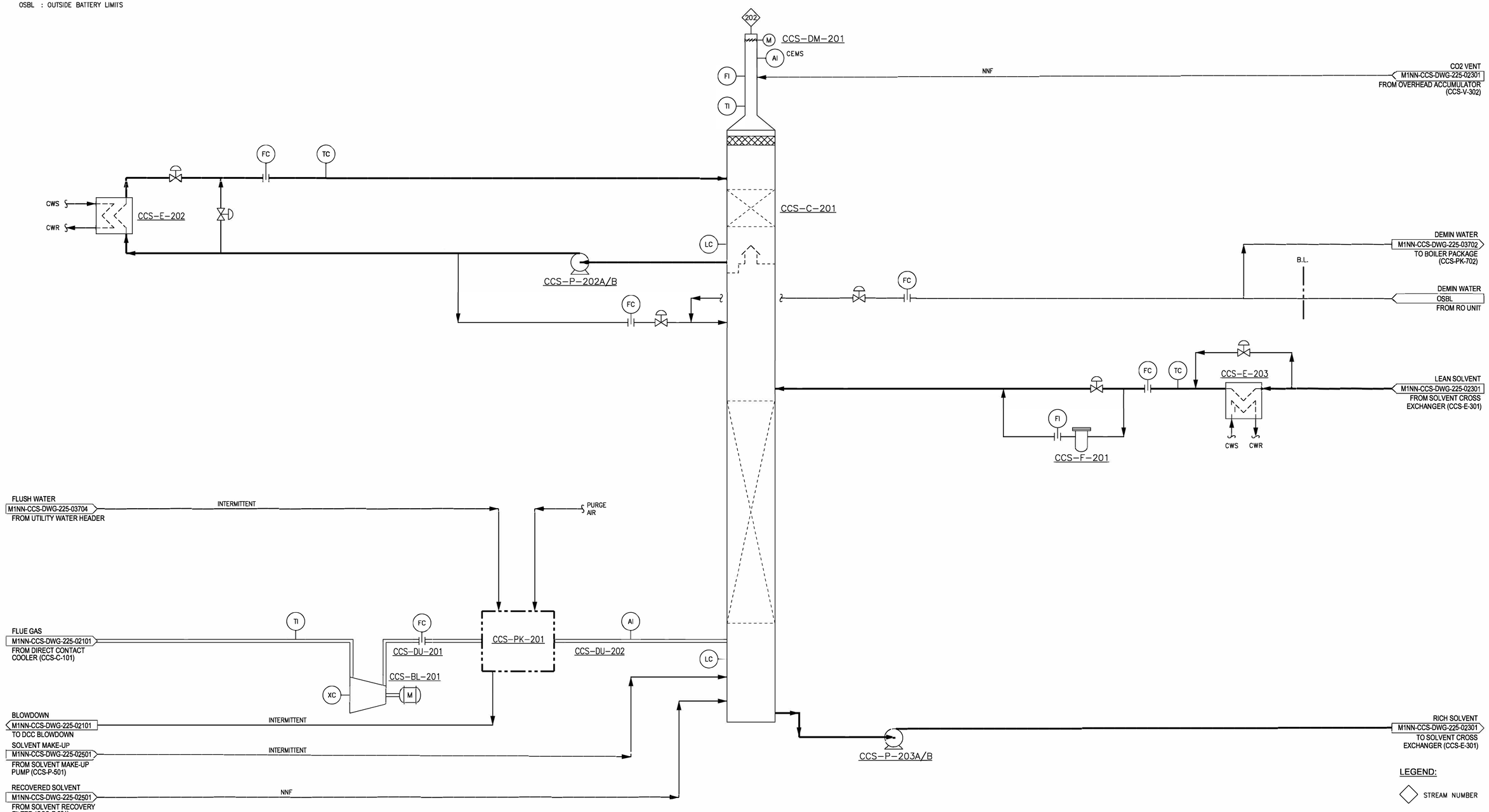
CAD FILE NAME M1NN-CCS-DWG-225-02101.dwg

F-022.DWG 01JUL09

NOTES:

1. ABBREVIATIONS:
   BL : BATTERY LIMITS
   CWR : COOLING WATER RETURN
   CWS : COOLING WATER SUPPLY
   NNF : NORMALLY NO FLOW
   OSBL : OUTSIDE BATTERY LIMITS

CCS-E-202 ABSORBER WASH WATER COOLER | CCS-BL-201 BLOWER | CCS-PK-201 **IMPURITY REMOVAL PACKAGE** | CCS-DU-201 BLOWER OUTLET DUCT | CCS-DU-202 ABSORBER INLET DUCT | CCS-P-202A/B ABSORBER WASH WATER PUMP | CCS-DM-201 ABSORBER STACK DAMPER | CCS-C-201 ABSORBER | CCS-P-203A/B RICH SOLVENT PUMP | CCS-F-201 LEAN SOLVENT FILTER | CCS-E-203 LEAN SOLVENT COOLER



LEGEND:

◇ STREAM NUMBER

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REFERENCE DWG NUMBER	REFERENCE DRAWINGS
0	N/A	ISSUED FOR REPORT	MI	KA	SR								

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CONTRACT M1NN

CONTRACT	M1NN	
DESIGNED BY	M. ITO	
CHECKED BY	K. AFSHAR	
SUPERVISOR	S. REDDY	APP DATE
LEAD ENGR/SPEC.	K. AFSHAR	APP DATE
FLUOR	R. GRAEBE	APP DATE
CLIENT	D. WOLF	APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA

CARBON CAPTURE AND SEQUESTRATION

PROCESS FLOW DIAGRAM ECONAMINE FG PLUS℠ PROCESS CO2 ABSORPTION

SCALE	DRAWING NUMBER	REV
NONE	M1NN-CCS-DWG-225-02201	0

CAD FILE NAME M1NN-CCS-DWG-225-02201.dwg

F-022.DWG 01JUL09

CCS-E-301 SOLVENT CROSS EXCHANGER

CCS-P-301A/B LEAN SOLVENT PUMP

CCS-C-301 STRIPPER

CCS-E-303 CONDENSER

CCS-P-302A/B REFLUX PUMP

CCS-V-302 OVERHEAD ACCUMULATOR

CCS-E-302 REBOILER

CCS-V-303 REBOILER CONDENSATE DRUM

CCS-P-303A/B REBOILER CONDENSATE PUMP

CCS-DS-301 REBOILER STEAM DESUPERHEATER

NOTES:

1. ABBREVIATIONS:
   BL : BATTERY LIMITS
   CWR : COOLING WATER RETURN
   CWS : COOLING WATER SUPPLY
   IGV : INLET GUIDE VANES
   MP : MEDIUM PRESSURE
   OSBL : OUTSIDE BATTERY LIMITS

CO2 VENT
M1NN-CCS-DWG-225-02201
TO ABSORBER STACK (CCS-C-201)

NNF

CWR CWS

CCS-E-303

PC

LOW PRESSURE CO2
M1NN-CCS-DWG-225-02601
TO CO2 PRODUCT COMPRESSOR (CCS-K-601)

LC

CCS-V-302

FC

CCS-P-302A/B

RICH SOLVENT
M1NN-CCS-DWG-225-02201
FROM RICH SOLVENT PUMP (CCS-P-203A/B)

FC

CCS-E-301

TC

4

1

TC

CCS-C-301

LEAN SOLVENT
M1NN-CCS-DWG-225-02201
TO LEAN SOLVENT COOLER (CCS-E-203)

RECOVERED SOLVENT
M1NN-CCS-DWG-225-02401
FROM SOLVENT MAINTENANCE SYSTEM (CCS-PK-401)

PROCESS CONDENSATE
M1NN-CCS-DWG-225-02601
FROM PROCESS CONDENSATE PUMP (CCS-P-601A-D)

LC

CCS-E-302

FC PC TC

CCS-DS-301

MP STEAM
M1NN-CCS-DWG-225-03702
FROM BOILER PACKAGE (CCS-PK-702)

STEAM CONDENSATE
M1NN-CCS-DWG-225-02401
FROM SOLVENT MAINTENANCE SYSTEM (CCS-PK-401)

CCS-V-303

LC

LEAN SOLVENT
M1NN-CCS-DWG-225-02401
TO SOLVENT MAINTENANCE SYSTEM (CCS-PK-401)

STEAM CONDENSATE
M1NN-CCS-DWG-225-03705
TO GLYCOL WATER HEATER (CCS-E-711)

CCS-P-303A/B

CCS-P-301A/B

LEGEND:

◇ STREAM NUMBER

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REFERENCE DWG NUMBER	REFERENCE DRAWINGS
0	N/A	ISSUED FOR REPORT	MI	KA	SR								

FLUOR®

CONTRACT M1NN

CONTRACT	M1NN	
DESIGNED BY	M. ITO	
CHECKED BY	K. AFSHAR	
SUPERVISOR	S. REDDY	APP DATE
LEAD ENGR/SPEC.	K. AFSHAR	APP DATE
FLUOR	R. GRAEBE	APP DATE
CLIENT	D. WOLF	APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA

CARBON CAPTURE AND SEQUESTRATION

PROCESS FLOW DIAGRAM ECONAMINE FG PLUS℠ PROCESS SOLVENT REGENERATION

SCALE	DRAWING NUMBER	REV
NONE	M1NN-CCS-DWG-225-02301	0

CAD FILE NAME M1NN-CCS-DWG-225-02301.dwg

F-022.DWG 01AUG19

CCS–PK–401
SOLVENT MAINTENANCE
SYSTEM

CCS–TK–401
SPENT SOLVENT TANK

CCS–H–401
SPENT SOLVENT
TANK HEATER

NOTES:

1. ABBREVIATIONS:
   - BL : BATTERY LIMITS
   - CWR : COOLING WATER RETURN
   - CWS : COOLING WATER SUPPLY
   - MP : MEDIUM PRESSURE
   - NNF : NORMALLY NO FLOW
   - OSBL : OUTSIDE BATTERY LIMITS

MP STEAM
M1NN-CCS-DWG-225-03702
FROM BOILER PACKAGE
(CCS-PK-702)

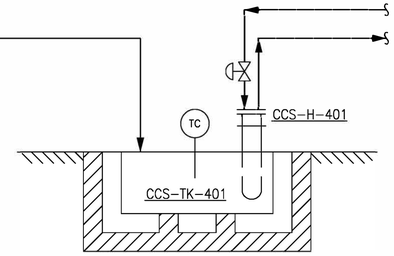
STEAM CONDENSATE
M1NN-CCS-DWG-225-02301
TO REBOILER CONDENSATE
DRUM (CCS-V-303)

LEAN SOLVENT
M1NN-CCS-DWG-225-02301
FROM STRIPPER
(CCS-C-301)

CCS–PK–401

FREE DRAINING

RECOVERED SOLVENT
M1NN-CCS-DWG-225-02301
TO STRIPPER (CCS-C-301)



LEGEND:

◇ STREAM NUMBER

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REFERENCE DWG NUMBER	REFERENCE DRAWINGS
0	N/A	ISSUED FOR REPORT	MI	KA	SR								

FLUOR®
CONTRACT M1NN

CONTRACT	M1NN	
DESIGNED BY	M. ITO	
CHECKED BY	K. AFSHAR	
SUPERVISOR	S. REDDY	APP DATE
LEAD ENGR/SPEC.	K. AFSHAR	APP DATE
FLUOR	R. GRAEBE	APP DATE
CLIENT	D. WOLF	APP DATE

MINNKOTA POWER COOPERATIVE
PROJECT TUNDRA
CARBON CAPTURE AND SEQUESTRATION
PROCESS FLOW DIAGRAM
ECONAMINE FG PLUS℠ PROCESS
SOLVENT MAINTENANCE

SCALE	DRAWING NUMBER	REV
NONE	M1NN–CCS–DWG–225–02401	0

CAD FILE NAME M1NN-CCS-DWG-225-02401.dwg

F-022.DWG 01JUL09

NOTES:

1. ABBREVIATIONS:
   BL : BATTERY LIMITS
   OSBL : OUTSIDE BATTERY LIMITS
   NNF : NORMALLY NO FLOW
   TEG : TRIETHYLENE GLYCOL

2. TANK REQUIRES SELF-REGULATING EXTERNAL ELECTRIC TRACING.

CCS-P-504A/B DCC NaOH INJECTION PUMP
CCS-P-501 SOLVENT MAKE-UP PUMP
CCS-TK-504 20 WT% NaOH STORAGE TANK
CCS-MX-501 NaOH DILUTION MIXER
CCS-TK-501 SOLVENT STORAGE TANK
CCS-F-501 SOLVENT RECOVERY FILTER
CCS-TK-505 TEG STORAGE TANK
CCS-P-505 TEG MAKE-UP PUMP
CCS-TK-503 50 WT% NaOH STORAGE TANK
CCS-TK-502 SOLVENT RECOVERY TANK
CCS-H-502 SOLVENT RECOVERY TANK HEATER
CCS-H-501 SOLVENT STORAGE TANK HEATER
CCS-P-503A/B 50 WT% NaOH PUMP
CCS-P-502 SOLVENT RECOVERY PUMP

TO ATMOSPHERE AT SAFE LOCATION
NITROGEN (FROM CYLINDERS)
CCS-TK-501
CCS-H-501
GLYCOL WATER SUPPLY
GLYCOL WATER RETURN
TC
SOLVENT (TRUCK CONNECTION)
SOLVENT MAKE-UP
M1NN-CCS-DWG-225-02201
TO ABSORBER (CCS-C-201)
INTERMITTENT
CCS-P-501
CCS-TK-505
(NOTE 2)
TEG (TRUCK CONNECTION)
CCS-P-505
INTERMITTENT
TEG MAKE-UP
M1NN-CCS-DWG-225-02601
TO DEHYDRATION PACKAGE (CCS-PK-601)
RECOVERED SOLVENT
M1NN-CCS-DWG-225-02201
TO ABSORBER (CCS-C-201)
NNF
CCS-F-501
CCS-P-502
GLYCOL WATER SUPPLY
GLYCOL WATER RETURN
TC
CCS-H-502
SOLVENT (DRAINS)
CCS-TK-502
CCS-TK-503
(NOTE 2)
50 WT% NaOH (TRUCK CONNECTION)
FC
FRC
CCS-P-503A/B
INTERMITTENT
CCS-TK-504
(NOTE 2)
CCS-MX-501
20 WT% NaOH
M1NN-CCS-DWG-225-02101
TO DCC SCRUBBING SOLUTION PUMP (CCS-P-102A/B)
INTERMITTENT
CCS-P-504A/B
INTERMITTENT
DCC WATER
M1NN-CCS-DWG-225-02101
FROM DCC WATER COOLER (CCS-E-101)

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REFERENCE DWG NUMBER	REFERENCE DRAWINGS
0	N/A	ISSUED FOR REPORT	MI	KA	SR								

FLUOR®
CONTRACT M1NN

CONTRACT	M1NN	
DESIGNED BY	M. ITO	
CHECKED BY	K. AFSHAR	
SUPERVISOR	S. REDDY	APP DATE
LEAD ENGR/SPEC.	K. AFSHAR	APP DATE
FLUOR	R. GRAEBE	APP DATE
CLIENT	D. WOLF	APP DATE

MINNKOTA POWER COOPERATIVE
PROJECT TUNDRA
CARBON CAPTURE AND SEQUESTRATION
PROCESS FLOW DIAGRAM
ECONAMINE FG PLUS℠ PROCESS
CHEMICAL STORAGE AND SUPPLY

SCALE: NONE
DRAWING NUMBER: M1NN-CCS-DWG-225-02501
REV: 0
CAD FILE NAME M1NN-CCS-DWG-225-02501.dwg

F-022.DWG 01JUL09

CCS-P-601A-D
PROCESS CONDENSATE PUMP
(NOTE 3)

CCS-V-601A/B
CO_2 PRODUCT COMPRESSOR SUCTION KO DRUM
(NOTE 3)

CCS-VS-601
CO_2 VENT STACK

CCS-K-601A/B
CO_2 PRODUCT COMPRESSOR
(NOTE 3)

CCS-E-601A/B
CO_2 PRODUCT COMPRESSOR AFTERCOOLER
(NOTE 3)

CCS-PK-601A/B
CO_2 DEHYDRATION PACKAGE
(NOTE 3)

NNF

CCS-VS-601
(NOTE 2)

CCS-PK-601A/B
(NOTE 3)

INTERMITTENT
TEG MAKE-UP
M1NN-CCS-DWG-225-02501
FROM TEG MAKE-UP PUMP (CCS-P-505)

CWR
CWS

AI

STRIPPER OVERHEAD PRESSURE
M1NN-CCS-DWG-225-02301
FROM STRIPPER OVERHEAD

NC
CWR
CWS
COND
TC
PC
FI
PI
TI
AI
B.L.
6066
COMPRESSED CO_2 PRODUCT
OSBL
(NOTE 4)
M

CCS-K-601A/B
(NOTE 3)

CCS-E-601A/B
(NOTE 3)

LOW PRESSURE CO_2
M1NN-CCS-DWG-225-02301
FROM OVERHEAD ACCUMULATOR (CCS-V-302)

LC

CCS-V-601A/B
(NOTE 3)

PROCESS CONDENSATE
M1NN-CCS-DWG-225-02301
TO STRIPPER (CCS-C-301)

CCS-P-601A-D
(NOTE 3)

NOTES:

1. ABBREVIATIONS:
   BL : BATTERY LIMITS
   COND : CONDENSATE
   CWR : COOLING WATER RETURN
   CWS : COOLING WATER SUPPLY
   NC : NORMALLY CLOSED
   OSBL : OUTSIDE BATTERY LIMITS
   TEG : TRIETHYLENE GLYCOL

2. SELF-REGULATING, EXTERNAL ELECTRIC TRACING, WINTERIZATION OF STACK TO BE CONFIRMED BASED ON FINAL DESIGN OF STACK.

3. CO2 PRODUCT COMPRESSOR OPERATES AS TWO PARALLEL (2x50%) TRAINS. EACH COMPRESSOR HAS A DEDICATED SUCTION KO DRUM, 2x100% PROCESS CONDENSATE PUMPS, CO2 DEHYDRATION PACKAGE, AND AFTERCOOLER.

4. CLASS VI ISOLATION REQUIRED FOR CO2 PIPELINE BATTERY LIMIT VALVE.

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REFERENCE DWG NUMBER	REFERENCE DRAWINGS
0	N/A	ISSUED FOR REPORT	MI	KA	SR								

FLUOR®
CONTRACT M1NN

CONTRACT	M1NN	
DESIGNED BY	M. ITO	
CHECKED BY	K. AFSHAR	
SUPERVISOR	S. REDDY	APP DATE
LEAD ENGR/SPEC.	K. AFSHAR	APP DATE
FLUOR	R. GRAEBE	APP DATE
CLIENT	D. WOLF	APP DATE

MINNKOTA POWER COOPERATIVE
PROJECT TUNDRA
CARBON CAPTURE AND SEQUESTRATION
PROCESS FLOW DIAGRAM
ECONAMINE FG PLUS℠ PROCESS
CO2 COMPRESSION

SCALE	DRAWING NUMBER	REV
NONE	M1NN-CCS-DWG-225-02601	0

CAD FILE NAME M1NN-CCS-DWG-225-02601.dwg

F-0223.DWG 01JUL09

ATTACHMENT 2 – UTILITY FLOW DIAGRAMS

CCS–PK–701
COOLING TOWER CHEMICAL
INJECTION PACKAGE

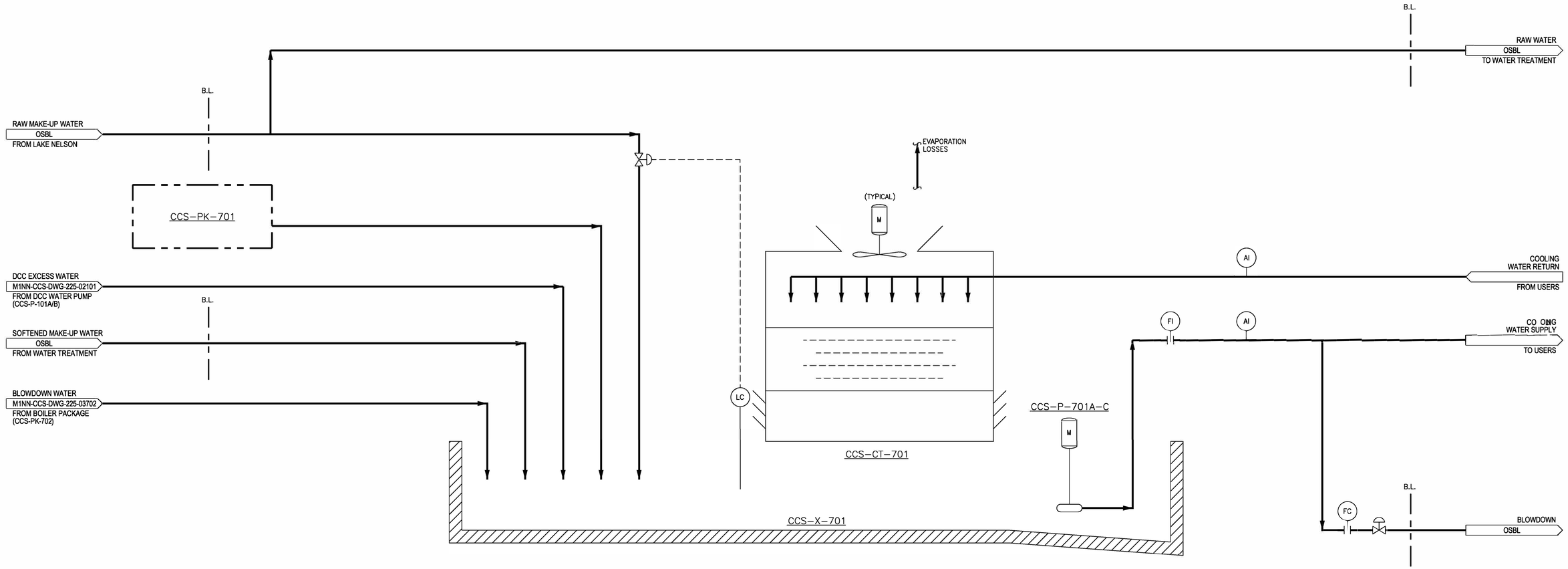
CCS–CT–701
COOLING TOWER

CCS–X–701
COOLING TOWER BASIN

CCS–P–701A–C
COOLING WATER PUMPS

NOTES:

1. ABBREVIATIONS:
   BL : BATTERY LIMITS
   CWR : COOLING WATER RETURN
   CWS : COOLING WATER SUPPLY
   OSBL : OUTSIDE BATTERY LIMITS
   TOC : TOTAL ORGANIC CARBON



REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REFERENCE DWG NUMBER	REFERENCE DRAWINGS
0	N/A	ISSUED FOR REPORT	MI	KA	SR								

FLUOR®
CONTRACT M1NN

CONTRACT	M1NN	
DESIGNED BY	M. ITO	
CHECKED BY	K. AFSHAR	
SUPERVISOR	S. REDDY	APP DATE
LEAD ENGR/SPEC.	K. AFSHAR	APP DATE
FLUOR	R. GRAEBE	APP DATE
CLIENT	D. WOLF	APP DATE

MINNKOTA POWER COOPERATIVE
PROJECT TUNDRA
CARBON CAPTURE AND SEQUESTRATION
UTILITY FLOW DIAGRAM
ECONAMINE FG PLUS℠ PROCESS
COOLING WATER SYSTEM

SCALE	DRAWING NUMBER	REV
NONE	M1NN–CCS–DWG–225–03701	0

CAD FILE NAME M1NN–CCS–DWG–225–03701.dwg

F-0223.DWG 01JUL09

CCS-PK-702
BOILER PACKAGE

NOTES:

1. ABBREVIATIONS:
   BL : BATTERY LIMITS
   MP : MEDIUM PRESSURE
   OSBL : OUTSIDE BATTERY LIMITS

STEAM CONDENSATE
M1NN-CCS-DWG-225-03705
FROM GLYCOL WATER HEATER (CCS-E-711)

NATURAL GAS
OSBL

B.L.

DEMIN WATER
M1NN-CCS-DWG-225-02201
FROM RO UNIT

CCS-PK-702

FLUE GAS
M1NN-CCS-DWG-225-02101
TO DIRECT CONTACT COOLER (CCS-C-101)

MP STEAM
M1NN-CCS-DWG-225-02301
TO REBOILER STEAM DESUPERHEATER (CCS-DS-301)

MP STEAM
M1NN-CCS-DWG-225-02401
TO SOLVENT MAINTENANCE SYSTEM (CCS-PK-401)

BLOWDOWN WATER
M1NN-CCS-DWG-225-03701
TO COOLING TOWER BASIN (CCS-X-701)

CWR

CWS

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REFERENCE DWG NUMBER	REFERENCE DRAWINGS
0	N/A	ISSUED FOR REPORT	MI	KA	SR								

FLUOR®
CONTRACT M1NN

CONTRACT	M1NN	
DESIGNED BY	M. ITO	
CHECKED BY	K. AFSHAR	
SUPERVISOR	S. REDDY	APP DATE
LEAD ENGR/SPEC.	K. AFSHAR	APP DATE
FLUOR	R. GRAEBE	APP DATE
CLIENT	D. WOLF	APP DATE

MINNKOTA POWER COOPERATIVE
PROJECT TUNDRA
CARBON CAPTURE AND SEQUESTRATION
UTILITY FLOW DIAGRAM
ECONAMINE FG PLUS℠ PROCESS
BOILER

SCALE	DRAWING NUMBER	REV
NONE	M1NN-CCS-DWG-225-03702	0

CAD FILE NAME M1NN-CCS-DWG-225-03702.dwg

F-0223.DWG 01JUL09

CCS–PK–703
PLANT AND INSTRUMENT AIR PACKAGE

CCS–PK–703

CWR

CWS

INSTRUMENT AIR SUPPLY
TO USERS

PLANT AIR SUPPLY
TO USERS

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REFERENCE DWG NUMBER	REFERENCE DRAWINGS
0	N/A	ISSUED FOR REPORT	MI	KA	SR								

FLUOR®
CONTRACT M1NN

CONTRACT	M1NN	
DESIGNED BY	M. ITO	
CHECKED BY	K. AFSHAR	
SUPERVISOR	S. REDDY	APP DATE
LEAD ENGR/SPEC.	K. AFSHAR	APP DATE
FLUOR	R. GRAEBE	APP DATE
CLIENT	D. WOLF	APP DATE

MINNKOTA POWER COOPERATIVE
PROJECT TUNDRA
CARBON CAPTURE AND SEQUESTRATION
UTILITY FLOW DIAGRAM
ECONAMINE FG PLUS℠ PROCESS
PLANT AND INSTRUMENT AIR

SCALE	DRAWING NUMBER	REV
NONE	M1NN–CCS–DWG–225–03703	0

CAD FILE NAME M1NN–CCS–DWG–225–03703.dwg

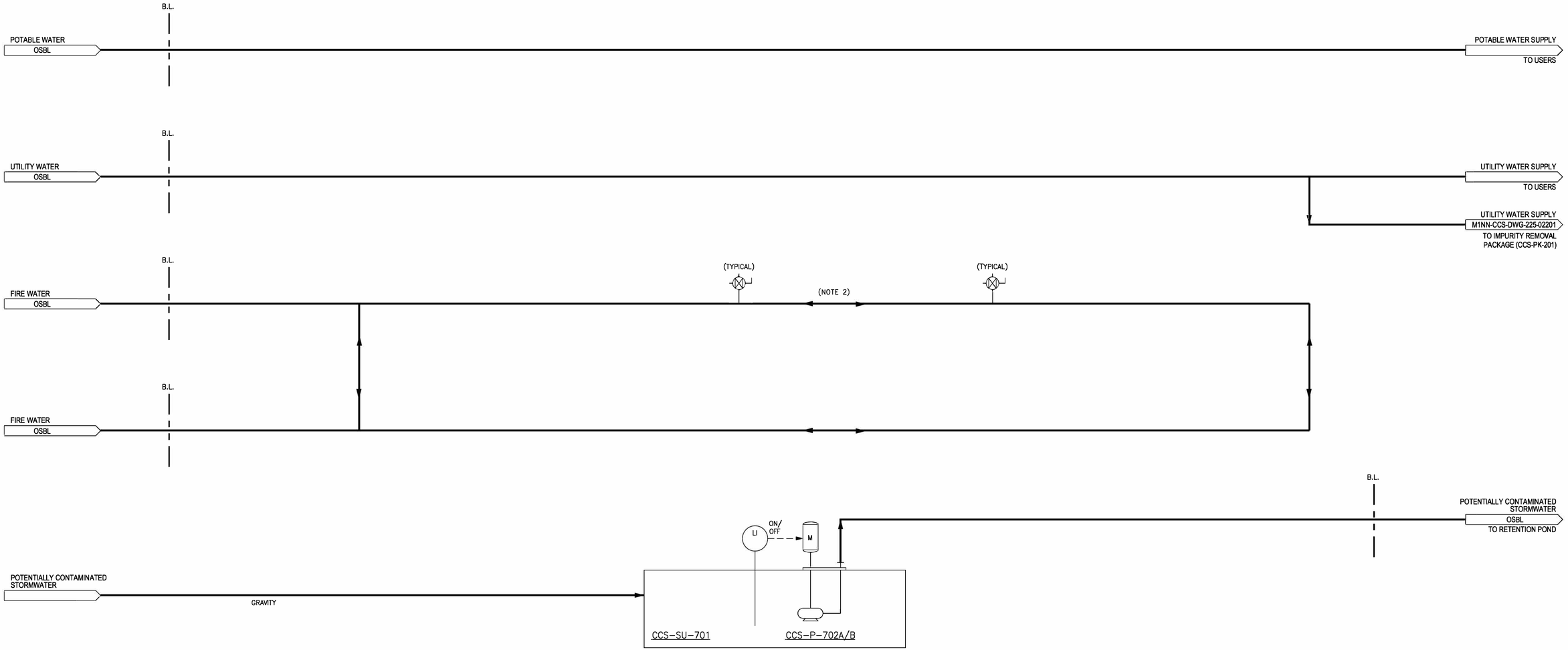
r–022.DWG 11JUL09

CCS–SU–701
POTENTIALLY CONTAMINATED
STORMWATER SUMP

CCS–P–702A/B
POTENTIALLY CONTAMINATED
STORMWATER PUMP

NOTES:

1. ABBREVIATIONS:
   BL : BATTERY LIMITS
   OSBL : OUTSIDE BATTERY LIMITS
2. NUMBER AND LOCATIONS OF HYDRANTS, MONITORS, SPRINKLERS, AND DELUGE SYSTEMS TO BE DEVELOPED DURING FEED AS PART OF FIRE PROTECTION DESIGN.



REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REFERENCE DWG NUMBER	REFERENCE DRAWINGS
0	N/A	ISSUED FOR REPORT	MI	KA	SR								

FLUOR®
CONTRACT M1NN

CONTRACT	M1NN	
DESIGNED BY	M. ITO	
CHECKED BY	K. AFSHAR	
SUPERVISOR	S. REDDY	APP DATE
LEAD ENGR/SPEC.	K. AFSHAR	APP DATE
FLUOR	R. GRAEBE	APP DATE
CLIENT	D. WOLF	APP DATE

MINNKOTA POWER COOPERATIVE
PROJECT TUNDRA
CARBON CAPTURE AND SEQUESTRATION
UTILITY FLOW DIAGRAM
ECONOMINE FG PLUS℠ PROCESS
MISCELLANEOUS WATER SERVICES

SCALE	DRAWING NUMBER	REV
NONE	M1NN–CCS–DWG–225–03704	0

CAD FILE NAME M1NN–CCS–DWG–225–03704.dwg

P–022.DWG 01JUL09

CCS-V-711
COMPRESSION TANK

CCS-V-712
AIR SEPARATOR

CCS-P-711A/B
GLYCOL WATER
CIRCULATION PUMP

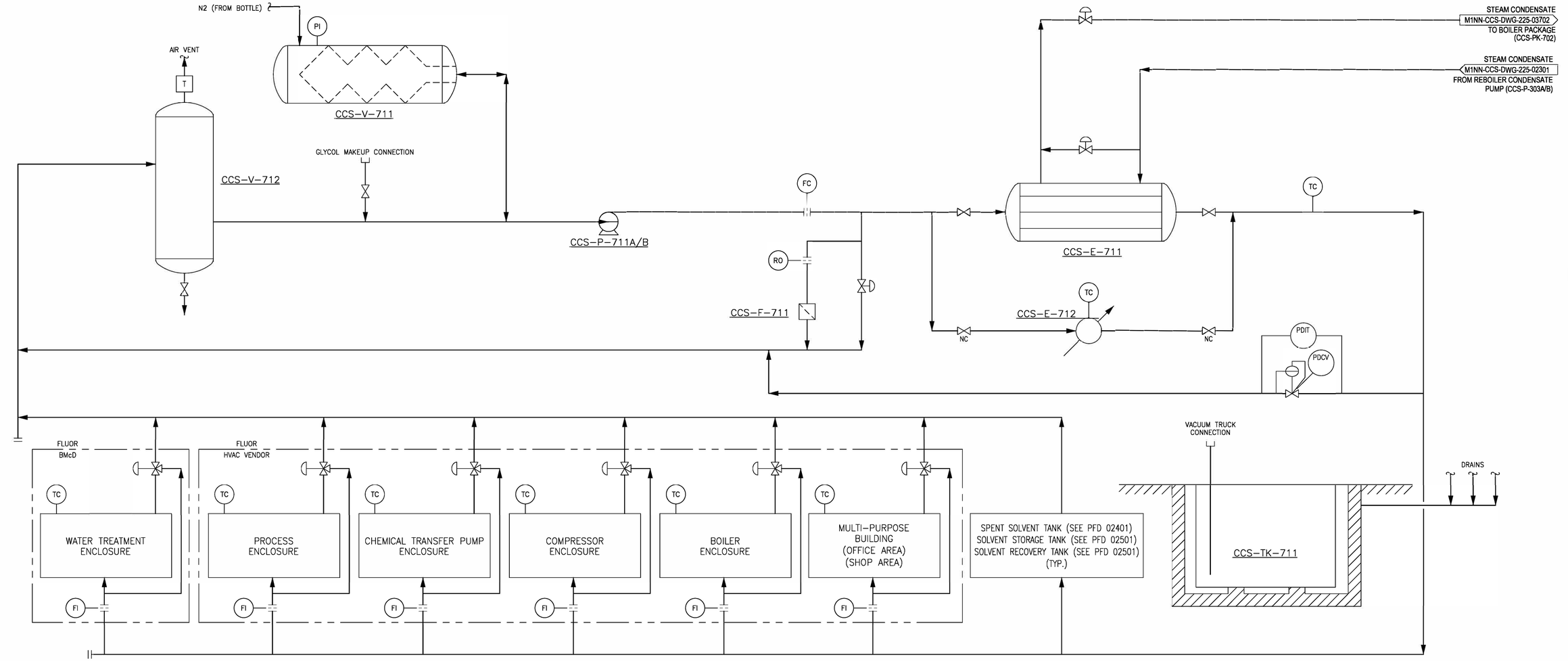
CCS-F-711
GLYCOL WATER FILTER

CCS-E-711
GLYCOL WATER
HEATER

CCS-E-712
GLYCOL WATER
ELECTRIC HEATER

CCS-TK-711
GLYCOL WATER
DRAIN TANK

NOTES:



REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REFERENCE DWG NUMBER	REFERENCE DRAWINGS
0	N/A	ISSUED FOR REPORT	RW	KA	SR								

FLUOR®
CONTRACT M1NN

CONTRACT	M1NN	
DESIGNED BY	R. WARREN	
CHECKED BY	K. AFSHAR	
PROCESS TECHNOLOGY	S. REDDY	APP DATE
LEAD ENGR/SPEC.	K. AFSHAR	APP DATE
FLUOR	R. GRAEBE	APP DATE
CLIENT	N/A	APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA
CARBON CAPTURE AND SEQUESTRATION

UTILITY FLOW DIAGRAM
ECONAMINE FG PLUS℠ PROCESS
GLYCOL WATER SYSTEM

SCALE	DRAWING NUMBER	REV
NONE	M1NN-CCS-DWG-225-03705	0

CAD FILE NAME M1NN-CCS-DWG-225-03705.dwg

F-022.DWG 13JUL09

ATTACHMENT 3 – PROCESS EQUIPMENT LIST

FLUOR

PROJECT TUNDRA

PROCESS EQUIPMENT LIST - COLUMNS

CONTRACT:	M1NN		
DATE:	N/A	REV.:	0
BY:	CHK'D:	APP'D:	
MI	MS		

Seq. No.	Equipment Tag No.	Description	Design Conditions		Insulation	Remarks
			Press	Temp		
			psig	°F		
1	CCS-C-101	Direct Contact Cooler (DCC)	+2 / -3	250	PP (partial)	
2	CCS-C-201	Absorber	2	250	None	
3	CCS-C-301	Stripper	50 / FV	310	Hot	

FLUOR

PROJECT TUNDRA

PROCESS EQUIPMENT LIST - COMPRESSORS

CONTRACT:	M1NN		
DATE:	N/A	REV.:	0
BY:	CHK'D:	APP'D:	
MI	MS	0	

Seq. No.	Equipment Tag No.	Description	Compressor Type	Driver Type	Remarks
1	CCS-BL-201	Blower	Axial Fan	Electric Motor	
2	CCS-K-601A/B	CO_2 Product Compressor	Integrally Geared Centrifugal	Electric Motor	2x50% compressors.

FLUOR

PROJECT TUNDRA

PROCESS EQUIPMENT LIST - HEAT EXCHANGERS

CONTRACT:	M1NN		
DATE:	N/A	REV.:	0
BY:	CHK'D:	APP'D:	
MI	MS	0	

Seq. No.	Equipment Tag No.	Description	Design Conditions				Exchanger Type	Remarks
			Shell / Hot Side		Tube / Cold Side			
			Press	Temp	Press	Temp		
			psig	°F	psig	°F		
1	CCS-E-101	DCC Water Cooler	100	250	100	250	Gasketed Plate	
2	CCS-E-202	Absorber Wash Water Cooler	130	250	130	250	Gasketed Plate	
3	CCS-E-203	Lean Solvent Cooler	175	250	175	250	Gasketed Plate	
4	CCS-E-301	Solvent Cross Exchanger	220	310	220	310	Gasketed Plate	
5	CCS-E-302	Reboiler	75 / FV	350	50 / FV	310	BEM	
6	CCS-E-303	Condenser	100	250	100	250	Gasketed Plate	
7	CCS-E-601A/B	CO_2 Product Compressor Aftercooler	1770	290	1370	250	NEU	Each CO_2 Compressor train has a dedicated aftercooler
8	CCS-E-711	Glycol Water Heater	140	350	170	350	NEU	

FLUOR

PROJECT TUNDRA

PROCESS EQUIPMENT LIST - HEAT EXCHANGERS

CONTRACT:	M1NN		
DATE:	N/A	REV.:	0
BY:	CHK'D:	APP'D:	
MI	MS	0	

Seq. No.	Equipment Tag No.	Description	Design Conditions				Exchanger Type	Remarks
			Shell / Hot Side		Tube / Cold Side			
			Press	Temp	Press	Temp		
			psig	°F	psig	°F		
9	CCS-E-712	Glycol Water Electric Heater	170	250	-	-	Electric Heater	

FLUOR

PROJECT TUNDRA

PROCESS EQUIPMENT LIST - FILTERS

CONTRACT:	M1NN		
DATE:	N/A	REV.:	0
BY:	CHK'D:	APP'D:	
MI	MS	0	

Seq. No.	Equipment Tag No.	Description	Design Conditions		Remarks
			Temp	Press	
			°F	psig	
1	CCS-F-101A/B	DCC Water Filter	250	70	Cartridge type filter.
2	CCS-F-201	Lean Solvent Filter	180	175	Cartridge type filter.
3	CCS-F-501	Solvent Recovery Filter	180	70	Cartridge type filter.
4	CCS-F-711	Glycol Water Filter	250	170	Cartridge type filter.

FLUOR

PROJECT TUNDRA

PROCESS EQUIPMENT LIST - PUMPS

CONTRACT:	M1NN		
DATE:	N/A	REV.:	0
BY:	CHK'D:	APP'D:	
MI	MS	0	

Seq. No.	Equipment Tag No.	Description	Design Conditions		Pump Type	Driver Type	Remarks
			Temp	Press			
			°F	psig			
1	CCS-P-101A/B	DCC Water Pump	250	70	Centrifugal	Electric Motor	One operating pump with one installed spare.
2	CCS-P-102A/B	DCC Scrubbing Solution Pump	250	95	Centrifugal	Electric Motor	One operating pump with one installed spare.
3	CCS-P-202A/B	Absorber Wash Water Pump	250	130	Centrifugal	Electric Motor	One operating pump with one installed spare.
4	CCS-P-203A/B	Rich Solvent Pump	250	220	Centrifugal	Electric Motor	One operating pump with one installed spare.
5	CCS-P-301A/B	Lean Solvent Pump	310	175	Centrifugal	Electric Motor	One operating pump with one installed spare.
6	CCS-P-302A/B	Reflux Pump	250	170	Centrifugal	Electric Motor	One operating pump with one installed spare.
7	CCS-P-303A/B	Reboiler Condensate Pump	350	120	Centrifugal	Electric Motor	One operating pump with one installed spare.
8	CCS-P-501	Solvent Make-Up Pump	250	55	Centrifugal	Electric Motor	Normally not running.
9	CCS-P-502	Solvent Recovery Pump	310	70	Vertical	Electric Motor	Normally not running. Mounted on top of sump flange.

FLUOR

PROJECT TUNDRA

PROCESS EQUIPMENT LIST - PUMPS

CONTRACT:	M1NN		
DATE:	N/A	REV.:	0
BY:	CHK'D:	APP'D:	
MI	MS	0	

Seq. No.	Equipment Tag No.	Description	Design Conditions		Pump Type	Driver Type	Remarks
			Temp	Press			
			°F	psig			
10	CCS-P-503A/B	50 wt% NaOH Pump	250	60	Centrifugal	Electric Motor	Normally not running. One operating pump with one installed spare.
11	CCS-P-504A/B	DCC NaOH Injection Pump	250	70	Rotary	Electric Motor	One operating pump with one installed spare.
12	CCS-P-505	TEG Make-Up Pump	250	25	Positive Displacement	Electric Motor	Normally not running.
13	CCS-P-601A-D	Process Condensate Pump	250	100	Centrifugal	Electric Motor	Two operating pumps with two installed spares.
14	CCS-P-701A-C	Cooling Water Pumps	150	100	Centrifugal	Electric Motor	Two operating pumps with one installed spare.
15	CCS-P-711A/B	Glycol Water Circulation Pump	250	170	Centrifugal	Electric Motor	One operating pump with one installed spare.

FLUOR

PROJECT TUNDRA

PROCESS EQUIPMENT LIST - VESSELS

CONTRACT:	M1NN		
DATE:	N/A	REV.:	0
BY:	CHK'D:	APP'D:	
MI	MS	0	

Seq. No.	Equipment Tag No.	Description	Design Conditions		Insulation	Orientation	Remarks
			Press	Temp			
			psig	°F			
1	CCS-V-302	Overhead Accumulator	50 / FV	250	None	Horizontal	Equipped with inlet box and demister.
2	CCS-V-303	Reboiler Condensate Drum	75 / FV	350	Hot	Horizontal	
3	CCS-V-601A/B	CO_2 Product Compressor Suction KO Drum	50 / FV	250	None	Vertical	Two identical vessels, one for each CO_2 Product Compressor. Equipped with inlet box and demister.
4	CCS-V-711	Compression Tank	170 / FV	250	Hot	Horizontal	
5	CCS-V-712	Air Separator	170	250	None	Vertical	

FLUOR

PROJECT TUNDRA

PROCESS EQUIPMENT LIST - TANKS

CONTRACT:	M1NN		
DATE:	N/A	REV.:	0
BY:	CHK'D:	APP'D:	
MI	MS	0	

Seq. No.	Equipment Tag No.	Description	Tank Type	Design Conditions		Remarks
				Press	Temp	
				inH2O	°F	
1	CCS-TK-401	Spent Solvent Tank	Rectangular	+8 / -4	300	
2	CCS-TK-501	Solvent Storage Tank	Cone Roof	+15 / -8	200	
3	CCS-TK-502	Solvent Recovery Tank	Rectangular	+8 / -4	310	
4	CCS-TK-503	50 wt% NaOH Storage Tank	Cone Roof	+8 / -4	200	
5	CCS-TK-504	20 wt% NaOH Storage Tank	Cone Roof	+8 / -4	200	
6	CCS-TK-505	TEG Storage Tank	Cone Roof	+8 / -4	200	
7	CCS-TK-711	Glycol Water Drain Tank	Rectangular	+8 / -4	250	

FLUOR

PROJECT TUNDRA

PROCESS EQUIPMENT LIST - MISCELLANEOUS

CONTRACT:	M1NN		
DATE:	N/A	REV.:	0
BY:	CHK'D:	APP'D:	
MI	MS	0	

Seq. No.	Equipment Tag No.	Description	Specifications	Remarks
1	CCS-DM-101	Unit 1 Isolation Damper	Guillotine type damper. Design Temperature: 350 °F with excursions to 400 °F for up to 15 minutes Design Pressure: ±25 in H2O(g)	
2	CCS-DM-102	Unit 2 Isolation Damper	Guillotine type damper Design Temperature: 350 °F with excursions to 400 °F for up to 15 minutes Design Pressure: ±25 in H2O(g)	
3	CCS-DM-103	Boiler Package Isolation Damper	Guillotine type damper Design Temperature: 350 °F Design Pressure: ±25 in H2O(g)	
4	CCS-DU-101	DCC Inlet Ducting System	Design Temperature: 350 °F (ducts to be designed to handle temperature excursions up to 400 °F for up to 15 minutes) Design Pressure: ±25 in H2O(g)	
5	CCS-DU-102	DCC Outlet Duct	Design Temperature: 250°F Design Pressure: ±25 in H2O(g)	
6	CCS-PK-201	Impurity Removal Package	Packaged unit to remove particulate matter from the flue gas.	
7	CCS-DU-201	Blower Outlet Duct	Design Temperature: 250°F Design Pressure: ±25 in H2O(g)	
8	CCS-DU-202	Absorber Inlet Duct	Design Temperature: 250°F Design Pressure: ±25 in H2O(g)	
9	CCS-DM-201	Absorber Stack Damper	Design Temperature: 250°F Design Pressure: 2 psig	

FLUOR

PROJECT TUNDRA

PROCESS EQUIPMENT LIST - MISCELLANEOUS

CONTRACT:	M1NN		
DATE:	N/A	REV.:	0
BY:	CHK'D:	APP'D:	
MI	MS	0	

Seq. No.	Equipment Tag No.	Description	Specifications	Remarks
10	CCS-DS-301	Reboiler Steam Desuperheater	Design Temperature: 425°F Design Pressure: 75 psig / FV	
11	CCS-PK-401	Solvent Maintenance System	Proprietary equipment system to maintain solvent hygiene.	
12	CCS-H-401	Spent Solvent Tank Heater	Heating coil required to maintain CCS-TK-401 waste tank contents above 100°F and to be able to heat the contents from 100°F to 140°F in 6 hours prior to vacuum truck haul-off.	
13	CCS-MX-501	NaOH Dilution Mixer	Mixer to dilute 50 wt% NaOH to 20 wt% NaOH using DCC water as dilution water.	
14	CCS-H-501	Solvent Storage Tank Heater	Heating coil required to maintain CCS-TK-501 internal tank temperature between 80°F and 100°F.	
15	CCS-H-502	Solvent Recovery Tank Heater	Heating coil required to maintain CCS-TK-502 internal tank temperature between 50°F and 60°F.	
16	CCS-PK-601A/B	CO_2 Dehydration Package	TEG type dryer. Vendor supplied package of 2x50% units. Each unit processes 112.2 MMSCFD of wet CO_2 gas. Outlet water content < 30 lb/MMscf in the product CO_2. Design Pressure: 750 psig (TEG Contactor)	
17	CCS-VS-601	CO_2 Vent Stack	Design Pressure: 2 psig Design Temperature: -45 / 250°F	
18	CCS-CT-701	Cooling Tower	CW Supply Temperature: 80 °F, CW Return Temperature: 110 °F.	

FLUOR

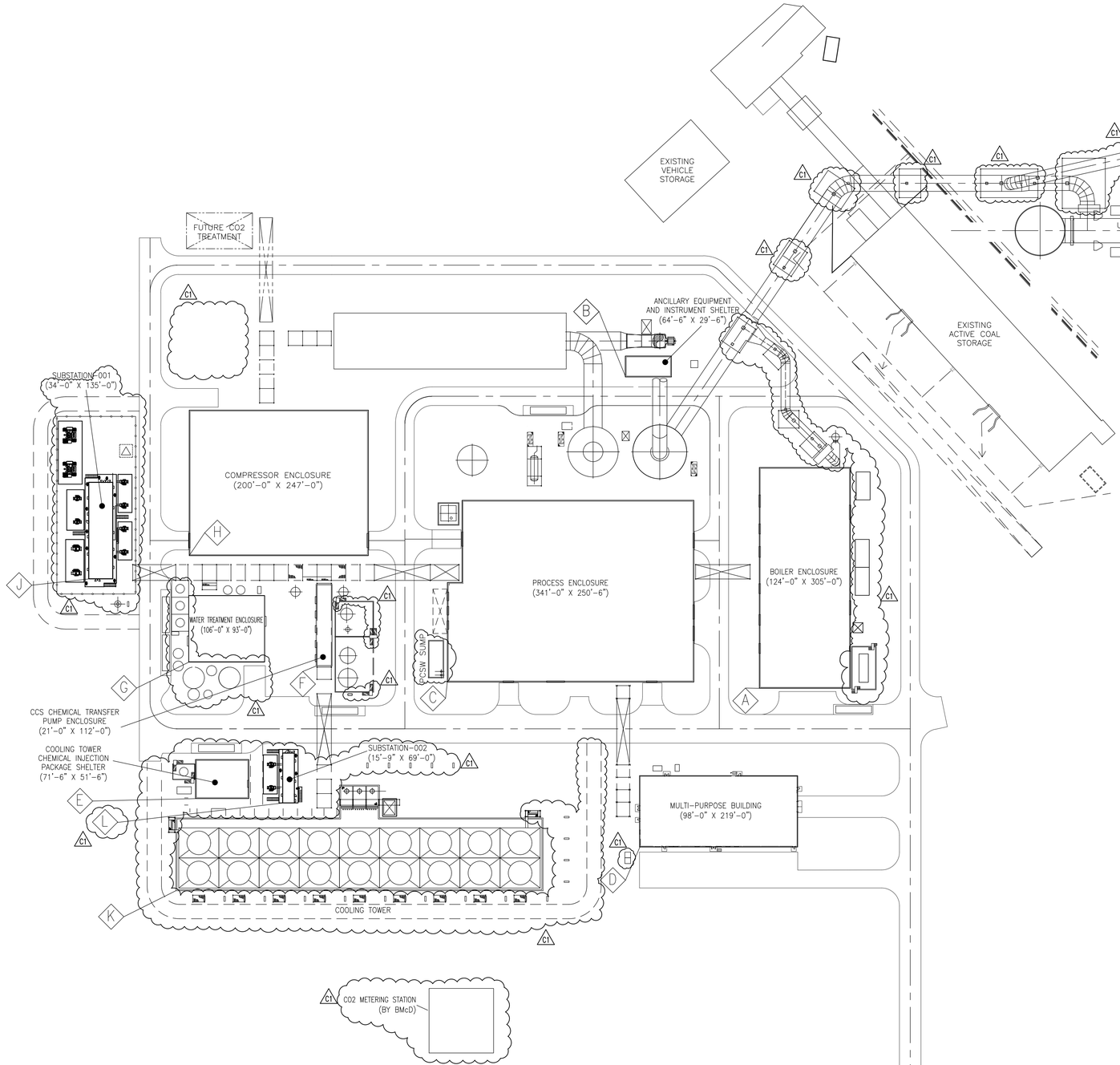
PROJECT TUNDRA

PROCESS EQUIPMENT LIST - MISCELLANEOUS

CONTRACT:	M1NN		
DATE:	N/A	REV.:	0
BY:	CHK'D:	APP'D:	
MI	MS	0	

Seq. No.	Equipment Tag No.	Description	Specifications	Remarks
19	CCS-X-701	Cooling Tower Basin		
20	CCS-PK-701	Cooling Tower Chemical Injection Package	Package to include storage tanks/totes and dosing pumps for sulfuric acid, corrosion inhibitor, scale inhibitor, dispersant, chlorine dioxide, and non-oxidizing biocide. Vendor to provide a dedicated pump (1x100%) and a warehouse spare for each chemical.	
21	CCS-PK-702	Boiler Package	Packaged system to include boiler drums & convection tubes, boiler furnace, burner & windbox assembly, burner throat, air blower, economizer, blowdown drum, feed water pumps, deaerator, ammonia injection / SCR catalyst system, and stack. Boiler is designed to produce medium pressure saturated steam.	
22	CCS-PK-703	Plant and Instrument Air Package	Package to incude two (2) 100% compressors (one operating / one spare), one (1) wet air receiver, two (2) 100% air dryers with a common pre-filter and after filter, and one (1) dry air receiver.	

ATTACHMENT 4 – PLOT PLAN



CCS UNIT
BUILDING LOCATION COORDINATES

Point Letter	Description	Southwest Corner in Plant Coordinates (Decimal Feet) Easting	Northing	Southwest Corner in State Plane Coordinates (Decimal Feet) (NAD27 – North Dakota State Plane Coordinate) Easting	Northing
A	Boiler Enclosure	146,714.333	22,139.250	1,821,306.963	510,453.690
B	Ancillary Equipment and Instrument Shelter	146,527.500	22,573.250	1,821,120.130	510,887.690
C	Process Enclosure	C1 146,279.250	22,148.000	C1 1,820,871.880	510,462.440
D	Multi-Purpose Building	146,547.167	21,917.833	1,821,139.797	510,232.273
E	Cooling Tower Chemical Injection Package Shelter	C1 145,928.000	21,985.500	1,820,520.630	C1 510,299.940
F	CCS Chemical Transfer Pump Enclosure	146,096.000	22,170.250	1,820,688.630	510,484.690
G	Water Treatment Enclosure	145,918.667	22,175.500	1,820,511.297	510,489.940
H	Compressor Enclosure	145,919.250	22,324.250	1,820,511.880	510,638.690
J	Substation-001 C1	145,783.415	22,291.750	1,820,376.045	510,606.190
K	Cooling Tower Basin	145,900.750	21,857.000	1,820,493.380	510,171.440
L	Substation-002	146,049.500	21,979.250	1,820,642.130	510,293.690

C1

NOTES:
1. STATE PLANE COORDINATES BASED ON STATE PLANE, NORTH DAKOTA SOUTH 27, NAD27. VERTICAL ELEVATION BASED ON USGS NAVD 1929. CCS UNIT HIGH POINT OF FINISHED SURFACE IS 1988-0" ABOVE MEAN SEAL LEVEL.
2. PLANT COORDINATES BASED ON COORDINATE SYSTEM ON PROVIDED DRAWING 4000-LO-745 (AREA SITE BUILDING MAP)

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REFERENCE DWG NUMBER	REFERENCE DRAWINGS
A	N/A	NOT USED											
B	N/A	NOT USED											
C	30OCT20	ISSUED FOR INFORMATION	LJC	PW	PW								
C1	11JAN21	ISSUE FOR INFORMATION	LJC	PW	PW								
			LJC	wil4084g	wil4084g								

FLUOR

CONTRACT M1NN

CONTRACT	M1NN
DESIGNED BY	L. CHEEK
CHECKED BY	P. WILLIAMS
SUPERVISOR	L. CHEEK APP DATE
LEAD ENGR/SPEC.	P. WILLIAMS APP DATE
DRAWN	Jayesh Patel Digitally signed by Jayesh Patel Date: 2021.01.20 14:22:11 -06'00' APP DATE
CLIENT	APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA
CARBON CAPTURE AND SEQUESTRATION
CCS UNIT
OVERALL PLOT PLAN (NON-CONFIDENTIAL)

SCALE

DRAWING NUMBER M1NN-CCS-SKT-250-00028 REV C1

CAD FILE NAME M1NN-CCS-SKT-250-00028_C1.dwg

PLOT DATE: Z:\250_PIPING\250H_PIPING_DESIGN\250H_200_Unit_Plot_Plans\M1NN-CCS-SKT-250-00028_C1.dwg 01-12-21 11:35 am Printed By: che5259G

F-022.DWG 01JAL09

ATTACHMENT 5 – GEOTECHNICAL INVESTIGATION REPORT

A - PROCEED

FLUOR

Authorization to proceed does not relieve Contractor/Supplier of its responsibility or liability under the Contract and or Purchase Order.

By: Naga Swamy,SWA76248,1/25/2021

Terracon GeoReport

Geotechnical Engineering Report

Tundra Carbon Capture and Sequestration (CCS) Project

Minnkota Power Cooperative, Inc.

Center, North Dakota

Terracon Project No. M2205062-Revised

Prepared for:

Fluor Corporation

Greenville, North Carolina

Prepared by:

Terracon Consultants, Inc.

Bismarck, North Dakota

Terracon GeoReport

November 11, 2020

A - PROCEED
FLUOR
Authorization to proceed does not relieve Contractor/Supplier of its responsibility or liability under the Contract and or Purchase Order.
By: Naga Swamy,SWA76248,1/25/2021

Fluor Corporation
100 Fluor Daniel Drive
Greenville, North Carolina 29607

Attn: Mr. David Alewine, Director (Contracts Management)
P: (864) 517- 1940
E: David.alewine@fluor.com

Re: Geotechnical Engineering Report
Tundra Carbon Capture and Sequestration (CCS) Project
Center, North Dakota
Terracon Project No. M2205062-Revised

Dear David:

Terracon is pleased to present the results of our geotechnical study for the above referenced project. This study was authorized by Mr. David Alewine with Fluor Corporation (Fluor) through Letter of Award, dated August 14, 2020. This report presents the findings of our subsurface exploration and geotechnical recommendations to help others in the design and construction of the foundations for the proposed Carbon Capture and Sequestration (CCS) Facility.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us at (713) 329-2545.

Sincerely,
Terracon Consultants, Inc.

Rae Kim, Ph.D., E.I.T.
Staff Geotechnical Engineer

Chad Cowley, P.E.
Project Manager

Rao Gudavalli, Ph.D., P.E., P.Eng.
Principal | Chief Engineer

John Juenger, P.E.
Senior Principal | National Director

Terracon GeoReport

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Exhibit No.

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PERMEABILITY ..... Appendix F
PROCTOR TEST RESULTS ..... Appendix G
CBR ..... Appendix H
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CONSOLIDATION .....Appendix J

Note: This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the Terracon GeoReport logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

GEOTECHNICAL ENGINEERING REPORT
TUNDRA CARBON CAPTURE AND SEQUESTRATION (CCS) PROJECT
MINNKOTA POWER COOPERATIVE, INC
CENTER, NORTH DAKOTA
TERRACON PROJECT NO. M2205062-REVISED

1.0 INTRODUCTION

Terracon is pleased to present the results of our geotechnical study for the proposed Tundra Carbon Capture & Sequestration (CSS) Project located in Center, North Dakota. Terracon was requested to perform geotechnical exploration at the site and provide geotechnical recommendations for the above-mentioned project. The project description is based on discussions with Fluor about fieldwork, laboratory work, and geotechnical recommendations. Our understanding of the project is provided in the following sections of this report.

1.1 PROJECT DESCRIPTION

The project information obtained from our discussions with Fluor is provided in **Table 1**.

Table 1: Project Description

Item	Description
Project Description	We understand Minnkota Power Cooperative Inc. (Minnkota) is planning to construct the Tundra Carbon Capture and Sequestration (CCS) project at their site located near the town of Center, North Dakota. We also understand Fluor is selected to perform the FEED design for this project. The site location is shown on **Exhibit 1**. The project includes the construction of a cooling tower basin and a large building which houses several flue gas quenchers, DCC/Absorber, regenerators, ductwork, piping, fans and other associated structures. The proposed project also consists of piperacks, small equipment, pavements and roads. Currently, the site exists as undeveloped land adjacent to coal stockpiles on the west side of the main generation station. Fluor has provided us with the site topographic survey performed by others. Based on this topographic survey of the site, the existing grade varies from about EL.+2,068 feet in the southwestern portion of the site to about EL.+1,978 feet in the northeastern portion of the site. The final grade is at EL.+1,988 feet. Therefore, southwestern portion of the site will have a maximum cut of about 80 feet which gradually decreases to zero in the northeast direction. A small portion

GEOTECHNICAL ENGINEERING REPORT
TUNDRA CARBON CAPTURE AND SEQUESTRATION (CCS) PROJECT
MINNKOTA POWER COOPERATIVE, INC
CENTER, NORTH DAKOTA
TERRACON PROJECT NO. M2205062-REVISED

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Item	Description
	of the site in the northeastern portion of the site will have a maximum fill of about 10 feet. Refer to **Exhibit 2** for the topographic survey provided by Fluor.
Foundations	We understand that the current plans are to support the proposed structures either on shallow spread footings/mat foundations or on deep foundations consisting of steel pipe piles/drilled shafts.
Loading Conditions	The following loads were provided to us in the RFP No. M1NN-00-K002, Rev. No. 0, dated June 26, 2020: • Equipment Structures : 100-600 kips/column • Piperacks : 20 - 200 kips/column • Buildings : 500 – 2,000 psf • Cooling Tower/Sump : 1200 psf • Equipment Columns : 500 - 2000 kips • Absorber column (70' Dia): 7000 kips • Equipment at Grade : 1 – 1,000 kips • Lightly loaded supports : 1 - 20 kips
Pavements	We understand that several access roads and parking lots will be constructed as part of the proposed development. Traffic information, except Off-Highway 772G truck information, is not available at the time of this report. We understand that total gross weight of the Off-Highway 772G truck is 181 kips with 70 percent of the load will be carried by the rear axle.

1.2 PURPOSES AND SCOPE

The purposes of our geotechnical study were to explore and evaluate the existing site and subsurface conditions at the project site to develop geotechnical engineering recommendations for the proposed project. Our scope does not include the evaluation and assessment of the environmental conditions and compliance with regulatory requirements. Our scope also does not include fault study and geohazard assessment of the site.

2.0 FIELD EXPLORATION

2.1 General

Our field exploration consists of drilling soil borings and performing Cone Penetration Tests (CPTs) and a test pit. The depths and locations of the borings were selected by Fluor. CPTs were stopped prior to reaching the planned depths due to cone refusal. The planned and the actual boring/CPT depths are shown in **Table 2**.

Table 2: Summary of Soil Borings and Cone Penetration Tests (CPTs)

Boring ID	Latitude	Longitude	Elevation, ft	Boring Depth, Feet	
				Planned	Actual
Soil Borings					
B-1	47.06515947	-101.218755	2000.942	120	121
B-2	47.06518301	-101.2179086	1988.002	120	121
B-3	47.0640299	-101.2176408	2000.122	60	61
B-4	47.06455351	-101.2198173	2031.282	80	81
DH-1	47.06506534	-101.2200332	2031.992	100	101
Cone Penetration Tests (CPTs)					
C-1	47.06485355	-101.2171658	1993.372	80	39
C-2	47.06455351	-101.2177877	1993.542	80	37
C-3	47.06551834	-101.21885	2004.522	80	55
C-4	47.06378869	-101.2195669	2035.932	80	16
C-5	47.06460057	-101.2185218	1992.562	80	36
C-6	47.06408873	-101.2184441	2014.582	60	45
C-7	47.06300621	-101.2185391	2038.992	80	20
C-8	47.06606547	-101.2162071	1982.827	80	36
Test Pits					
TP-1	47.06278264	-101.2180036	2041.392	5	5
Total = 14				1,105 feet	774 feet

Locations of the soil borings and CPTs are provided on **Exhibit 3**. Terracon's exploration team using a measuring wheel/tape and/or a hand-held GPS unit, established boring locations with reference to known landmarks or points. The actual exploration point is usually within 10 feet of the noted location.

2.2 Drilling & Sampling Methods

We drilled soil borings with a track-mounted drill rig using hollow stem augers and mud rotary drilling techniques. We obtained representative samples primarily by the split-barrel sampling procedure. Soil samples were generally taken continuously up to a depth of 10 feet and at about 5-foot intervals thereafter to the completion depth of the borings as indicated on the boring logs.

Our granular soil sampling was conducted in general accordance with the Standard Method for Penetration Test and Split-Barrel Sampling of Soils (ASTM D1586). In the split-barrel sampling procedure, a standard, 2-inch O.D., split-barrel sampling spoon is driven into the boring with a 140-pound automatic SPT (Standard Penetration Test) hammer falling 30 inches. Our field technician recorded the number of hammer blows required to advance the sampling spoon the last 12 inches of an 18-inch sampling interval as the SPT N-value. The N-values are recorded on the field boring logs. The soil samples obtained from the split-barrel sampler were visually classified and packaged for transportation to our laboratory.

Our exploration team prepared field boring logs as part of the drilling operations. The field logs include visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs and presented on **Exhibits 4 through 9**. Terms and symbols used on the logs are presented on **Appendix A.** The final boring logs represent the geotechnical engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory. Our borings were backfilled with cement bentonite after the completion of soil sampling.

2.3 Depth-to-Water Observations

As mentioned earlier, borings were drilled using hollow-stem auger method and mud rotary drilling. We were unable to measure groundwater in the boreholes due to the use of drilling fluid to advance many of the boreholes. Groundwater was not encountered during drilling in any of the soil borings. Additional discussion about groundwater observations is provided in the following sections of the report.

2.4 Cone Penetrometer Testing (CPT)

CPT soundings were conducted using a truck-mounted CPT rig. The CPT rig hydraulically pushes an instrumented cone through the soil while nearly continuous readings are recorded to a portable computer. The cone is equipped with electronic load cells to measure tip resistance and sleeve resistance and a pressure transducer to measure the generated ambient pore pressure. The face of the cone has an apex angle of 60° and an area of 10 cm^2. Digital data representing the tip

resistance, friction resistance, and probe inclination angle are recorded about every 2 centimeters while advancing through the ground at a rate between 1½ and 2½ centimeters per second. These measurements were correlated to various soil properties used for geotechnical design. No soil samples were gathered through this subsurface investigation technique. CPT testing was conducted in general accordance with ASTM D5778 "Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils." CPT logs are provided on **Exhibits 10 through 17** of this report. **Table 2** outlines the CPTs performed for this project.

2.5 Geophysical Survey and Downhole Test

Terracon was requested to perform GPR survey to identify the possible presence of utility lines and other subsurface obstructions across the site. Terracon also performed a downhole test at the location of Boring DH-1. The location of DH-1 is shown on **Exhibit 3** of this report. The results of our GPR survey as well as the downhole survey are presented in **Appendix B** of this report.

2.6 Field Electrical Resistivity Tests

One (1) field electrical resistivity test was performed at the project site by Terracon. Test was conducted using the Wenner 4-pin Method. Per our proposal, the testing consisted of two perpendicular arrays, with electrode “a” spacing of 5, 10, 20, 30, 40, and 50 feet. Soil electrical resistivity data was obtained in accordance with ASTM G57 Wenner Four (4) Electrode Method at one boring location on September 18, 2020. The tests were performed in two directions, North-South and East-West.

The test results indicate that the subsurface materials at the time of the testing had an average field electrical resistivity values in the range of 2,030 to 12,450 Ω-cm. The results of field electrical resistivity tests are provided in **Appendix C** of this report.

3.0 LABORATORY TESTING

3.1 General

Our project engineer reviewed field data and assigned various laboratory tests to better understand the engineering properties of the existing soil strata. Exact types and number of tests were defined after the completion of the field work. Procedural standards noted in **Table 3** are for reference to methodology in general. In some cases, local practices and professional judgement require method variations. The classification tests included tests for natural moisture content, liquid and plastic limits (collectively termed Atterberg Limits), and material finer than a No. 200 sieve. The results from the classification tests are recorded in the appropriate columns on the boring logs of this report. In addition, pH, sulfate, and chloride tests were performed to determine the corrosion potential of the existing soils.

Table 3: Summary of Laboratory Tests

Laboratory Test	Test Standard
Water Content and Visual Classification	ASTM D2216/2488
Atterberg Limits	ASTM D4318
Sieve Analyses	ASTM D422
Percent Finer than a No. 200 Sieve	ASTM D1140
Sulfate	ASTM D516-11
Chloride	SM 4500-C1-E
pH	SW 846-9045
Unconfined Compression Test	ASTM D2166
Unconsolidated Undrained Test	ASTM D2850
CBR Test	ASTM D1883
Standard Proctor Test	ASTM D698-Method A
One Dimensional Consolidation Test	ASTM D2435
Permeability	ASTM D5856

Our laboratory testing program often includes examination of soil samples by an Engineer. Based on the material's texture and plasticity, we describe and classify soil samples in accordance with the Unified Soil Classification System (USCS). Our laboratory test results are presented in **Appendices D thru H**. Liquefaction study is provided in **Appendix I**. Consolidation test results are presented in **Appendix J**

4.0 GENERAL SITE CONDITIONS

The site and subsurface conditions based upon our field exploration, laboratory testing, and our experience in this area are discussed in this section. A brief description of the site conditions and groundwater conditions is also included in this section.

Table 4: Summary of General Site Conditions

Item	Description
Site Location	The project is located near the south shoreline of Nelson lake, Center, North Dakota. Latitude: 47.065000N Longitude: -101.216667W (approximate) See **Exhibit 1** for site location.
Site Conditions	The proposed site is located on the southwest side of the existing Milton R Young power station. Overhead transmission lines intersect about halfway through the site. The ground surface varied from bare earth, aggregate surfaced to lightly vegetated. The existing grade slopes down from the southwest corner of the site to the northeast corner with a relief of about 80 feet. Drainage ditches exist along the existing roads. Piles of dirt/rock and coal are noticed near Boring B-3 and also scattered across the job site.

5.0 SUBSURFACE CONDITIONS

The subsurface conditions encountered at the site were based on the soils encountered in the borings and CPTs performed at the site as well as the laboratory test results.

5.1 Geology

The geology of the site includes the Tertiary Sentinel Butte Formation overlain by the Quaternary Coleharbor Group. The Sentinel Butte Formation consists of alternating beds of sandstone, siltstone, mudstone, claystone, lignite, baked clay, and minor layers of limestone. The formation can be characterized as the product of deltaic, lacustrine, and riverine environments of deposition.

The Coleharbor Group appears only scattered in the project area and includes a discontinuous glacial sediment veneer of material deposited by glacier ice on pre-Pleistocene formations (such as the Sentinel Butte formation at the project site). The veneer does not greatly alter the pre-existing topography. This formation generally includes an unsorted mixture of clay, silt, sand, cobbles and boulders that compose a glacial till unit.

5.2 Soil Conditions

We have developed a general characterization of the subsurface soil conditions based upon our review of the information from the soil borings/CPTs and laboratory test results. We also reviewed soil and groundwater information from the previous report titled "*Preliminary Geotechnical Evaluation Report, dated October 08, 2018*" performed by Braun Intertec Corporation provided to us by Fluor.

Based on soil information encountered in the soil borings and the CPTs, generally fill materials consisting of coal, lean clays, landfill debris, and Lignite were encountered from the existing grade to a maximum depth of about 12 feet below existing grade.

Below the fill materials, mostly fat clays were encountered to a depth of 120 feet below the existing grade, the maximum depth drilled at the site. The existing fat clays are generally very stiff to very hard with recorded N-values ranging from 27 blows per foot to greater than 100 blows per foot. Measured liquid limits within the fat clays range from 57 to 143 and the plasticity index values range from 44 to 126 indicating that these soils are high plastic. Measured moisture contents within the fat clays range from 17 to 28 with an average of about 20. Within the large stratum of fat clays, thin layers of lean clays and silty clays with thicknesses ranging from 7 to 12 feet were encountered in Borings DH-1, B-2, and B-4 at various depths below the existing grade.

Thin layers of Lignite with thicknesses ranging from 1 to 5 feet were encountered at various depths below the existing grade. Please note Lignite layers may be encountered at the proposed final grade of El.+1988 feet.

Layers of clayey sands/silty sands with thicknesses ranging from 6 to 28 feet were encountered at various depths in all soil borings as well as in CPTs. The existing silty sands/clayey sands are

generally medium dense to very dense with recorded N-values ranging from 14 to greater than 50 blows per foot. At few locations, loose silty sands with recorded N-values of about 5 blows per foot were encountered. Silty sands are mostly non-plastic based on the results from the Atterberg Limits tests performed on some of these soil samples. Liquid limits in the clayey sands range from 28 to 39 and plasticity index values range from 6 to 25 based on the results from the Atterberg Limits tests performed on some of these soil samples.

Soil conditions encountered at each boring location are indicated on the individual boring logs shown on **Exhibits 4 through 9** of this report. Terms and symbols shown on the boring logs are presented in **Appendix A** of this report. CPT logs are presented in **Exhibits 10 through 17**. Generalized soil profiles are presented on **Exhibit 18**. Graphs of Shear Strength versus Depth, Standard Penetration Test (SPT) N-values versus Depth, Friction Angle versus Depth, and Moisture Content versus Depth are presented on **Exhibits 19, 20, 21 and 22**, respectively.

5.3 Groundwater Conditions

Borings were drilled using hollow-stem auger or mud rotary techniques. Groundwater was not encountered in the borings during drilling, or for the short duration the borings could remain open. We also reviewed soil and groundwater information from the previous report titled "*Preliminary Geotechnical Evaluation Report, dated October 08, 2018*" performed by Braun Intertec Corporation. Based on the information from the above report, groundwater was encountered at El.+1957 feet in Boring B-2 and at El.+1997 feet in Boring B-3.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors that were not evident at the time the borings were performed. Therefore, we recommend installing piezometers during detailed design to measure the permanent groundwater levels at the site. Based on the groundwater levels observed in the previous report by Braun Intertec, groundwater level should be considered at final ground surface for design purposes.

6.0 SLAB-ON-GRADE FOUNDATIONS

6.1 Introduction

Lightly-loaded structures that can tolerate settlements and/or heaving, on the order of 3 to 4 inches, due to either swelling/consolidation of the fat clays or due to frost action in the upper about 6 to 7 feet may be supported on slab-on-grade structures. For slab-on-grade foundations that can't tolerate significant settlements or heave, we recommend using insulation below the foundations. Slab-on-grade foundations may be placed at final grade level (El.+1988 feet) on the existing undisturbed natural soils or on properly-compacted non-frost susceptible soils such as clean structural sand fill or crushed stone. The applied pressures (combined dead and live loads) should be limited to an allowable bearing pressure of 1,000 psf.

6.2 Grade Beams

Exterior (or turned down edges) and interior grade beams should be used in conjunction with spread footings to support loads between footings and to stiffen the floor slab, if planned. We recommend that perimeter grade beams, or a thickened edge, extending at least 2 feet below the lowest adjacent grade, be incorporated into any design utilizing a slab-on-grade foundation to reduce potential damage to the foundations from wind or water erosion. The width of the grade beam should be at least 12 inches with proper drainage away from the foundations. Extra reinforcement and expansion and isolation joints will be required around columns and walls. The depth of exterior and interior grade beams can be varied according to the structural requirements of the floor slab. Grade beams should be designed using an allowable net bearing pressure of 1,000 psf. We do not recommend the use of void boxes below grade beams because of the potential to collect free water within the void space.

6.3 Frost/Shrink-Swell Considerations

Based on the final grade of El.+1988 feet, most of the site may require cut to a maximum depth of 80 feet and a small portion may require about 10 feet of fill in the northeastern portion. Based on the existing soils encountered in our borings/CPTs, the proposed slab-on-grade foundations may rest either on fat clays or on clayey sands/silty sands or Lignite that may be encountered at El.+1988 feet. We expect significant movements (3 to 4 inches) due to swelling/consolidation of fat clays and/or freezing and thawing of the upper 6 to 7 feet of frost zone.

Special construction procedures such as vapor barrier below the floor slab should be used to prevent moisture migration into the subgrade soils from the floor slab. Horizontal and vertical moisture barriers around the perimeter of the buildings should also be considered to reduce the seasonal moisture fluctuations and associated subgrade soil deformations. We recommend performing swell tests and detailed Potential Vertical Rise (PVR) calculations during the final geotechnical investigation of the project and revise these recommendations, if necessary.

The subgrade should be prepared in accordance with the recommendations provided in the **Earthwork** and **Frost Considerations** sections of this report. Also, refer to **Exhibits 29 & 31** for insulation recommendations for slab-on-grade/floor slab foundations.

7.0 SHALLOW FOUNDATIONS

7.1 General

As mentioned earlier, most of the site will have a significant cut and a small portion of the site may require about 10 feet of fill. Based on the soil information encountered in our borings/CPTs, the proposed spread footings may rest either on fat clays or on clayey sands/silty sands/Lignite that may be encountered at the final grade of El.+1988 feet. We expect significant movements (3 to 4 inches) due to freezing and thawing of the upper 6.5 feet of frost zone unless the shallow foundations are placed close to the bottom of the 6.5-foot thick frost zone. Alternatively, shallow foundations can be insulated as discussed in following sections of this report. Geotechnical recommendations for shallow foundations including foundation depth, allowable net bearing pressure, resistance to uplift loads, resistance to lateral loads, resistance to overturning loads, and estimated settlements are discussed in the following sections. These recommendations are valid for the foundations supported on existing natural soils or on well-compacted non-frost susceptible soils such as clean structural sand fill. The distance between a grade slope, if any, and the edge of the foundation must be equal to at least the size of the foundation for these recommendations to be valid.

7.2 Foundation Depth

Shallow spread/mat foundations should bear on undisturbed, natural soils or clean structural sand fill at a depth of at least 3 feet below existing grade provided insulation is used and at a depth of 6 feet without insulation. Therefore, special construction procedures will be required. The subgrade should be prepared in accordance with the recommendations provided in the **Earthwork** and **Frost Considerations** sections of this report. Also, refer to **Exhibits 30 & 32** for insulation recommendations for spread footings.

7.3 Allowable Net Bearing Pressure

The allowable net bearing pressure of the existing soils depends primarily on the strength of the foundation soils, and in part, on the size, shape, and depth of the foundation. The allowable net bearing pressure for spread footings with a size of at least 3 feet and bearing on the existing natural soils between depths of 3 and 6 feet below final grade may be taken as 4,500 psf. This should be reduced to 3,500 psf if the footings are placed on well-compacted fill materials in the site grade rise areas. Spread footings should be proportioned so that the maximum contact pressure under the combined effects of dead, live, and transient loads does not exceed the allowable net bearing pressure. The allowable net bearing pressure given above includes a factor of safety of at least 2 with respect to shear failure of the foundation soils.

7.4 Resistance to Uplift Loads

The ultimate uplift capacity of a spread/mat foundation depends on the weight of the foundation plus the weight of any soil directly above the foundation. We recommend effective unit weights of

67.6 pcf for soil and 87.6 pcf for reinforced concrete assuming the groundwater will be at the final grade of El.+1988 feet according to existing geotechnical report performed by Braun Intertec. We recommend that the calculated ultimate uplift capacity for shallow foundations be reduced by a factor of 1.3 to compute the allowable uplift resistance.

7.5 Resistance to Lateral Loads

Typically, resistance of spread footings to lateral loads will be provided by adhesion or friction acting at the base of the foundation and the passive resistance by the soil in front of the foundation which can be assumed to be developed simultaneously. We do not recommend passive resistance in the frost zone of 6.5 feet. For concrete foundations poured in good contact with the existing cohesive soils, the allowable base adhesion may be taken as 600 psf. An allowable coefficient of friction value between the concrete and soils may be taken as 0.30. These allowable values will provide a factor of safety of at least 2 with respect to the ultimate values. Trapezoidal stress distribution should be considered if the footings are subjected to overturning moments. At least 75 percent contact area between the base of the footing and the foundation soil should be maintained for all combinations of loads including wind and seismic combinations. The resultant force should be located in the middle third of the footing base for all cases.

7.6 Settlement of Shallow Foundations

Settlement analyses were performed for various foundation sizes subjected to different applied pressures. Settlement analyses were performed for shallow, isolated foundations with an embedment depth of 5 feet and subjected to applied pressures. These settlements are also applicable for foundations bearing at embedment depths greater than 5 feet below final grade. Shallow foundations with sizes of 4’ x 4’, 6’ x 6’, 8’ x 8’, 10’ x 10’, 20’ x 20’, 30’ x 30’ and 40’ x 40’ subjected to applied pressures of 1,000, 2,000, 3,000, 4,000, and 4,500 psf were considered in the analyses. Soil parameters used for the settlement analyses using UNISETTLE are shown below.

Table 5: Design Soil Parameters for Shallow Foundation Settlement Analysis

Depth to Bottom of Soil Layer[1] (feet)	Soil Types	Total Unit Weight (pcf)	Compressibility Parameters					
			e_0	OCR	Cc	Cr[2]	M	m_r
5	Stiff Clay	125	0.7	3	0.12	0.025	-	-
25	API Sand	130	0.4	-	-	-	250	1,250
120	Stiff Clay	125	0.7	3	0.12	0.025	-	-

Note 1: Below final grade.

Note 2: Recompression index values from consolidation tests appear to be very high. We reduced these values based on existing correlations between moisture contents and these index values.

Results of our settlement analyses are presented on **Exhibit 23**. The settlements presented on **Exhibit 23** are long-term settlements. About 30 percent of these settlements may occur during the construction and/or immediately after the equipment is placed on the foundations.

7.7 Modulus of Subgrade Reaction

The modulus of subgrade reaction is defined as the ratio between the pressure and the deformation at a given point under a mat foundation. Based on published correlations, the modulus of subgrade reaction for a 1 foot x 1 foot plate can be taken as 250 kcf (150 pci) for the existing natural soils or well compacted clean structural sand fill. This value for the modulus of subgrade reaction may be used for both vertical and horizontal directions. The modulus of subgrade reaction in the horizontal direction is applicable for soils located below the frost depth of 6.5 feet.

8.0 DEEP FOUNDATIONS

8.1 General

We understand that deep foundations such as drilled shafts and/or H-piles are also being considered to support the heavily loaded structures. Based on the existing soil conditions and the local practice, 18-inch and 24-inch diameter straight-sided drilled shafts and for 12x53 and 14x73 H-piles are considered suitable to support the heavily loaded structures at this site. Assuming experienced piling contractors and suitable equipment are available locally, auger cast-in-place (ACIP) piles are also suitable to support the heavily loaded structures at this site. Geotechnical recommendations for axial capacity, lateral capacity, settlements, and group reduction factors are provided for 18-inch and 24-inch diameter straight-sided drilled shafts and for 12x53 and 14x73 H-piles in the following sections.

8.2 Static Axial Capacity

Static axial capacities were computed for 18-inch and 24-inch diameter straight-sided drilled shafts using the commercial software SHAFT. Axial capacities for 12x53 and 14x73 H-Piles were analyzed using the commercial software APILE. The weight of the pile was neglected in our analyses. Please note buoyant weight of the pile may be included for ultimate tension capacity after the shaft size is selected. We recommend a buoyant unit weight of 87.6 pcf for drilled shaft and buoyant unit weight of 427 pcf for H-piles to compute the weight of the piles. The computed weights should then reduce by a factor of 1.3 to determine the allowable uplift capacity due to the weight of the piles. The soil parameters used for analyses of the axial capacities are shown in **Table 6**.

Table 6: Design Soil Parameters for Axial Pile Capacity Analysis

Depth to Bottom of Soil Layer[1] (feet)	Soil Type	Eff. Unit Weight (pcf)	Su (psf)	Friction Angle (deg)	Max. Side Friction (psf)	Nq	Max. End Bearing (ksf)
5	Clay	62.6	2,400	-	2,000	-	21.6
25	Sandy Silt / Silty Sand	67.6	-	36	2,000[2]	40[2]	200[2]
100	Clay	62.6	6,000	-	2,000	-	54

Note 1: Below final grade.

Note 2: From API Manual, the friction angle between the pile and the soil (δ) = 31 degrees.

The ultimate axial capacity curves for the drilled shafts and H-piles are presented on **Exhibits 24 and 25**, respectively. These ultimate capacities should be reduced by a factor of safety of at least 2 for sustained compression loads and transient uplift loads and by a factor of safety of 3 for

sustained uplift loads. These ultimate capacities can be reduced by a factor of safety of at least 1.75 for transient compression loads. Tensile reinforcement should extend to the bottom of shafts subjected to uplift loading. For preliminary design purposes, these axial capacities can also be used for ACIP piles.

8.3 Axial Group Effects

The overall allowable axial capacity of a group of piles depend on several factors such as the size of the pile, center-to-center spacing between the piles, number of piles, and length of the piles. Reduction in the individual pile/shaft capacity, to allow for group effects, is generally not required if the center-to-center spacing between the piles within a group is greater than 3D where D is the pile size. Therefore, we recommend that groups of piles be designed with a center-to-center spacing of at least 3 times the pile size.

8.4 Lateral Capacity

We performed lateral load analyses for the drilled shafts and H-piles using the Software program LPILE by Ensoft, Inc. L-Pile analyses were performed for the 18-inch and 24-inch diameter drilled shafts and for 12x53 and 14x73 H-piles. Analyses were performed using limiting deflections of 0.5 and 1.0 inches for free head and fixed head conditions assuming the shaft/pile is installed to at least 60 feet depth and lateral loads are applied at the ground surface. Please note these results are valid for individual, isolated shafts/piles installed to at least 10 diameters away from the top of the slopes, if any. In our analyses, we also evaluated the maximum bending moment in the shaft/pile section. The soil parameters used for the LPILE analyses are shown in **Table 7**.

Table 7: Design Soil Parameters for LPile Analyses

Depth to Bottom of Soil Layer[1] (feet)	Soil Type	Eff. Unit Weight (pcf)	Su (psf)	ε_{50}, in/in	Friction Angle, φ (deg)	Subgrade Modulus (pci)
5	Soft Clay	62.6	240[2]	0.01	-	-
25	API Sand	67.6	-	-	36	90
100	Stiff Clay w/o Free Water	62.6	6,000	0.005	-	-

Note 1: Below final grade.
Note 2: Shear strength reduced to 10 percent of original value due to freeze-thaw considerations.

The results of our analyses are presented in **Table 8**. Deflection and bending moment versus depth curves are presented on **Exhibits 26 and 27**.

Table 8: Results of Lateral Load Analyses

Shaft/Pile Size (in)	Shaft/Pile Top Fixity	Shaft/Pile Top Deflection (in)	Lateral Capacity (kips)	Maximum Bending Moment (in-kips)
Straight-Sided Drilled Shafts				
18	Free Head	0.5	9.0	490.4
		1.0	13.5	803.3
	Fixed Head	0.5	23.0	1191.9
		1.0	31.6	1641.5
24	Free Head	0.5	16.5	1036.9
		1.0	24.9	1688.0
	Fixed Head	0.5	42.2	2522.7
		1.0	54.7	3183.9
H-Piles				
12x53	Free Head	0.5	6.4	332.4
		1.0	10.4	593.4
	Fixed Head	0.5	17.5	862.6
		1.0	23.4	1097.6
14x73	Free Head	0.5	9.5	549.5
		1.0	15.3	973.5
	Fixed Head	0.5	26.0	1435.4
		1.0	35.0	1865.8

Individual drilled shafts are representative of a free head condition. A group of shafts structurally tied together with a rigid concrete cap is more closely representative of a fixed head condition. The Structural Engineer should determine the most representative condition.

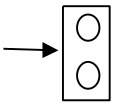
8.5 Lateral Group Effects

Detailed lateral group analysis is beyond the scope of this study. However, based on our experience with deep foundations and the existing soils, we recommend the group reduction

factors as shown in **Table 9**. As shown in **Table 9**, group reduction will not be required if the c/c spacing is equal to or greater than 7D. Using these reduction factors, the lateral capacity of a pile group can be computed as:

Pile group lateral capacity = Single pile lateral capacity x Number of Piles x Reduction Factor.

Table 9: Pile Lateral Group Reduction Factors

Pile Group Configuration	Pile Center-to-Center Spacing			
	2.5 D	3D	5D	≥7D
2x1 	0.9	0.95	1.0	1.0
2x1 	0.85	0.9	0.95	1.0
2x2	0.75	0.85	0.95	1.0
4x4	0.60	0.75	0.94	1.0
6x6	0.55	0.70	0.93	1.0
10x10	0.50	0.65	0.90	1.0

Note 1: D- Pile Diameter
Note 2: Lateral loads are assumed to be applied at the pile top which is assumed to be at the final grade.

8.6 Settlements

Post-construction settlements of individual, isolated, single drilled shaft/H-pile designed and constructed as described in this report are estimated to range from about 1/2 to 3/4 inch. Differential settlement between individual shafts/piles is expected to be about half of the total settlement. Please note groups of shafts/piles may settle more than the individual, isolated, single shafts/piles.

Details such as group configurations, center-to-center spacing, loading conditions are not available at the time of this report. Therefore, Terracon assumed 3 x 3, 5 x 5, 7 x 7 and 10 x 10 pile groups with a center-to-center spacing of 3D for the settlement analyses of the groups. We

also assumed applied pressures of 2,000, 4,000, 6,000, 8,000, and 10,000 psf on the above pile caps. The soil parameters used for the UNISETTLE analyses are shown in **Table 10**.

Table 10: Design Soil Parameters for UNISETTLE

Depth to Bottom of Soil Layer[1] (feet)	Soil Types	Total Unit Weight (pcf)	Compressibility Parameters					
			e_0	OCR	Cc	Cr	M	m_r
5	Stiff Clay	125	0.7	3	0.12	0.025	-	-
25	API Sand	130	0.4	-	-	-	250	1,250
120	Stiff Clay	125	0.7	3	0.12	0.025	-	-

Note 1: Below final grade.
Note 2: Recompression index values from consolidation tests appear to be very high. We reduced these values based on existing correlations between moisture contents and these index values.

Results of the settlement analyses for the pile groups and loading conditions listed above are shown on **Exhibit 28**.

8.6.1 Settlement of Tabletop Foundation

We understand that the proposed DCC/Absorber will be supported on a Tabletop mat foundation which in turn supported on a group of 50-foot long drilled shafts. The pilecap dimensions are 96 feet by 190 feet and will be embedded at a depth of 7 feet below the final grade. The allowable settlement of the Tabletop mat foundation is 1.0 inch or less. Based on information from Fluor, the applied pressure, including concrete weight, will be about 2,600 psf and it is 1,865 psf without the dead weight of concrete. The soil parameters used for the UNISETTLE analyses are shown in **Table 10**.

We performed settlement analyses using different lengths of drilled shafts to achieve a settlement of 1.0 inch or less. The results of our settlement analyses indicate that the length of the drilled shafts should be at least 90 feet to meet the settlement criteria of 1.0 inch or less when subjected to an applied pressure of 1,865 psf. The above results are based on limited soil borings and consolidation tests at the location of this structure. We recommend performing detailed settlement analyses during the final design of the project.

9.0 FROST CONSIDERATIONS

9.1 Introduction

The proposed project site is located near the town of Center, North Dakota where the 100-year return period air freezing index is 3,429 ° F-Days. Based on our experience in this area, the maximum frost penetration depth is about 6.5 feet below the final grade. Shallow foundations placed above the frost penetration depth of 6.5 feet may heave or settle due to frost action. The following subsections present our recommendations for frost consideration for shallow foundations.

9.2 Foundations - Heated Buildings

We recommend shallow footings be founded below frost depth or alternatively they should be insulated. Spread foundations and Slabs-on-grade founded above frost depth should be properly insulated. For heated buildings, the recommended minimum depth of exterior uninsulated foundations that will be subjected to frost is 5 feet below finished grade.

Insulation should be used around buildings to reduce the depth of frost penetration. We recommend expanded polystyrene boards (*e.g.*, Styrofoam SM or equivalent), or cellular concrete (*e.g.*, Cematrix) as insulation. Typical insulation details for shallow footings/slab-on-grade supported heated structures are shown on **Exhibits 29 & 30**. We recommend a minimum embedment depth of 3 feet for insulated spread footings.

Rigid polystyrene insulation is prone to damage by construction equipment and, therefore, needs proper care during placement and adequate cover to support traffic loading and prevent damage. It is also susceptible to hydrocarbon attack and should generally not be used where there is a risk of hydrocarbon spills. Where there is potential for hydrocarbon attack, other forms of insulation such as cellular concrete should be used.

The insulation should also be checked for expected loading conditions during and after construction. Where required, high strength insulation (i.e. Styrofoam HI or equivalent) should be used under areas that will be heavily loaded or subject to vehicle loading.

Placement of a subdrain at the base of spread footings is also desirable, where practical, to maintain the groundwater level at the base of the footings and reduce potential adverse effects on footing performance. To be effective, however, the subdrains need to be connected to a drainage system to direct water away from the grade beams and pile caps.

9.3 Unheated Buildings

Shallow foundations supporting unheated structures or equipment in unheated areas will be subjected to frost action. Foundations that cannot tolerate potential large frost heave movements should either be placed at a depth of at least 6 feet or alternatively should be insulated.

Typical details for insulation under unheated slabs-on-grade foundations are shown on **Exhibit 31**. The minimum recommended distance (L) from the edge of slab is 4.5 feet. A minimum thickness of 9 inches of rigid polystyrene insulation (*e.g.*, Styrofoam HI) is recommended, underlain by at least 1 foot of compacted frost stable granular fill. All granular fill should be compacted to a uniform dry density of at least 98% of Standard Proctor Maximum Dry Density. The recommended minimum depth for slab placement is 2 feet below finished grade.

Typical details for insulation under unheated spread footings are shown on **Exhibit 32**. **Table 11** provides recommended insulation thickness (T) and length (L) requirements for the spread footing placed at a depth of 3 feet below final grade.

Table 11: Recommended Dimensions of Rigid Insulation-Spread Footings-Unheated Areas

Minimum Depth of Spread Footing Below Ground Surface, feet	Recommended minimum Length (L) of Insulation, feet	Recommended Minimum Thickness (T) of Insulation, inches
3	3	9

The compressive strength of the rigid insulation should be 3 times (or greater) the design bearing pressure (working stress) of the footing or raft slab to avoid overstressing the rigid insulation. The compression of the rigid insulation should be accounted for in the estimation of foundation settlements. Placement of a subdrain at the base of slabs or footings is desirable in areas of high groundwater to provide drainage and reduce potential adfreeze forces on the sides of the foundations.

Where rigid insulation is placed below spread footings, the properties of the rigid insulation will determine the foundation resistance to sliding. For design purposes, it is recommended that an interface friction angle of 20° be used for rigid insulation bearing on non-frost susceptible clean sands. The sliding resistance may also be affected by the shearing strength of the rigid insulation used and this should be checked.

9.4 Adfreeze Stresses

Adfreeze (uplift) forces will be imposed on the piles and pile caps that are subjected to ground freezing. There is limited information in the literature dealing with measurement of adfreeze stresses on piles due to frost heave. The Canadian Foundation Engineering Manual, 4th Edition, 2006 (Section 13.5.1) cites the studies completed by Penner (Ref: Uplift Forces on Foundations in Frost Heaving Soils, Canadian Geotechnical Journal, Vol 11, No 3, August 1974) related to adfreeze stresses on steel and concrete piles.

Based on the review of the above data, we recommend using an adfreeze stress of 1,600 psf for the proposed shafts/piles and on the vertical faces of concrete at the proposed site. Please note the uplift force due to adfreeze stress on the vertical concrete faces/pile caps should be estimated.

For uplift force calculations due to adfreeze stresses and frost heave forces, we recommend using a factor of safety 1.0. We recommend that the ultimate shaft friction in the unfrozen soil may be used to resist frost heave (*i.e.*, an equivalent factor of safety of 1.0). Minimum recommended pile lengths for shafts/piles used to resist frost heave is at least 20 feet at this site.

The following recommendations should be followed if the uplift force due to adfreeze stress is significant on any vertical faces of concrete/pile cap.

We recommend using non-frost susceptible soils or insulation around the pile caps/pedestals to prevent adfreeze stresses. The zone of non-frost susceptible soils should be well-drained and extended horizontally for at least 2 times the thickness of the foundation. The minimum thickness of insulation should be at least 9 inches and extended for a horizontal distance of at least 5 feet. The insulation should be buried at a depth of at least 1.5 feet below the grade around the foundations.

9.5 Pile Caps and Grade Beams in Unheated Buildings

Precautions should be taken to prevent heaving of the pile caps or grade beams due to frost penetration, where the pile caps and grade beams lie above the seasonal frost line.

A typical recommended construction procedure for accommodating frost heave under the pile caps and grade beams in unheated areas subject to frost action is shown on **Exhibit 33**. A crushable nondegradable void form should be incorporated at the base of the grade beams and pile caps. In this method, the grade beam or pile cap must be designed in accordance with the crushing strength of the void filler used and the piles must be able to sustain the resulting uplift force. The type and thickness of void form required will depend on the application, expected magnitude of frost heave, and groundwater conditions. It is important that the void below the grade beams and pile caps not be allowed to fill with water that could subsequently freeze and impart heaving forces on the undersides of the grade beams or pile caps.

Where the grade beams or pile caps will be based above the permanent water table and there is no potential for water ingress into the void space, a collapsible non-rebounding type of void form may be used (*e.g.*, Beaver Plastics Frost Cushion).

However, where the void form will be placed below the water table, a non-collapsing rebounding type of void form should be used (*e.g.*, Ethafoam 150, formerly Ethafoam Nova) to prevent water from filling the void space and subsequently freezing.

For design purposes, a maximum frost heave of 3.5 inches should be assumed in unheated areas with water table at ground surface. The maximum frost heave may be prorated for grade beams and pile caps founded below ground surface according to **Table 12** below. The thickness of void form should be chosen to limit the compression to 25% of the original void form thickness; hence the suggested minimum void form thickness is also provided in **Table 12**. In addition, the pile caps and grade beams should be designed to resist the resulting compressive stress of the void form according to the manufacturer's specifications.

Table 12: Recommended Frost Heave and Void Form Thicknesses

Depth of Pile Cap/Grade Beam Below Ground Surface, feet	Design Frost Heave, inches	Minimum Thickness of Void Form, inches
0	3.5	14
3.0	2.0	8
6.0	0	0

10.0 BELOW-GRADE STRUCTURES

10.1 Introduction

Terracon understands that several below grade structures will be constructed as part of the proposed project. Details of these structures are not known at the time of this report. The following recommendations are provided for the general design of the below grade structures.

10.2 Soil Strength Parameters

Lateral earth pressures result from soil pressure, hydrostatic pressure, surcharge loads or combination of these pressures. Groundwater was not encountered in Terracon borings. However, based on our review of the existing information from previous geotechnical report performed by Braun Intertec and provided to us by Fluor, groundwater was encountered at El.+1993 feet which is 5 feet above the final grade of E.+1988 feet. For design purposes, we recommend assuming the groundwater is at the surface. The existing soils around the embedded structures or below grade structures will impose active, passive, and at-rest earth pressures against these structures.

Table 13: Soil Strength Parameters

Depth Below Final Grade (El.+1988 feet), in Feet	Soil Types	Undrained (Short-Term)		Drained (Long-Term)	
		Su (Cohesion), psf	Friction Angle, degrees	Su (Cohesion), psf	Friction Angle, degrees
5	Fat Clay	2,400	N/A	250	20
20	Sandy Silt / Silty Sand	N/A	36	200	20
100	Fat Clay	6,000	N/A	300	20

10.3 Lateral Earth Pressure Coefficients

Structures with unbalanced soil levels on opposite sides should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown in the diagram below. Active earth pressure is commonly used for design of free-standing

cantilever retaining walls and assumes wall movement. The “at-rest” condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls (unless stated).

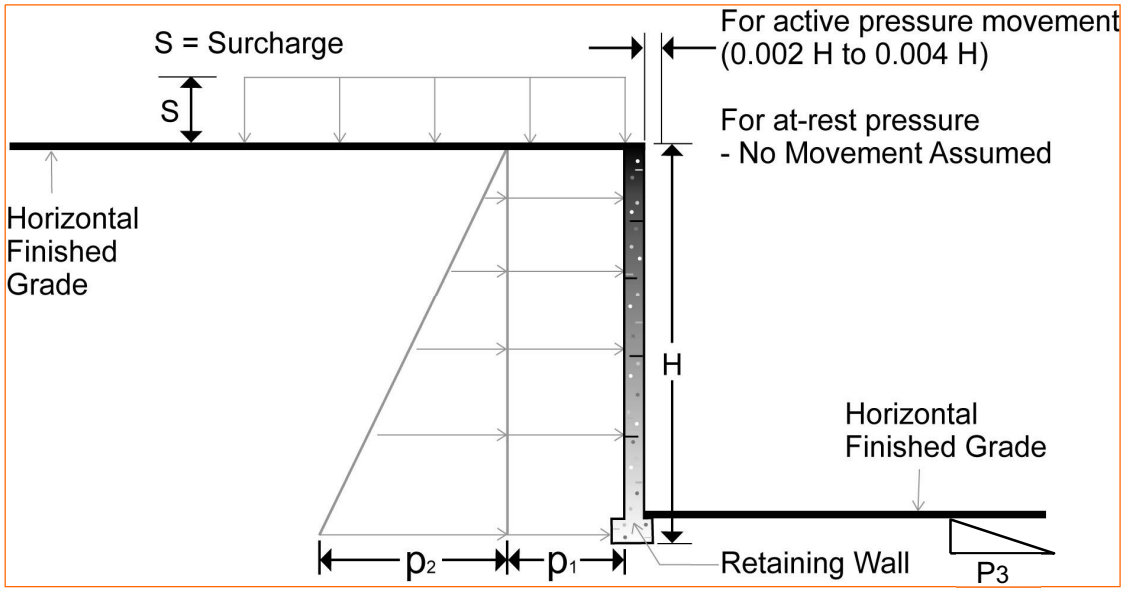


Table 14: Lateral Earth Pressure Design Parameters

Earth Pressure Condition [1]	Coefficient for Existing Soil[2]	Coefficient for Granular Backfill[2]	Surcharge Pressure [3, 4, 5] p_1 (psf)	Equivalent Fluid Pressures (psf) [2, 4, 5, 6]	
				Active Pressure, P2	Passive Pressure, P_3
Active (Ka)	0.5	N/A	0.5S	91H	N/A
	N/A	0.35	0.35S	83H	N/A
At-Rest (Ko)	0.7	N/A	0.7S	103H	N/A
	N/A	0.5	0.5S	91H	N/A
Passive (Kp)	2.0	N/A	2.0S	N/A	178H+1,500
	N/A	3.0	3.0S	N/A	236H

Note 1: For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance.

Note 2: Existing clay soils or uniform, horizontal structural clay fill, compacted to at least 95% of the ASTM D 698 maximum dry density, rendering a maximum unit weight of 120 pcf.

Note 3: Uniform surcharge, where S is surcharge pressure.

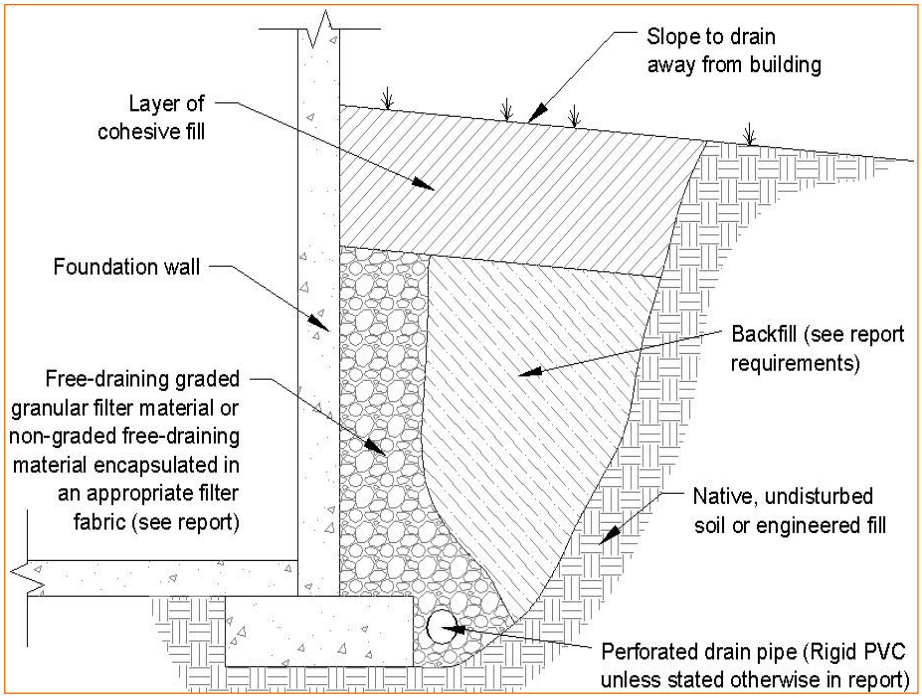
Earth Pressure Condition [1]	Coefficient for Existing Soil[2]	Coefficient for Granular Backfill[2]	Surcharge Pressure [3, 4, 5] p_1 (psf)	Equivalent Fluid Pressures (psf) [2, 4, 5, 6]	
				Active Pressure, P2	Passive Pressure, P_3

Note 4: Loading from heavy compaction equipment is not included.
Note 5: Groundwater was assumed to be at the surface. No safety factor is included in these values.
Note 6: Passive pressure should not be considered in the frost zone (i.e. 6.5 feet below the final grade)

Backfill placed against structures should consist of clean granular soils in the frost zone and clean granular soils or low plasticity cohesive soils below the frost zone. For the granular values to be valid, the granular backfill must extend out and up from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively.

10.4 Subsurface Drainage for Below-Grade Walls

A perforated rigid plastic drain line installed behind the base of walls and extends below adjacent grade is recommended to prevent hydrostatic loading on the walls. The invert of a drain line around a below-grade building area or exterior retaining wall should be placed near foundation bearing level.



The drain line should be sloped to provide positive gravity drainage to daylight or to a sump pit and pump. The drain line should be surrounded by clean, free-draining granular material having less than 5% passing the No. 200 sieve, such as No. 57 aggregate. The free-draining aggregate should be encapsulated in a filter fabric or nonwoven geotextile (e.g. Mirafi 500X). The granular fill should extend to within 2 feet of final grade, where it should be capped with compacted cohesive fill to reduce infiltration of surface water into the drain system.

As an alternative to free-draining granular fill, a pre-fabricated drainage structure may be used. A pre-fabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion and is fastened to the wall prior to placing backfill.

10.5 Groundwater Control

As mentioned earlier, we did not encounter groundwater in our borings. Based on information from the previous geotechnical report performed by Braun Intertec, groundwater was encountered at El.+1993 feet which is 5 feet above the proposed final grade for this project. Excavations below the final grade may expose clay soils and granular soils consisting of clayey sands and silty sands. Based on the groundwater conditions, excavations in the clayey soils may experience minor seepage. Seepage that occurs in the clay soils is likely to be managed by pumping water collected within sumps positioned at the bottom of the excavation. Care should be taken to slope the excavation towards the sumps such that water can be efficiently collected and removed from the excavation.

Excavations in the clayey sands/silty sands may potentially encounter seepage which may require some form of advanced dewatering, such as vacuum well-points, depending on the groundwater conditions at the time of construction. Groundwater within silty/sandy soils is typically controlled by the installation of vacuum well-points. However, vacuum well-points are generally less effective below a depth of 15 feet beneath the top of the well-point. Deeper dewatering typically requires educators or deep wells with submersible pumps or multiple-stage well-point systems.

The suggested methods given above serve as a guideline for groundwater control; other appropriate means may be required for groundwater control during construction. Control of groundwater should be accomplished in a manner that will preserve the strength of the soils and will not cause instability of the excavation. If necessary, the water should be lowered in advance of excavation. Open pumping should not be permitted if it results in boils, loss of fines, softening of the subgrade, or excavation instability. Wellpoints, deep wells and educators, if planned, should be installed with suitable screen and filter so that pumping of fines does not occur.

The well system should be in operation for at least several days prior to excavating to the design depth. We recommend that the groundwater head be lowered at least 3 feet below the bottom of the excavation to provide a working area with increased stability. The dewatering should continue until the construction has been completed, and the dewatering system should be turned off in stages to allow groundwater to recover to its original level gradually, over a period of about 3 to 5 days.

Dewatering of the soils might cause subsidence or compression of adjacent soils and adjacent structures, in spite of safeguards and methodology selected and used. For this reason, the dewatering operations must be performed and provided with great care to ensure caution and control of the potential subsidence resulting from the dewatering operations.

As stated previously, the groundwater levels will fluctuate with seasonal and climatic changes and should be evaluated just prior to construction. To further evaluate the groundwater at the time of construction, piezometers can be set just prior to construction. As an alternative, test pits may be dug to the planned excavation depths. Based on the results, the contractor should determine effective methods of groundwater management prior to starting excavation operations.

10.6 Uplift Pressures (Buoyancy Forces)

The effect of surcharge loads, where applicable, should be incorporated into pressure diagrams by adding a pressure component equal to the active lateral earth pressure coefficient multiplied by the surcharge load to the full height of the structure. Hydrostatic pressure should be included in the lateral pressure used for design of the below grade structures. A minimum 2-foot thick compacted clay seal should be placed at the top of sand or gravel backfill to reduce the amount of surface water infiltration.

The compactive effort should be controlled during backfill operations adjacent to below-grade pits. Over-compaction can produce lateral earth pressures in excess of at-rest magnitudes. Compaction levels adjacent to below-grade structures should be maintained between 93 and 96 percent of the Standard Proctor (ASTM D 698) maximum dry density.

Uplift forces are caused by a difference in water level in the soil adjacent to the below grade structure and inside the below grade structure. The most critical condition will be when the groundwater is at the ground surface and the below grade structures are empty. The groundwater level outside the structure (e.g. sump) should be assumed to be at the ground surface for calculations of buoyant forces. The uplift pressures will be resisted by adhesion or skin friction of the soil to the wall and by the dead weight of the structure. The value of allowable skin friction for an engineered clay fill compacted to a minimum of 95 percent of the maximum dry density as determined by the Standard Proctor (ASTM D 698) may be considered to be 250 psf. We recommend that the upper 6.5 feet of skin friction be neglected due to potential loss of strength in frost zone. Sand backfill, compacted to 70 percent of the maximum relative density (ASTM D 4253 and 4254), may be considered to have a value for allowable skin friction of zero at a depth of 6.5 feet below the final grade varying linearly to 175 psf at a depth of 10 feet below existing grade. The dead weight of a sufficiently sized perimeter ‘lip’ around the base of the below grade structure and the dead weight of the soil directly above the ‘lip’ can also be used to resist the uplift due to buoyancy forces.

10.7 Excavation Considerations

Excavation details are not available at the time of this report. Based on our understanding of the project and our experience, we are anticipating excavation depths up to 15 feet below existing grade. The sides may either be sloped or formed with vertical cuts. For vertical sided excavations greater than 5 feet in depth, the excavations will require the use of shoring, bracing or some form of retention to prevent sloughing and caving of the soil into the excavation.

OSHA standards provide recommendations for the design of temporary sloped excavations with a depth more than 5 feet and less than 20 feet. The OSHA standards provide maximum allowable slopes contingent on three designated soil types: Type A, Type B, and Type C. According to OSHA standards, temporary sloped excavations should be no steeper than 0.75-horizontal on 1-vertical (0.75H:1V) for Type A soils, 1H:1V for Type B soils, and 1.5H:1V for Type C soils. Based on the existing soils, the existing natural cohesive soils are considered as Type A soils and the fill soils and granular soils are considered as Type C soils. The soil types should be evaluated by a Contractor designated Competent Person or Geotechnical Engineer at the time of construction. The surface soils should be protected from deterioration and weathering if they are left open for significant periods of time.

As a safety measure, no equipment should be operated within 5 feet of the edge of the underground excavation and no materials should be stockpiled within 10 feet of the excavation. Excavations should not approach closer than 10 feet from existing structures/facilities without some form of protection for the facilities.

Excavations must be performed and inspected under the supervision of a contractor designated Competent Person. The Competent Person, as defined by the OSHA Standard, 29 CFR Part 1926.650 to .652, Subpart P – Excavations, must evaluate the excavations at the time of construction activity to safeguard workers.

Excavations should be performed with equipment capable of providing a relatively clean bearing area. Excavating equipment should not disturb the soil beneath the design excavation bottom and should not leave large amounts of loose soil in the excavation. The excavation bottom should be properly sloped to allow any water infiltrating into the excavation to be collected at a convenient location along the edge of the excavation. Water should not be allowed to stand on the bearing area.

10.8 Bedding - Utilities

Utility trenches are a common source of water infiltration and migration. All utility trenches that penetrate beneath the structures should be effectively sealed to restrict water intrusion and flow through the trenches that could migrate below the major structures. We recommend constructing an effective clay “trench plug” that extends at least 5 feet out from the exterior face of the structure. The plug material should consist of clay compacted at a water content at or above the soils optimum water content. The clay fill should be placed to completely surround the utility line and

be compacted in accordance with recommendations in this report. The bottom of the excavations should expose natural undisturbed soils as shown in the boring logs. The exposed soils at the base of the excavations should be verified through probing and/or density checks. All excavation should be backfilled as soon as possible.

Pipe bedding material should consist of Aggregate Base Course Cl 3 or Cl 5, as per of the *North Dakota Department of Transportation specifications,* and should be installed for a minimum of 4 inches below the bottom of the pipe. Pipe bedding should be compacted to at least 90 percent of the soil's maximum dry density as determined by the soil's Standard Proctor (ASTM D698) and should be within -3 to +3 percent of the optimum water content.

10.9 Backfill Recommendations - Utilities

The backfill of the trench should be placed and compacted in layers to obtain a minimum of 90 percent of the soil's maximum dry density and within -3 to +3 percent of the optimum water content as determined by the soil's Standard Proctor (ASTM D698), except for the top 4 feet of the trench. The top 4 feet of backfill in the trench should be compacted to a minimum of 95 percent of the soil's maximum dry density and no less than 3 percent below the soil's optimum water content, as determined by the soil's Standard Proctor (ASTM D698). Cobbles and/or boulders greater than 3 inches should be removed and not used as part of the backfill within 4 feet of the bedded pipe.

10.10 Cooling Tower Basin

Based on information from Fluor, a new Cooling Tower Basin with plan dimensions of 510 feet x 90 feet will be constructed at this site. The basin will be supported on a slab-on-grade foundation with turn-down around the perimeter underlain by insulation and 1-foot thick non-frost susceptible fill. The bottom of the non-frost susceptible soil on the perimeter will be at about 5.5 feet below the final grade and the bottom of the non-frost susceptible soil located inside the slab-on-grade will be at about 3 feet below the final grade. The slab-on-grade foundation will subject to a sustained load of 800 psf with an allowable settlement of 1.0 inches. We understand that a perforated drain pipe will be provided.

Settlement analyses were performed based on the above information and the soil parameters discussed in the previous sections. The results indicate that the existing soils should be over excavated to a depth of at least 6 feet below the final grade and back fill with non-frost susceptible soils, before placing the required insulation and the slab-on-grade foundation, to achieve a settlement of 1.0 inch or less.

11.0 PAVEMENTS

11.1 Introduction

We understand that both flexible pavement systems (consisting of asphaltic concrete and base material) and rigid pavement systems are being considered for this project. Detailed traffic loads and frequencies were not available at the time of this report. However, we understand that traffic will consist primarily of heavily loaded tractor-trailers (18-wheelers) in truck loading/unloading areas. Tabulated in **Table 15** are the assumed traffic frequencies and loads used to design pavement sections for this project. When actual traffic conditions have been determined Terracon should be contacted to review the information to consider a need for revision of the pavement designs and related recommendations.

Table 15: Assumed Traffic Frequencies

Pavement Area	Traffic Design Index	Description
Automobile Parking Areas	DI-1	Light traffic (Few vehicles heavier than passenger cars, no regular use by heavily loaded two axle trucks.) (EAL[(1)] < 6)
Driveways (Light Duty)	DI-2	Medium to light traffic (Similar to DI-1 including not over 50 loaded two axle trucks or lightly loaded larger vehicles per day. No regular use by heavily loaded trucks with three or more axles.)
Driveways and Truck Traffic Areas (Medium Duty)	DI-3	Medium traffic (Including not over 300 heavily loaded two axle trucks plus lightly loaded trucks with three or more axles and no more than 30 heavily loaded trucks with more than three axles per day.)
Medium-Heavy Truck Traffic Areas	DI-4	Medium to Heavy Truck Traffic (Including not over 900 two axle trucks plus lightly loaded trucks with three or more axles and no more than 60 heavily loaded trucks with more than three axles per day.)
Heavy Truck Traffic Areas	DI-5	Heavy Truck Traffic (Including not over 1,500 heavily loaded two axle trucks plus lightly loaded trucks with three or more axles and no more than 600 heavily loaded trucks with more than three axles per day.)

Pavement Area	Traffic Design Index	Description
772G Off-Highway Truck	N/A	Total Gross Weight = 181 kips No. of Axles = 2 Rear Axle = 126 kips (~70% of the weight) Front Axle = 55 kips)~30% of the weight) No. of Passes = 200/day No. of ESALs = 18 million (approx.)

Note 1: Equivalent daily 18-kip single-axle load applications.
Note 2: Used fourth-power law in the estimation of ESALs.

11.2 Subgrade Preparation

As discussed earlier, the existing soils across most of the site will be cut. The maximum cut is expected to be about 80 feet in the southwestern portions of the site and a small portion of the site in the northeastern portions of the site will receive a maximum fill of about 10 feet. Current plans are to reuse the cut soils to raise the site grade in the northeastern portion of the site. We understand that the existing subgrade will be raised using the onsite soils which meet the specifications of structural clay fill or clean structural sand fill or clean gravel fill and properly placed and compacted in accordance with the recommendations provided in the **Earthwork** section of this report.

Subgrade preparation of the areas under the proposed pavements should include clearing and stripping of vegetation, topsoil, tree roots, existing pavements (including crushed stone material) and debris/unsuitable surface material. Roots of trees to be removed within the construction areas should be grubbed to full depths. Once final subgrade elevations have been achieved, the exposed subgrade should be carefully proofrolled, within 2 days prior to actual pavement construction, with a 20-ton pneumatic roller or equivalent equipment, such as a fully loaded dump truck, to detect weak zones in the subgrade. Weak areas detected during proofrolling, as well as zones of fill containing organic matter and/or debris, should be removed and replaced with soils exhibiting similar classification, moisture content, and density as the adjacent in-situ soils or structural clay fill or non-frost susceptible fill materials.

Listed below are pavement component thicknesses, which may be used as a guide for pavement systems at the site for the traffic classifications stated herein. These systems were derived based on general characterization of the subgrade. Specific testing (such as CBR's, resilient modulus tests, etc.) was not performed for this project to evaluate the support characteristics of the subgrade.

Table 16: Asphalt Cement Concrete Thickness Recommendations

Traffic Area	Minimum Recommended ACC Pavement Thickness, Inches			
	Asphalt Surface[1]	Asphalt Base[1]	Aggregate Base[2]	Total Thickness, inches
Parking Area (DI-1)	2.0	2.0	6.0	10.0
Light Duty (DI-2 & 3)	2.0	2.0	8.0	12.0
Heavy Duty (DI-4)	3.0	4.0	8.0	15.0
Heavy Duty (DI-5)	4.0	6.0	10.0	20.0
772G Off-Highway Truck[2,3]	4.0	6.0	12.0	20.0

Note 1: NDDOT Superpave FAA 42
Note 2: NDDOT Class 5 Aggregate Base or Salvage Base Course
Note 3: We also recommend Tensar TX5 Geogrid below the Aggregate Base Layer.

Table 17: Recommended Rigid Pavement Sections

Component	Material Thickness, Inches				
	DI-1	DI-2	DI-3	DI-4	DI-5
Reinforced Concrete	5.0	6.0	7.0	8.0	10.0
Aggregate Base[1]	6.0	6.0	6.0	8.0	10.0

Note 1: NDDOT Class 5 Aggregate Base or Salvage Base Course

Waste dumpster areas should be constructed of at least 7 inches of reinforced concrete pavement. The concrete pad areas should be designed so that the vehicle wheels of the collection truck are supported on the concrete while the dumpster is being lifted to support the large wheel loading imposed during waste collection.

Presented below are our recommended material requirements for various components of the pavement sections.

11.2.1 Superpave FAA 42. The asphaltic concrete surface course should meet the requirements of NDDOT Class 29 Hot Bituminous Pavement.

11.2.2 Base Material. Base material should consist of NDDOT Class 5 Aggregate Base or Salvage Base Course in accordance with NDDOT Section 817. The base material should be

compacted to at least 95 percent of the Modified Effort (ASTM D1557) maximum dry density at moisture content within 2 percent of the optimum moisture content.

11.2.3. Reinforced Concrete Pavement. The materials and properties of reinforced concrete pavement should meet applicable requirements in the ACI Manual of Concrete Practice. The Portland cement concrete mix should have a minimum 28-day compressive strength of 4,000 psi.

11.2.4. Reinforcing Steel: ACI recommendations indicate that distributed steel reinforcement is not necessary when the pavement is properly jointed to form short panel lengths that will help reduce intermediate cracking. Provided the concrete pavement is designed and constructed as stated herein, the installation of reinforcing steel is optional and should be evaluated by the design team. Proper layout and installation of the joints within the pavement is critical to help control intermediate cracking.

If reinforcing steel is planned to be utilized in the concrete pavement by the design team, the following amount of reinforcing steel should be used as a guideline:

DI-1: #3 bars spaced at 18 inches or #4 bars spaced at 24 inches on centers in both directions.

DI-2: #3 bars spaced at 12 inches or #4 bars spaced at 18 inches on centers in both directions.

DI-3: #4 bars spaced at 18 inches on centers in both directions.

DI-4 & DI-5: #4 bars spaced at 12 inches on centers in both directions.

11.2.5. Control Joint Spacing. ACI recommendations indicate that control joints should be spaced at a maximum spacing of 30 times the thickness of the pavement for unreinforced parking lot pavements. Furthermore, ACI recommends a maximum control joint spacing of 12.5 feet for 5-inch pavements and a maximum control joint spacing of 15 feet for 6-inch or thicker pavements. Sawcut control joints should be cut within 4 to 12 hours of concrete placement to help control the formation of plastic shrinkage cracks as the concrete cures. The depth of the joint should be at least one-quarter of the slab depth when using a conventional saw or one inch when using early entry saws. The width of the cut should be in accordance with the joint sealant manufacturer recommendations.

11.2.6. Expansion Joint Spacing. ACI recommendations indicate that regularly spaced expansion joints may be deleted from concrete pavements. Therefore, the installation of expansion joints is optional and should be evaluated by the design team.

11.2.7. Construction Joints. When concrete is planned to be placed at different times, we recommend the use of a construction joint between paving areas. The construction joint should consist of a butt joint (not a keyway joint).

11.2.8. Concrete Curing Compound. A concrete curing compound, such as a Type 2, Class B membrane curing compound conforming to NDDOT Section 810.01 B.2 or equivalent, should be applied to the concrete surface within 30 minutes of screeding the concrete in accordance with NDDOT Standard Specifications.

11.2.9. Dowels at Expansion/Construction Joints. The dowels at expansion/construction joints should be spaced at 12-inch centers and consist of the following:

DI-1: 5/8-inch diameter, 12-inches long with 5-inch embedment.

DI-2: 3/4-inch diameter, 14-inches long with 6-inch embedment.

DI-3: 7/8-inch diameter, 14-inches long with 6-inch embedment.

DI-4: 1-inch diameter, 14-inch long with 6-inch embedment.

DI-5: 1-1/8-inch diameter, 16-inch long with 7-inch embedment.

11.2.10. Additional Considerations

The pavement design methods described above are intended to provide structural sections with adequate thickness over a particular subgrade such that wheel loads are reduced to a level the subgrade can support. The support characteristics of the subgrade for pavement design do not account for shrink/swell movements of an expansive clay subgrade such as the fat clays encountered at this site and the effects of frost action. Thus, the pavement may be adequate from a structural standpoint, yet still experience cracking and deformation due to shrink/swell related movement of the subgrade and frost action.

Post-construction subgrade movements and some cracking of pavements are not uncommon for clay subgrade conditions such as those observed at this site. Providing proper drainage and reducing the moisture changes in the subgrade is important to reduce frost action/shrink/swell movements. Removal of the existing soils within the frost zone (top 6.5 feet) and replacing with non-frost susceptible soils will help in reducing the frost elated movements, but, this option may not be economically feasible. Chemical treatment of the subgrade soils will also help to reduce such movement/cracking, but, this movement/cracking cannot be economically eliminated.

Related civil design factors such as subgrade drainage, shoulder support, cross-sectional configurations, surface elevations and environmental factors which will significantly affect the service life must be included in the preparation of the construction drawings and specifications. Normal periodic maintenance will be required.

Long-term pavement performance will be dependent upon several factors, including maintaining subgrade moisture levels and providing for preventative maintenance. The following recommendations should be implemented to help promote long-term pavement performance:

- The subgrade and the pavement surface should be designed to promote proper surface drainage, preferably at a minimum grade of 2 percent;
- Consideration should be given to the use of deep subgrade drains and maintain groundwater at a depth of 6.0 feet below the grade;
- Install joint sealant and seal cracks immediately;

- Extend curbs into the treated subgrade for a depth of at least 4 inches to help reduce moisture migration into the subgrade soils beneath the pavement section; and
- Place compacted, low permeability clayey backfill against the exterior side of the curb and gutter.

Preventative maintenance should be planned and provided for the pavements at this site. Preventative maintenance activities are intended to slow the rate of pavement deterioration and consist of both localized maintenance (e.g. crack and joint sealing and patching) and global maintenance (e.g. surface sealing). Prior to implementing any maintenance, additional engineering observations are recommended to determine the type and extent of preventative maintenance.

12.0 DYNAMIC SOIL PROPERTIES

12.1 Introduction

We understand that the proposed project includes the construction of vibratory equipment at the site. Typically, site-specific dynamic soil properties such as shear wave velocity, shear modulus, and Poisson's ratio are measured in the field using cross-hole testing, downhole testing, or Field Multichannel Analysis of Surface Waves (MASW) testing. Soil dynamic properties estimated from these tests are generally more precise and site specific than the values estimated from published literature.

Terracon was requested to provide dynamic soil parameters for the evaluation of the dynamic response of the above vibratory equipment foundations by performing one (1) downhole test in Boring DH-1. The test results are presented in **Appendix B** of this report. Based on the test results, the measured average shear wave velocity over a depth of 100 feet below the existing grade is about 1,064 feet/sec.

Table 18: Downhole Test Results (DH-1)

Parameter Description	Measured/Estimated Values
Design Average Shear Wave Velocity, V_s (feet/s)	1,064 to 1,200
Small Strain Shear Modulus, G_{max} (ksf)	4,570 to 5,814
Estimated Damping Ratio	0.03
Estimated Poisson's Ratio, μ	0.3 to 0.4
Note 1: The average shear velocity is 1,064 feet/sec within the top 100 feet below the existing grade (El.+2032 feet). Assuming the final grade is at El.+1988 feet and the upper 44 feet will be cut, the average shear velocity for the remaining soil depth (~56 feet) will increase to about 1,200 feet/sec.	

12.2 Dynamic Shear Modulus (G_{max})

Based on the measured shear wave velocity, the dynamic shear modulus can be computed using the following equation:

$$\text{Dynamic shear modulus, } G_{max}, \text{ psf} = \gamma_t (V_s)^2 / g$$

where

V_s = shear wave velocity, fps;

γ_t = total unit weight of soil, pcf; and

g = acceleration due to gravity, 32.2 ft./sec^2

Reductions to the initial shear modulus should be applied for different shear strain values. The shear modulus varies non-linearly with strain values. Large strain shear modulus values of

0.3Gmax to 0.5Gmax may be considered for design purposes. Please note advanced laboratory testing should be done for accurate shear modulus values at high displacement amplitudes.

12.3 Modulus of Elasticity (E)

The modulus of elasticity, E, values can be computed using the following equation:

$$E = 2G(\mu + 1)$$

where, G = Dynamic shear modulus, and μ = Poisson's ratio

12.4 Dynamic Spring Constants

Dynamic spring constants depend on the *in situ* dynamic soil properties and on the physical properties of the foundation element. Dynamic response of foundations is also dependent on the configuration of the foundation system. Dynamic spring constants for the proposed vibratory foundations are not included in our current scope of work. We will provide the spring constants under a separate report cover, if requested.

13.0 SEISMIC STUDY

13.1 Introduction

Terracon was requested to provide site classification information and liquefaction potential of the existing soils at the site based on the 2018 International Building Code (IBC). IBC-2018 requires a site soil profile determination extending a depth of 100 feet for seismic site classification. Boring DH-1 was drilled to a depth of 101 feet below existing grade (El.+2032 feet) and Borings B-1 was drilled to a depth of 121 feet below existing grade (El.+2000.9 feet) and Boring B-2 was drilled to a depth of 121 feet below existing grade (El.+1988 feet). Soil information from these borings was used in the site classification and liquefaction potential of the soils.

13.2 Seismic Site Classification

Based on the soil information from the borings and average shear wave velocity of 1,064 feet/sec measured in the downhole test, the site can be classified as Site Class “D”. Since the shear wave velocity was measured below the existing grade (El.+2032 feet) and the final grade is at El.+1988 feet, the average shear wave velocity may increase is measure again below the final grade of El.+1988 feet.

13.3 Site Liquefaction Potential

Terracon was requested to perform liquefaction potential of the existing soils at the site. Based on our evaluation of CPT data and the SPT data, liquefaction is not expected to occur at this site. For additional details, refer to **Appendix I** of this report.

14.0 CORROSION POTENTIAL

14.1 Introduction

Corrosion potential tests including pH, sulfate, chloride, and field resistivity tests were performed to evaluate the corrosion potential of existing near-surface soils on the steel and concrete elements. The results are provided in **Appendix C** of this report. The laboratory test results are compared with published guidelines to estimate potential corrosive characteristics of the on-site soils.

14.2 Laboratory Test Results

The laboratory tests were performed on the soil samples collected from the borings. The results are presented in **Table 19.**

Table 19: Corrosion Potential Test Results

Boring No.	Sample Depth (feet)	Soil Description	pH	Soluble Sulfate[1] (ppm)	Chloride[1] (ppm)	Field Electrical Resistivity (Ω-cm)
DH-1	9.5 to 11	Sandy Lean Clay	8.7	227	22.6	N/A
B-2	4.5 to 6	Silty Sand	8.0	357	92.7	N/A
B-4	N/A	N/A	N/A	N/A	N/A	2030 to 12,450

14.3 Published Guidelines

The following table presents some general guidelines that will be used in the evaluation of the corrosion potential of a soil based on chloride ion concentration, pH, and electrical resistivity[1]. Please note each of the columns in **Table 20** should be used independently.

Table 20: Corrosion Potential Guidelines - Steel

Resistivity, ohm-cm	Chlorides, ppm	pH	Corrosion Potential
0 - 1,000		0-4.5	Very High
1,000 - 2,000	> 500	4.5 - 5.5	High
2,000 - 5,000	< 500	5.5 - 6.5	Moderate
> 5,000		> 6.5	Mild

[1] *Palmer, J. F. (1974), "Soil Resistivity Measurements and Analysis", Materials Performance, Vol. 13.*

The guidelines presented in **Table 21** can be used to evaluate the need for protection of concrete[2]:

Table 21: Sulfate Ion Effect - Concrete

Sulfate Ion Concentration, ppm	Aggressiveness
> 20,000	Very Severe
2,000 to 20,000	Severe
1,000 to 2,000	Moderate
< 1,000	Mild

14.4 Corrosion Potential of Steel

The resistivity measured in the field are in a range of 2,30 to 12,450 ohm-centimeter. Resistivity results indicate the soil has mild to high corrosive potential to buried steel. Laboratory tests for pH and chloride concentrations indicate the soils at the site have mild to moderate corrosion potential to buried steel. If corrosion of buried metal is critical, it should be protected using a non-corrosive backfill, wrapping, coating, sacrificial anodes, or a combination of these methods, as designed by a qualified corrosion engineer. We recommend consulting with a Corrosion Engineer for recommendations regarding the protection of buried metals from corrosion.

14.5 Concrete Degradation

Results of soluble sulfate testing indicate the on-site soils possess mild concentrations when classified in accordance with Table 4.3.1 of the ACI Design Manual. Concrete should be designed in accordance with the provisions of the ACI Design Manual, Section 318, Chapter 4.

[2] *ACI Manual of Concrete Practice, Part 1, Section 201.2R-12, (1986).*

15.0 PERMANENT CUT AND FILL SLOPES

We understand that permanent slopes may be planned in different areas including: zones between area site grades, property boundaries, haul roads, storm water channels, and containment dikes. We did not perform detailed slope stability analyses due to lack of details including the loading conditions and the configuration of the slopes. However, we would like to provide the following recommendations based on our experience with soils similar to the soil conditions encountered at this site.

Permanent cut slopes in the areas of very stiff to hard clays should be designed with slopes of 2-horizontal to 1-vertical. Permanent fill constructed with structural sand fill and general fill or permanent cut slopes in the existing granular soils at the site should be designed with slopes of 3-horizontal to 1-vertical.

The exposed slopes should be protected from erosion by diverting surface runoff using shallow berms or channels. Where erosion due to wind or water is a concern, the slopes should be protected with a layer of crushed stone or geomat. If the fill slope will require equipment access, consideration should be given to flattening of the permanent fill slopes, constructed with structural sand fill and general fill, to 4-horizontal to 1-vertical.

We recommend that stockpiled materials be kept back from excavations at least a distance equal to the excavation depth to avoid surcharging the walls. Maximum slope of stockpiles will depend on the type of material. Stockpiles of silty sand/clayey sand/sandy clay should be designed with slopes of 3-horizontal to 1-vertical.

We recommend that the stability of cut and fill slopes be reviewed by a Geotechnical Engineer at the detailed design stage. We also recommend performing detailed slope stability analyses for permanent slopes and for slopes which require equipment access.

16.0 EARTHWORK

Earthwork generally includes clearing and grubbing, excavations, and fill placement. The following sections provide recommendations for use in the preparation of specifications for the earthwork.

16.1 Site Preparation

Site preparation should include clearing and grubbing and stripping all organics/vegetation and other deleterious materials. We expect this surficial loose soil will either be removed during grading or compacted/densified during site preparation. Subsequently, the exposed subgrade should be proof-rolled prior to the placement of any fill or base materials. The proof-rolling should be performed with a fully loaded, tandem-axle dump truck or other equipment providing an equivalent subgrade loading. A minimum gross weight of 20 tons is recommended for the proof-rolling equipment. The proof-rolling should consist of several overlapping passes in mutually perpendicular directions over a given area. Any soft or pumping areas should be excavated to firm ground. Over-excavated areas should be backfilled with properly placed and compacted fill as discussed in the following sections.

16.2 Fill Materials and Placement

Recommendations for general fill, granular fill, crushed stone fill, and NDDOT class 5 Aggregate Base are provided below.

16.2.1 General Fill. General fill is material used to achieve grade in areas located outside of foundation footprints. Near surface soils at the site, free of vegetation, debris, and rocks less than 4 inches in maximum dimension, are generally suitable as general fill. The existing soils that will be cut above the final grade of El.+1988 feet and consisting of lean clays/fat clays/clayey sands/silty sands are suitable as General Fill. Fill materials consisting of Lignite, coal, and landfill debris are also encountered at the existing ground surface. These fill materials are not suitable as General Fill. General Fill can be used in the areas located outside the footprint of the structures and pavements.

16.2.2 Structural Clay Fill. The on-site fat clays and granular soils are not considered acceptable for use as structural clay fill. Structural Clay Fill may be used to backfill around foundations and to achieve design grade. Structural Clay Fill should have a liquid limit of less than 40, a plasticity index between 8 and 20. It also should have at least 60 percent of the material finer than the No. 200 Sieve effective clod diameter of less than 3 inches. Structural Clay Fill should be placed in 6- to 9-inch-thick loose lifts and uniformly compacted at a moisture content of optimum to 2 percent “wet” to 1 percent “dry” of optimum. Structural clay fill should be compacted to at least 95 percent of the maximum dry density determined in accordance with Standard Proctor ASTM D698.

16.2.3 Clean Structural Sand Fill (Non-Frost Susceptible Soil). The on-site granular soils that will be excavated above the final grade are not suitable as clean structural sand fill due to high fines content. However, the existing clayey sands and silty sands can be used in areas located below the bottom of the frost zone. Clean structural sand fill can be used beneath the foundations,

slabs, and pavements. Granular select fill should consist of a well-graded sand/silty sand with fines no more than 10 percent passing No. 200 sieve. Granular select fill should be placed in loose lifts not more than 8 inches in thickness and should be compacted to at least 95 percent of the Modified Effort (ASTM D1557) maximum dry density. Granular material to be used should be well graded with the grain-size distribution shown in **Table 22.**

Table 22: Grain-Size Distribution

U.S. Sieve Standard Size	Percent Passing
No. 4	60 to 100
No. 10	40 to 85
No. 40	25 to 80
No. 200	0 to 10

16.2.4 Crushed Stone Fill (Non-Frost Susceptible Soil). Crushed stone can be used to raise grade beneath the proposed structures or as heavy haul road surfaces. In general, the crushed stone should be well graded and have the grain-size characteristics shown in **Table 23**.

Table 23: Gradation for Crushed Stone Fill

U.S. Sieve Standard Size	Percent Passing
1-½ " (38.1 mm)	100
7/8 " (22.23 mm)	70 to 90
No. 4	30 to 55
No. 10	20 to 34
No. 40	5 to 20
No. 200	6 to 10

Crushed stone should be well graded and have a maximum particle size of less than 38 mm. Crushed stone should be angular and have no more than 10 percent material passing the No. 200 sieve. The crushed stone should be placed in loose lifts not more than 150- to 200-mm-thick and uniformly compacted to 98 percent of the maximum dry density at a moisture content within 1 percent dry to 3 percent wet of the optimum moisture content. We expect a local product, likely crushed quarry stone will be available to meet the required specifications. That portion of the material passing the No. 40 sieve shall have a maximum liquid limit of 35 and a maximum plasticity index of 12 per ASTM D4318. Liquid limit and plastic limit tests are not required for select fill material with less than 15 % passing the No. 200 sieve. A Geotechnical Engineer should review the final selected material.

16.2.5 NDDOT Class 5 - Aggregate Base Course (Non-Frost Susceptible Soil). Aggregate base course should conform to North Dakota specifications-Section 816-03, Class 5 Aggregate Base. Aggregate base course can be used to raise grade beneath the proposed structures or as part of the pavement section. In general, the aggregate base course stone should be well graded and have the grain-size characteristics shown in Table 24.

Table 24: NDDOT Class 5 – Aggregate Base Course

US Sieve Standard Size	Percent Passing
1 inch	100
3/4 inch	90 to 100
#4	35 to 70
30	16 to 40
200	4 to 10

16.2.6 Grading and Drainage

All grades must provide effective drainage away from the foundation areas during and after construction and should be maintained throughout the life of the structure. Water ponding next to the foundation areas can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential floor slab and/or foundation movements, cracked slabs. Exposed ground should be sloped and maintained at a minimum 5 percent away from the foundation areas for at least 10 feet beyond the perimeter of the foundation areas.

After foundation construction and landscaping, final grades should be verified to document effective drainage has been achieved. Grades around the structures should also be periodically inspected and adjusted as necessary as part of the structure's maintenance program. Where paving or flatwork abuts the structure a maintenance program should be established to effectively seal and maintain joints and prevent surface water infiltration.

17.0 CONSTRUCTION CONSIDERATIONS

17.1 Introduction

Construction considerations for shallow foundations, drilled shafts, and driven H-piles are provided in this section.

17.2 Shallow Foundations

Excavations for the shallow foundations should be performed with equipment capable of providing a relatively clean bearing area. The bottom 6 inches of the excavations should be performed using a smooth-mouthed excavation bucket or by hand labor. The excavations should be neatly excavated and properly formed. Disturbance of the bearing area of the foundations should be minimized during the excavation operations. Soft zones observed during construction should be over-excavated to a firm and undisturbed soil layer and all loose materials in the excavation bottom should be removed before placement of concrete. Water should not be allowed to accumulate at the bottom of the foundation excavations. To reduce the potential for groundwater seepage into the excavations and to minimize disturbance to the bearing area, we recommend that steel and concrete be placed as soon as possible after the excavations are completed and properly cleaned. Excavations should not be left open for more than 24 hours. The bearing surface of the foundations should be evaluated immediately prior to placing concrete.

A thin seal slab (approximately 2 to 4 inches thick) should be placed at the bottom of the footing excavation to protect the bearing surface of the footing from disturbance if the footing cannot be poured within 24 hours following excavation.

17.3 Drilled Shaft Foundations

The drilling contractor should be experienced in the subsurface conditions observed at the site, and the excavations should be performed with equipment capable of providing a relatively clean bearing area. The drilled straight shaft foundations should be installed in general accordance with the procedures presented in " Drilled Shafts: Construction Procedures and LRFD Design Methods," by Brown, D.A., Turner, J.P., and Castelli, R.J., FHA Publication No. FHWA-NHI-10-016, 2010 and "Standard Specification for the Construction of Drilled Piers", ACI Publication No. 336.1-01, 2001.

The successful completion of the drilled shafts will depend to a large extent on the suitability of the equipment and the operator’s skills. The operation sequence should be scheduled so that the shaft excavations can be completed, reinforcing steel placed, and the concrete poured in a continuous, rapid, and orderly manner to minimize the time the excavations are open. Concrete should be placed as soon as practical and should be placed within the same day. Concrete should be poured with a tremie and should exhibit a six-inch slump with a ±one-inch tolerance.

Zones of sloughing soils and/or groundwater inflow may occur during construction, particularly in the more silty/sandy zones within the subgrade. Therefore, we recommend that provisions be

incorporated into the plans and specifications to utilize slurry or casing to control sloughing and/or groundwater seepage during shaft construction.

The need for casing or slurry will depend on the depth of the drilled shaft and the groundwater conditions at the time of construction. If casing is used and seepage persists, the water accumulating in the foundation excavation should be pumped out. The condition of the bearing surface should be evaluated immediately prior to placing concrete, if casing is used in lieu of slurry. If groundwater inflow is too severe to be controlled by the use of casing and pumping or significant sloughing of the sidewalls occurs, the slurry method of construction should be utilized to complete the foundation installation.

Where casing is used, removal of the casing should be performed with extreme care and under proper supervision to minimize mixing of the surrounding soil and water with the fresh concrete. Rapid withdrawal of the casing may develop a suction that could cause the soil and water to flow into the excavation. An insufficient head of concrete in the casing during withdrawal could also allow the water to intrude into the wet concrete. Under no circumstances should loose soil be placed in the annulus between the casing and the drilled shaft sidewalls. The casing must be removed in order to utilize the skin friction values previously provided.

During slurry displacement, the foundation excavation is filled with a slurry mixture. The level of slurry should be maintained above the groundwater level to maintain a positive head in the foundation excavation. Therefore, the slurry tends to seep out of the excavation, rather than the groundwater seeping into the open excavation. The slurry must be maintained in the foundation excavation until design termination depth is achieved and should be removed only as concreting proceeds. The properties of the slurry including the density, viscosity, and pH must be carefully controlled and should be in accordance with North Dakota Department of Transportation (NDDOT) Standard Specifications.

Slurry left in place for long periods of time will build up on the sides of the shaft causing a reduction in skin friction.

The following procedures and equipment are recommended for installation of the drilled shafts by the Slurry Displacement Method:

1. The bottom of the shaft should be cleaned as well as practical just prior to concreting to remove cuttings.
2. The concrete should be placed by means of a tremie with a one-way valve to prevent slurry from entering the pipe. The tremie should extend to the bottom of the shaft to allow displacement of the slurry.
3. The end of the tremie should remain several feet within the concrete mass to reduce the entrapment of slurry.
4. The concrete should be relatively fluid to reduce the entrapment of slurry. We recommend that concrete with a slump of 6 to 8 inches be used.

5. The upper few feet of concrete should be expunged from the shaft excavation if found to be contaminated with slurry or soil.

A surface casing may be required in addition to the slurry for shaft installation at this site if sloughing of the surficial soils occurs. Where casing is used, removal of the casing should be performed with extreme care as previously discussed in this section.

Production shaft installation should be closely monitored by a qualified engineer experienced in drilled shaft installation techniques. At a minimum, the engineer should monitor shaft excavation, note any unusual installation occurrences, monitor slurry properties and/or casing installation and removal, monitor concrete placement and generally evaluate if shaft installation is being performed in accordance with the project specifications.

17.4 Driven Piles

The installation of driven piles at this site should preferably be accomplished by driving alone. However, predrilling or controlled jetting may be required to achieve the design penetrations if excessive resistance to penetration occurs during driving. The effects and methods of pile installation should be given proper consideration when choosing and designing pile foundation systems. In most situations, the greatest stress a pile will experience is during installation. Pile and soil properties, embedment length requirements and driving equipment are only a few of the many variables to consider in determining the most efficient method of pile installation.

Production piles should be driven to a predetermined depth with blow count as a secondary consideration. Because set-up during interruptions can produce increased resistance to driving, a pile should be driven to its design depth without any delays, if possible.

Also, if a pile exhibits a resistance lower than the terminal resistance values given by driving formulas at an appreciable depth below the predetermined depth, the pile may be re-tapped after a suitable elapsed time and after the installation of other nearby piles. The re-tap should be performed at the contractor's discretion to prove the acceptability of the pile. Should, in the Geotechnical Engineer's judgment, the re-tap not indicate adequate capacity, a new pile should be installed to provide sufficient capacity.

We recommend that the pile driving contractor perform a wave equation analysis of pile driving (WEAP) prior to pile installation to evaluate the proposed pile driving system. The results of this analysis should be provided to Terracon for review prior to pile installation. In addition, we recommend the use of a "Pile Driving Analyzer" (PDA) during pile installation. The PDA can monitor driving stresses and hammer energy during pile installation, and also provides a continuous record of the pile installation. Such information can be beneficial in evaluation of the acceptability of a driven pile. Varying installation methods and soil conditions can have an effect on the soil-pile interaction and capacity.

The performance of the piles will be highly dependent upon the quality of construction. Thus, we recommend that pile installation be closely observed by a qualified inspector experienced in pile

installation techniques. At a minimum, the inspector should record blows, note any unusual installation occurrences, observe the hammer operation and generally evaluate if pile installation is being performed in accordance with the specifications.

17.5 Foundation Construction Monitoring

The performance of the foundation systems will be highly dependent upon the quality of construction. Thus, we recommend that subgrade preparation, fill compaction, and foundation installation be observed full time by an experienced Terracon soil technician under the direction of our geotechnical engineer. During foundation construction, the base of the footing excavations should be observed to evaluate the condition of the subgrade. We would be pleased to develop a plan for compaction and foundation installation observation to be incorporated in the overall quality control program.

19.6 Construction Observation and Testing

The earthwork efforts should be monitored under the direction of the Geotechnical Engineer. This monitoring should include documentation of adequate removal of vegetation and top soil, proof-rolling and mitigation of areas delineated by the proof-roll to require mitigation.

Each lift of compacted fill should be tested, evaluated, and reworked as necessary until approved by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency of at least one test for every 2,500 square feet of compacted fill in the building areas and 5,000 square feet in pavement areas. One density and water content test for every 50 linear feet of compacted utility trench backfill.

In areas of foundation excavations, the bearing subgrade should be evaluated under the direction of the Geotechnical Engineer. In the event unanticipated conditions are encountered, the Geotechnical Engineer should prescribe mitigation options.
In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

18.0 GENERAL COMMENTS

As the project progresses, we address assumptions by incorporating information provided by the design team, if any. Revised project information that reflects actual conditions important to our services is reflected in the final report. The design team should collaborate with Terracon to confirm these assumptions and to prepare the final design plans and specifications. This facilitates the incorporation of our opinions related to implementation of our geotechnical recommendations. Any information conveyed prior to the final report is for informational purposes only and should not be considered or used for decision-making purposes.

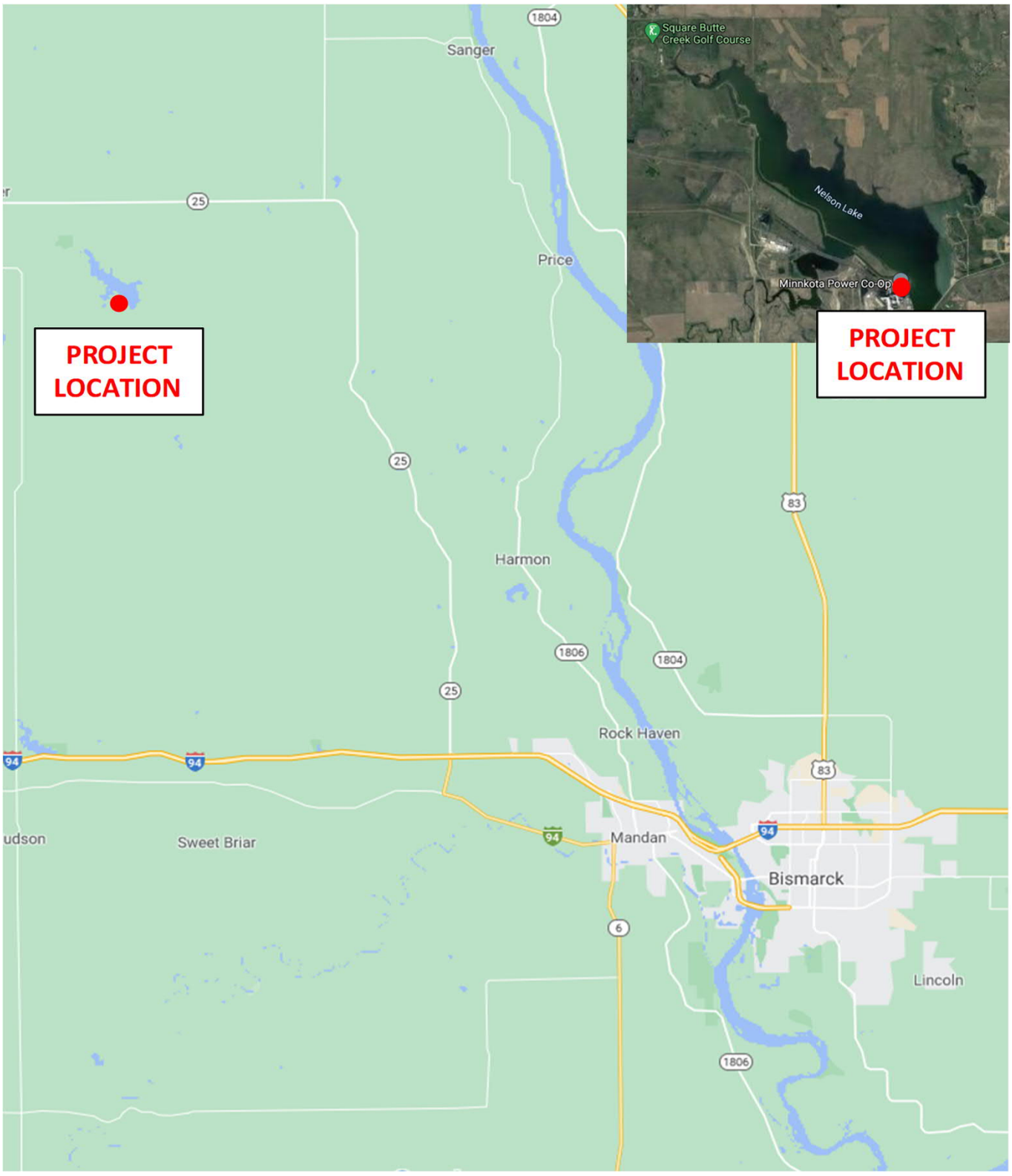
Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in the final report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our scope of services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken. Our services and any correspondence are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no 3rd party beneficiaries intended. Any 3rd party access to services or correspondence is solely for information purposes only. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

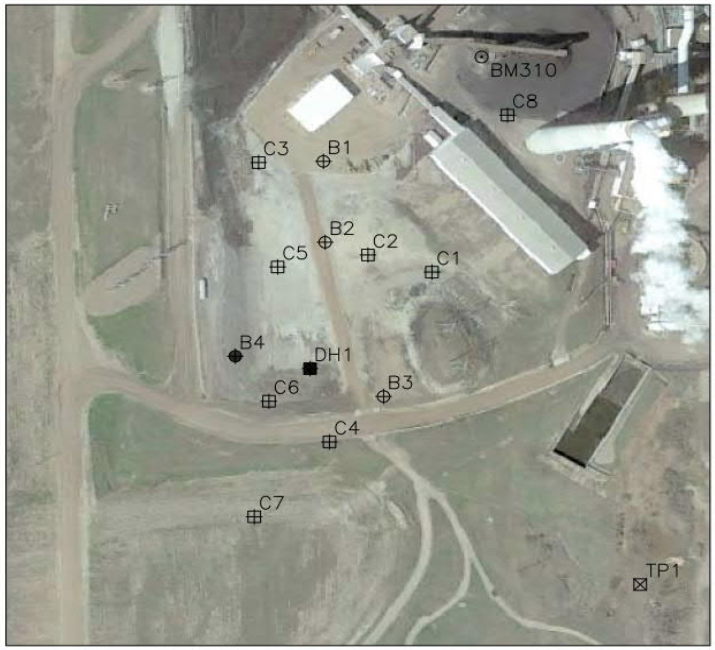
* * * *

EXHIBITS



Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	**VICINITY MAP** **PROJECT TUNDRA** **MINNKOTA POWER COOPERATIVE, INC.** **CENTER, NORTH DAKOTA**	**EXHIBIT** **1**
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/02/2020			
Approved by:	SRG					


BM-1001
BM-1003
BH S-1
BH S-1-2
BH S-1-3
BH S-2
BH S-2-2
BH S-2-3
BH S-2-4
BH S-2-5
BH S-2-7
BH S-2-8
BH S-3
BH S-3-1
BH S-3-3
BH S-3-4
BH S-4-2
BH S-5
BH S-5-1
BH S-5-2
BH S-5-3
BH S-5-4
BH S-5-5
BH B-1
BH B-3
BH B-4
BH C-1
BH C-2
BH C-5
BH C-6
BH D-1
EXISTING ACTIVE COAL STORAGE
F.F. EL.1908.87
ROTARY KILN MAINTENANCE BLDG
UNIT 2 CHIMNEY
EXISTING SILO
EXISTING LANDFILL
FUTURE CO2 TREATMENT AREA
COAL STORAGE (APPROX.)
FUTURE PIPERACK
PROPOSED RELOCATION OF 230 kV OVEF (APPROX.)
EXIST. 8" FIREWATER
EXIST. 20"-30" WOOD CHIP STORAGE
EXIST. 20" FIRE WATER
EXIST. BURNED AREA
EXIST. 8" FOOD RETURN LINE (ABANDONED)
EXIST. 8" FOOD RETURN LINE (ABANDONED)
EXIST. 6" FOOD RETURN LINE (ABANDONED)
EXIST. 4" FOOD RETURN LINE (ABANDONED)
EXIST. 4" FOOD RETURN LINE (ABANDONED)
EXIST. 4





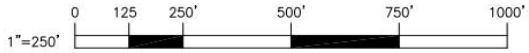
NOTES:

1. COORDINATES PROVIDED ARE IN NORTH DAKOTA SOUTH STATE PLANE, ZONE 3302, NAD 27, US SURVEY FEET; NGVD 29 (VERTICAL) COORDINATE SYSTEM.
2. CONTRACTOR SHALL WORK AROUND THE EXISTING FACILITIES AS NECESSARY.
3. DH1 SHALL BE USED TO DEVELOP DYNAMIC PROPERTIES OF SOIL USING DOWN HOLE TEST.
4. CONTRACTOR TO PROPOSE ALTERNATE BOREHOLE AND CPT LOCATIONS IN PLACES WHERE PROPOSED LOCATION IS EITHER INACCESSIBLE OR PERMIT CANNOT BE OBTAINED.

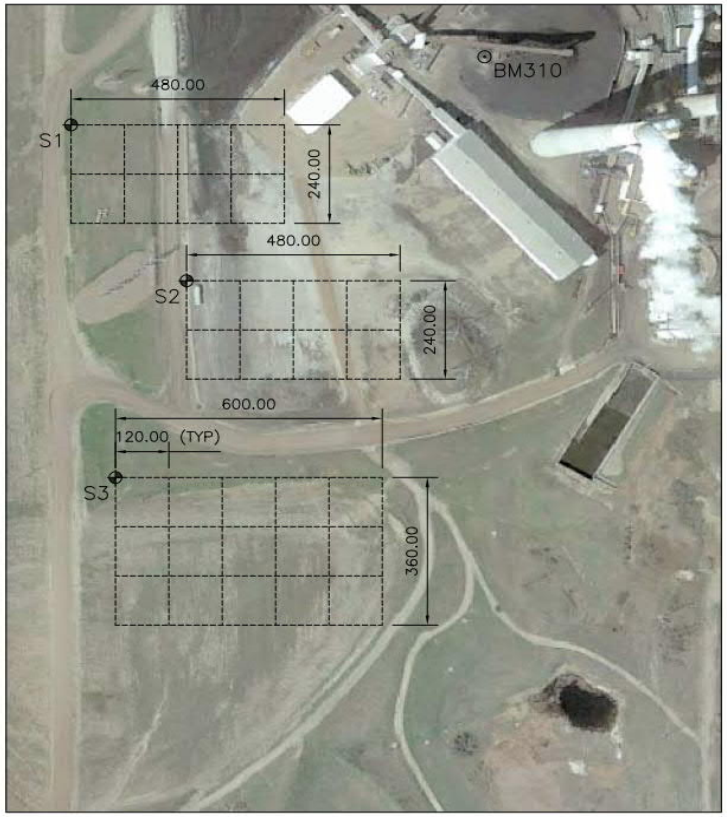
NUMBER	EASTING	NORTHING	DEPTH
B1	E 146604.00	N 22724.00	120 FT
B2	E 146608.00	N 22521.00	120 FT
B3	E 146743.00	N 22134.00	60 FT
B4	E 146400.00	N 22235.00	80 FT
C1	E 146855.00	N 22446.00	80 FT
C2	E 146707.00	N 22489.00	80 FT
C3	E 146454.00	N 22721.00	80 FT
C4	E 146618.00	N 22020.00	80 FT
C5	E 146498.00	N 22459.00	80 FT
C6	E 146478.00	N 22122.00	60 FT
C7	E 146444.00	N 21832.00	80 FT
C8	E 147030.00	N 22840.00	80 FT
DH1	E 146573.00	N 22204.00	100 FT
TP1	E 147337.00	N 21662.00	5 FT

LEGEND:

- BM310 — BENCHMARK (REFERENCE)
- B1 — BOREHOLE
- B4 — BOREHOLE, ELECTRICAL AND THERMAL RESISTIVITY TEST
- C1 — CONE PENETRATION TEST (CPT) USING A 20–TON RIG
- DH1 — DOWN HOLE TEST
- TP1 — TEST PIT



Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	**EXPLORATION PLAN** **PROJECT TUNDRA** **MINNKOTA POWER COOPERATIVE, INC.** **CENTER, NORTH DAKOTA**	**EXHIBIT** **3A**
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/02/20			
Approved by:	SRG					





NOTES:

1. COORDINATES PROVIDED ARE IN NORTH DAKOTA SOUTH STATE PLANE, ZONE 3302, NAD 27, US SURVEY FEET; NGVD 29 (VERTICAL) COORDINATE SYSTEM.
2. CONTRACTOR SHALL WORK AROUND THE EXISTING FACILITIES AS NECESSARY.
3. APPROXIMATE GPR SCAN LENGTH = 9840 FT.
4. ALL DIMENSIONS ARE IN FEET.

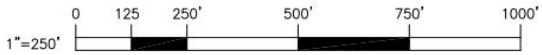
LEGEND:

BM310 — BENCHMARK (REFERENCE)

S1 — SURVEY POINT

-------- GPR SCAN PATH

NUMBER	EASTING	NORTHING
S1	E 146040.00	N 22820.00
S2	E 146300.00	N 22440.00
S3	E 146140.00	N 21960.00



Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	**EXPLORATION PLAN PROJECT TUNDRA MINNKOTA POWER COOPERATIVE, INC. CENTER, NORTH DAKOTA**	**EXHIBIT 3B**
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/02/20			
Approved by:	SRG					

BORING LOG NO. DH-1

PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

SITE: 3401 24th Street SW
Center, ND

LOCATION See Exploration Plan

Latitude: 47.0651° Longitude: -101.2201°

Surface Elev.: 2031.9 (Ft.)

DEPTH	ELEVATION (Ft.)	Description
0.6	2031.5	**FILL - TOPSOIL**, brown
		FILL - SANDY LEAN CLAY (CL), brown, landfill debris consisting of wood, paper, and metal wiring, coal
12.0	2020	**CLAYEY SAND (SC)**, fine grained, light brown to light gray, medium dense, sandstone layer at 21.5-24'
39.5	1992.5	**FAT CLAY (CH)**, very dark brown to olive gray, hard

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		14	9-11-16 N=27			
5		3	4-2-2 N=4	12.2		
10		13	6-8-11 N=19			
15		17	6-9-12 N=21	18.2	35-16-19	
20		18	6-12-18 N=30			
25		16	21-14-24 N=38	21.2	39-14-25	37
30		15	6-9-13 N=22			
35		14	6-9-14 N=23	21.9	39-15-24	36
40		16	6-21-25 N=46			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4¼" Inside Diamter, Hollow Stem Auger 0-19½', Mud Rotary 19½-99½

Abandonment Method:
Boring backfilled with cement-bentonite grout upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

None encountered

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Boring Started: 09-14-2020 | Boring Completed: 09-14-2020

Drill Rig: Mobile B-57 | Driller: Mike Roberts

Project No.: M2205062

EXHIBIT 4A

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/28/20

BORING LOG NO. DH-1

PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

SITE: 3401 24th Street SW
Center, ND

LOCATION See Exploration Plan

Latitude: 47.0651° Longitude: -101.2201°

Surface Elev.: 2031.9 (Ft.)

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	FAT CLAY (CH), very dark brown to olive gray, hard *(continued)*							
46.0	1986	45	X	16	7-26-65 N=91	22.8	87-18-69	
	SILTY SAND (SM), fine grained, light gray, dense to very dense	50	X	15	11-18-48 N=66			40
		55	X	16	8-13-18 N=31			
58.0	1974							
	SANDY FAT CLAY (CH), gray, hard	60	X	16	13-19-34 N=53	27.5	89-16-73	99
		65	X	16	10-16-21 N=37			
		70	X	15	10-27-36 N=63			
73.0	1959							
	FAT CLAY (CH), olive gray, hard	75	X	16	16-28-65 N=93			
76.0	1956							
77.0	**LIGNITE**, black 1955							
	FAT CLAY (CH), very dark gray, hard, silt seams	80	X	16	15-26-38 N=64	24.1	122-17-105	

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4¼" Inside Diamter, Hollow Stem Auger 0-19½', Mud Rotary 19½-99½

Abandonment Method:
Boring backfilled with cement-bentonite grout upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

None encountered

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Boring Started: 09-14-2020 | Boring Completed: 09-14-2020

Drill Rig: Mobile B-57 | Driller: Mike Roberts

Project No.: M2205062

EXHIBIT 4B

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/28/20

BORING LOG NO. DH-1

PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

SITE: 3401 24th Street SW
Center, ND

LOCATION See Exploration Plan

Latitude: 47.0651° Longitude: -101.2201°

Surface Elev.: 2031.9 (Ft.)

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		85									
					17	20-31-56 N=87					
		90									
					16	21-27-48 N=75		18.3		57-13-44	
		95									
					14	23-53-46 N=99					
		100									
					13	24-44-51 N=95					

FAT CLAY (CH), very dark gray, hard, silt seams
(continued)

101.0 1931

Boring Terminated at 101 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4¼" Inside Diamter, Hollow Stem Auger 0-19½', Mud Rotary 19½-99½

Abandonment Method:
Boring backfilled with cement-bentonite grout upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

None encountered

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Boring Started: 09-14-2020 Boring Completed: 09-14-2020

Drill Rig: Mobile B-57 Driller: Mike Roberts

Project No.: M2205062

EXHIBIT 4C

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/28/20

BORING LOG NO. B-1

PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

SITE: 3401 24th Street SW
Center, ND

LOCATION See Exploration Plan

Latitude: 47.0652° Longitude: -101.2186°

Surface Elev.: 2000.9 (Ft.)

DEPTH	ELEVATION (Ft.)	Description
0.3	2000.5	**TOPSOIL**, brown
		FILL - LIGNITE, black, clay seams
12.5	1988.5	
14.0	1987	**SANDSTONE**, light gray, very dense
16.0	1985	**CLAYEY SAND (SC)**, fine grained, light gray, medium dense
19.0	1982	**LEAN CLAY WITH SAND (CL)**, grayish brown, very stiff
29.0	1972	**FAT CLAY (CH)**, very dark grayish brown, very stiff to hard
33.5	1967.5	**FAT CLAY WITH SAND (CH)**, gray, hard
		FAT CLAY (CH), gray, hard, silt seams

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		8	3-5-5 N=10				
5		12		62.2		71-28-43	68
		13	6-10-11 N=21				
10		12					
		6	100 N= 100/5	19.2	105		
15		16					40
		15	9-9-14 N=23	18.6		37-16-21	79
20		24					
		16	12-19-28 N=47				
25		20					
		14	9-9-13 N=22				
30		18					
		12	8-14-21 N=35	25.0		65-15-50	74
35		14	6-9-11 N=20				
40		16	13-18-27 N=45	21.2		68-16-52	

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4¼" Inside Diamter, Hollow Stem Auger 0-19½', Mud Rotary 19½-119½

Abandonment Method:
Boring backfilled with bentonite grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

None encountered

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Boring Started: 09-15-2020 | Boring Completed: 09-15-2020

Drill Rig: Mobile B-57 | Driller: Mike Roberts

Project No.: M2205062

EXHIBIT 5A

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/28/20

BORING LOG NO. B-1

PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

SITE: 3401 24th Street SW
Center, ND

LOCATION See Exploration Plan

Latitude: 47.0652° Longitude: -101.2186°

Surface Elev.: 2000.9 (Ft.)

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
	FAT CLAY (CH), gray, hard, silt seams *(continued)*	45	17	11-18-20 N=38		
		50	0			
55.5	1945.5	55	6	100 N= 100/6		
	LIGNITE, black					
57.5	1943.5					
	FAT CLAY (CH), dark gray, hard, silt seams	60	16	15-35-54 N=89	17.3	59-16-43
		65	15	16-37-53 N=90		
		70	13	25-40-60 N=100 100/10		
74.0	1927					
	LEAN CLAY (CL), gray, hard	75	12	30-44-56 N=100	27.9	32-21-11
77.0	1924					
	FAT CLAY (CH), gray, hard	80	15	17-22-30 N=52		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4¼" Inside Diamter, Hollow Stem Auger 0-19½', Mud Rotary 19½-119½

Abandonment Method:
Boring backfilled with bentonite grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

None encountered

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Boring Started: 09-15-2020 | Boring Completed: 09-15-2020

Drill Rig: Mobile B-57 | Driller: Mike Roberts

Project No.: M2205062

EXHIBIT 5B

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/28/20

BORING LOG NO. B-1

PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

SITE: 3401 24th Street SW
Center, ND

LOCATION See Exploration Plan

Latitude: 47.0652° Longitude: -101.2186°

Surface Elev.: 2000.9 (Ft.)

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	FAT CLAY (CH), gray, hard *(continued)*	85			16	20-26-31 N=57					
		90			16	19-24-34 N=58		18.3		96-13-83	
		95			16	19-24-34 N=58					
		100			17	28-35-54 N=89					
		105			15	23-37-52 N=89		16.8		73-15-58	
		110			16	21-25-36 N=61					
		115			17	20-26-39 N=65					
121.0	1880	120			17	22-30-46 N=76					
	Boring Terminated at 121 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4¼" Inside Diamter, Hollow Stem Auger 0-19½', Mud Rotary 19½-119½

Abandonment Method:
Boring backfilled with bentonite grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

None encountered

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Boring Started: 09-15-2020 | Boring Completed: 09-15-2020

Drill Rig: Mobile B-57 | Driller: Mike Roberts

Project No.: M2205062

EXHIBIT 5C

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/28/20

BORING LOG NO. B-2

PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

SITE: 3401 24th Street SW
Center, ND

LOCATION See Exploration Plan

Latitude: 47.0652° Longitude: -101.2179°

Surface Elev.: 1988.0 (Ft.)

DEPTH	ELEVATION (Ft.)	Material Description
0.5	1987.5	**FILL - TOPSOIL**, brown
		FILL - SILTY SAND, fine to medium grained, light brown, lignite/bottom ash
6.0	1982	
		FAT CLAY (CH), brownish gray, very stiff to hard
28.0	1960	
		LIGNITE, black
32.0	1956	
		FAT CLAY (CH), brownish gray, hard
41.0	1947	
		SILT (ML), gray, hard

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		11	7-7-7 N=14					
5		8	2-2-3 N=5					30
		10		6930	20.1	107		
10		16	6-12-15 N=27					
		24						
15		16	12-18-21 N=39		17.5		79-17-62	
20		10						
25		15	8-13-21 N=34					
30		6	100 N= 100/6					
35		14	12-17-24 N=41		19.5		92-16-76	
40		0						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4¼" Inside Diamter, Hollow Stem Auger 0-19½', Mud Rotary 19½-119½

Abandonment Method:
Boring backfilled with bentonite grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

None encountered

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Boring Started: 09-16-2020 | Boring Completed: 09-16-2020

Drill Rig: Mobile B-57 | Driller: Mike Roberts

Project No.: M2205062

EXHIBIT 6A

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/28/20

BORING LOG NO. B-2

PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

SITE: 3401 24th Street SW
Center, ND

LOCATION See Exploration Plan

Latitude: 47.0652° Longitude: -101.2179°

Surface Elev.: 1988.0 (Ft.)

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SILT (ML), gray, hard *(continued)*						
44.0	1944		13	20-50-50 N=100 100/9			
	FAT CLAY, gray, hard	45	17	25-37-59 N=96			
		50	16	26-40-58 N=98			
53.0	1935						
	LEAN CLAY (CL), dark gray, hard	55	16	17-21-28 N=49	20.1	36-17-19	99
		60	17	16-23-30 N=53			
62.0	1926						
	FAT CLAY (CH), dark gray, hard	65	15	13-17-23 N=40			
		70	16	14-19-24 N=43			
		75	16	15-21-26 N=47	21.3	76-14-62	
		80	6	100 N= 100/6			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4¼" Inside Diamter, Hollow Stem Auger 0-19½', Mud Rotary 19½-119½

Abandonment Method:
Boring backfilled with bentonite grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

None encountered

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Boring Started: 09-16-2020 | Boring Completed: 09-16-2020

Drill Rig: Mobile B-57 | Driller: Mike Roberts

Project No.: M2205062

EXHIBIT 6B

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/28/20

BORING LOG NO. B-2

PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

SITE: 3401 24th Street SW
Center, ND

LOCATION See Exploration Plan

Latitude: 47.0652° Longitude: -101.2179°

Surface Elev.: 1988.0 (Ft.)

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		85									
					17	19-28-43 N=71					
		90									
					17	20-25-40 N=65		21.0		87-15-72	
		95									
					16	21-24-28 N=52					
		100									
					15	19-25-29 N=54					
		105									
					16	20-22-25 N=47		23.0		58-12-46	39
		110									
					16	19-26-27 N=53					
		115									
					17	20-21-23 N=44					
		120									
					17	21-23-24 N=47					

FAT CLAY (CH), dark gray, hard *(continued)*

98.0 1890

SANDY FAT CLAY (CH), gray, hard

121.0 1867

Boring Terminated at 121 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4¼" Inside Diamter, Hollow Stem Auger 0-19½', Mud Rotary 19½-119½

Abandonment Method:
Boring backfilled with bentonite grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

None encountered

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Boring Started: 09-16-2020 Boring Completed: 09-16-2020

Drill Rig: Mobile B-57 Driller: Mike Roberts

Project No.: M2205062

EXHIBIT 6C

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/28/20

BORING LOG NO. B-3

PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

SITE: 3401 24th Street SW
Center, ND

LOCATION See Exploration Plan

Latitude: 47.064° Longitude: -101.2176°

Surface Elev.: 2000.1 (Ft.)

DEPTH	ELEVATION (Ft.)	Description
1.0	1999	**FILL - SAND WITH GRAVEL**, fine to coarse grained, light brown
2.0	1998	**FILL - LIGNITE**, black
		CLAYEY SAND (SC), fine grained, light brown, medium dense
9.0	1991	
		FAT CLAY (CH), gray, very stiff
11.0	1989	
		LIGNITE, black
14.0	1986	
		FAT CLAY (CH), gray, hard, claystone 17-18'
33.0	1967	
		FAT CLAY (CH), light olive gray, hard, very hard layer at 33' (weathered shale)

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		10	1-4-6 N=10			37
5		24		18.3	35-17-18	32
		13	5-6-8 N=14			
10		10	4-6-14 N=20			
		10	5-6-6 N=12			
15		24				
20		15	7-11-18 N=29	20.9	79-14-65	
25		10				
30		14	8-13-24 N=37			
35		4				
40		16	14-22-39 N=61	20.5	143-17-126	

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3¼" Inside Diamter, Hollow Stem Auger 0-59½'

Abandonment Method:
Boring backfilled with bentonite grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

None encountered

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Boring Started: 09-16-2020 | Boring Completed: 09-16-2020

Drill Rig: Mobile B-57 | Driller: Mike Roberts

Project No.: M2205062

EXHIBIT 7A

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/28/20

BORING LOG NO. B-3

PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

SITE: 3401 24th Street SW
Center, ND

LOCATION See Exploration Plan

Latitude: 47.064° Longitude: -101.2176°

Surface Elev.: 2000.1 (Ft.)

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
	FAT CLAY (CH), light olive gray, hard, very hard layer at 33' (weathered shale) *(continued)*	45	16	20-29-42 N=71	16.2	67-16-51
		50	14	21-27-41 N=68		
54.0	1946					
	SILTY CLAY (CL-ML), light gray, hard	55	10	20-30-44 N=74	20.8	27-21-6
61.0	1939	60	5	100 N= 100/6		
	Boring Terminated at 61 Feet					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3¼" Inside Diamter, Hollow Stem Auger 0-59½'

Abandonment Method:
Boring backfilled with bentonite grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

None encountered

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Boring Started: 09-16-2020 | Boring Completed: 09-16-2020

Drill Rig: Mobile B-57 | Driller: Mike Roberts

Project No.: M2205062

EXHIBIT 7B

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/28/20

BORING LOG NO. B-4

PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

SITE: 3401 24th Street SW
Center, ND

LOCATION See Exploration Plan

Latitude: 47.0646° Longitude: -101.2198°

Surface Elev.: 2031.3 (Ft.)

DEPTH	ELEVATION (Ft.)	LITHOLOGY
0.5	2031	**TOPSOIL**, brown
2.0	2029.5	**SANDY LEAN CLAY (CL)**, brown, very stiff
		SILTY CLAYEY SAND (SC-SM), fine grained, light brown, medium dense
8.0	2023.5	**SILTY SAND (SM)**, fine to medium grained, brown, medium dense
33.0	1998.5	**FAT CLAY (CH)**, dark gray, hard
41.0	1990.5	**LIGNITE**, black

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
			4-9-9 N=18				
		24					
5		24		12.5	98	28-22-6	29
			4-3-3 N=6				
10		24					
			6-9-13 N=22				
15			6-9-14 N=23				
20		24					32
25			6-8-14 N=22				36
30		24					
35		0					
			10-29-36 N=65	25.2		98-20-78	
40			11-24-50 N=74				

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4¼" Inside Diamter, Hollow Stem Auger 0-19½', Mud Rotary 19½-79½

Abandonment Method:
Boring backfilled with bentonite grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

None encountered

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Boring Started: 09-17-2020 | Boring Completed: 09-17-2020

Drill Rig: Mobile B-57 | Driller: Mike Roberts

Project No.: M2205062

EXHIBIT 8A

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/28/20

BORING LOG NO. B-4

PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

SITE: 3401 24th Street SW
Center, ND

LOCATION See Exploration Plan

Latitude: 47.0646° Longitude: -101.2198°

Surface Elev.: 2031.3 (Ft.)

DEPTH	ELEVATION (Ft.)	Material Description
42.5	1989	**FAT CLAY (CH)**, gray, hard
54.0	1977.5	**CLAYEY SAND (SC)**, fine grained, light gray, dense
56.0	1975.5	**FAT CLAY (CH)**, dark gray, hard, sand seams
76.0	1955.5	
77.0	1954.5	**LIGNITE**, black
		SILTY CLAY WITH SAND (CL-ML), brownish gray, hard
81.0	1950.5	
		Boring Terminated at 81 Feet

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
45			10-15-23 N=38			
			11-17-24 N=41	18.8	93-18-75	
50			6-11-13 N=24			
55		16		22.3	49-17-32	45
60			10-15-27 N=42			
65			11-14-24 N=38	19.5	69-14-55	
70			17-34-46 N=80			
75			17-32-68 N=100 100/9			
80			17-35-65 N=100 100/9	22.8	26-21-5	77

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4¼" Inside Diamter, Hollow Stem Auger 0-19½', Mud Rotary 19½-79½

Abandonment Method:
Boring backfilled with bentonite grout upon completion

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

None encountered

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Boring Started: 09-17-2020 | Boring Completed: 09-17-2020

Drill Rig: Mobile B-57 | Driller: Mike Roberts

Project No.: M2205062

EXHIBIT 8B

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/28/20

TEST PIT LOG NO. TP-1

PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

SITE: 3401 24th Street SW
Center, ND

LOCATION See Exploration Plan

Latitude: 47.0661° Longitude: -101.2162°

Surface Elev.: 2041.4 (Ft.)

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.6	2041										
TOPSOIL, dark brown											
SANDY LEAN CLAY (CL), brown								13.5		49-13-36	61
4.0	2037.5										
5.0 **CLAYEY SAND (SC)**, fine grained, light brown	2036.5	5									
Test Pit Terminated at 5 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

Elevations referenced to Benchmark 310
Elevations referenced to CP 100 - IME base control

WATER LEVEL OBSERVATIONS

None encountered

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Test Pit Started: 09-18-2020 | Test Pit Completed: 09-18-2020

Excavator: Trackhoe | Operator: Mike Roberts

Project No.: M2205062

EXHIBIT 9

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/28/20

CPT LOG NO. C - 1

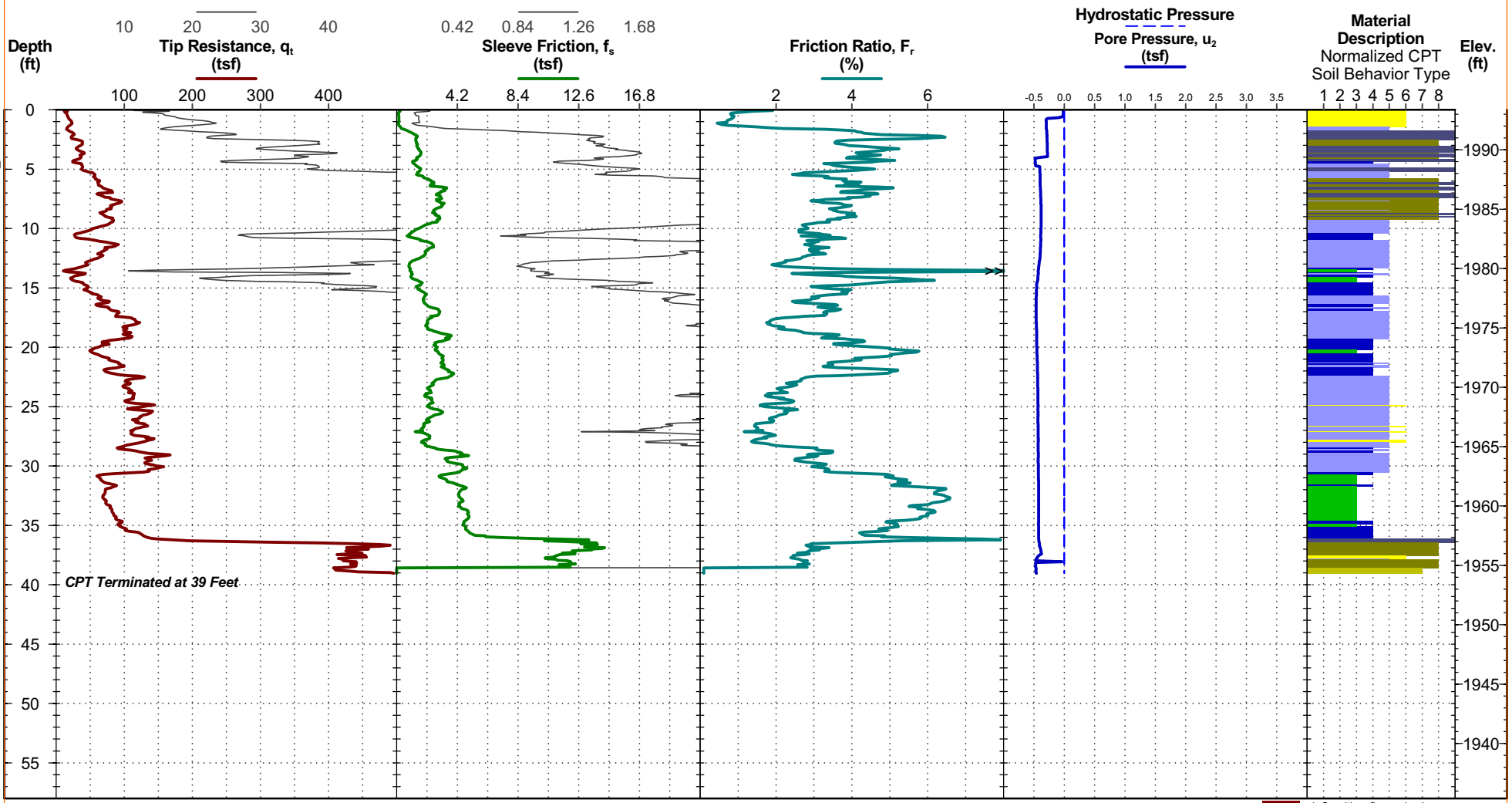
PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

TEST LOCATION: See Exploration Plan

Surface Elev.: 1993.372 ft
Latitude: 47.06485355°
Longitude: -101.2171658°

SITE: 3401 24th Street SW
Center, ND



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

WATER LEVEL OBSERVATION

▼ 60 ft estimated water depth
(used in normalizations and correlations; See Supporting Information)

Probe no. DDG1555 with net area ratio of .807
U2 pore pressure transducer location
Manufactured by Vertek; calibrated 9/17/2020
Tip and sleeve areas of 15 cm^2 and 225 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

CPT Started: 10/1/2020
CPT Completed: 10/1/2020
Rig:
Operator: Michael
Project No.: M2205062

EXHIBIT 10

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT REPORT M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/13/20

CPT LOG NO. C - 2

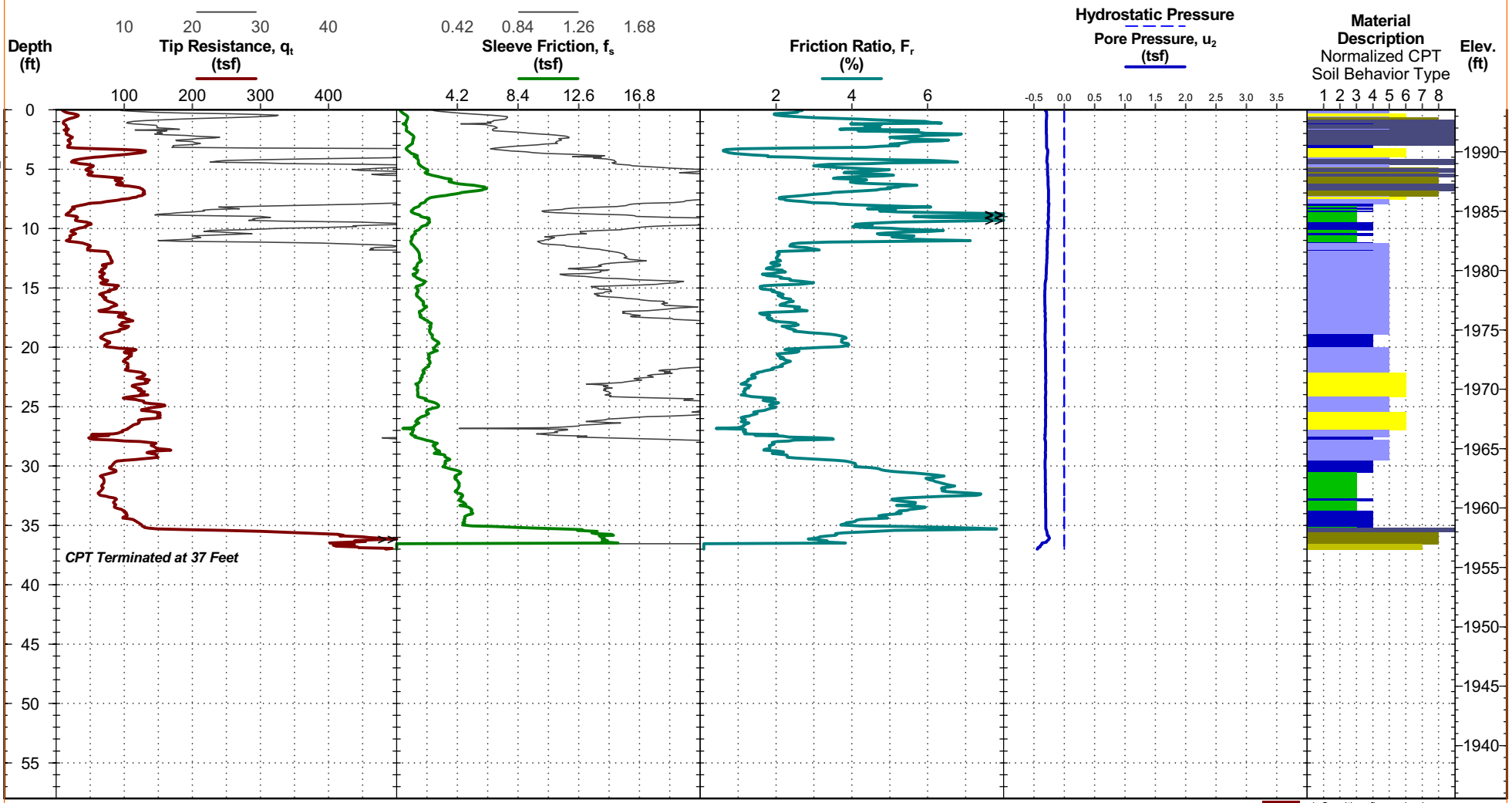
PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

TEST LOCATION: See Exploration Plan

Surface Elev.: 1993.542 ft
Latitude: 47.06455351°
Longitude: -101.2177877°

SITE: 3401 24th Street SW
Center, ND



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

WATER LEVEL OBSERVATION

60 ft estimated water depth
(used in normalizations and correlations; See Supporting Information)

Probe no. DDG1555 with net area ratio of .807
U2 pore pressure transducer location
Manufactured by Vertek; calibrated 9/17/2020
Tip and sleeve areas of 15 cm^2 and 225 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

CPT Started: 10/1/2020
CPT Completed: 10/1/2020
Rig:
Operator: Michael
Project No.: M2205062

EXHIBIT 11

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT REPORT M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/13/20

CPT LOG NO. C - 3

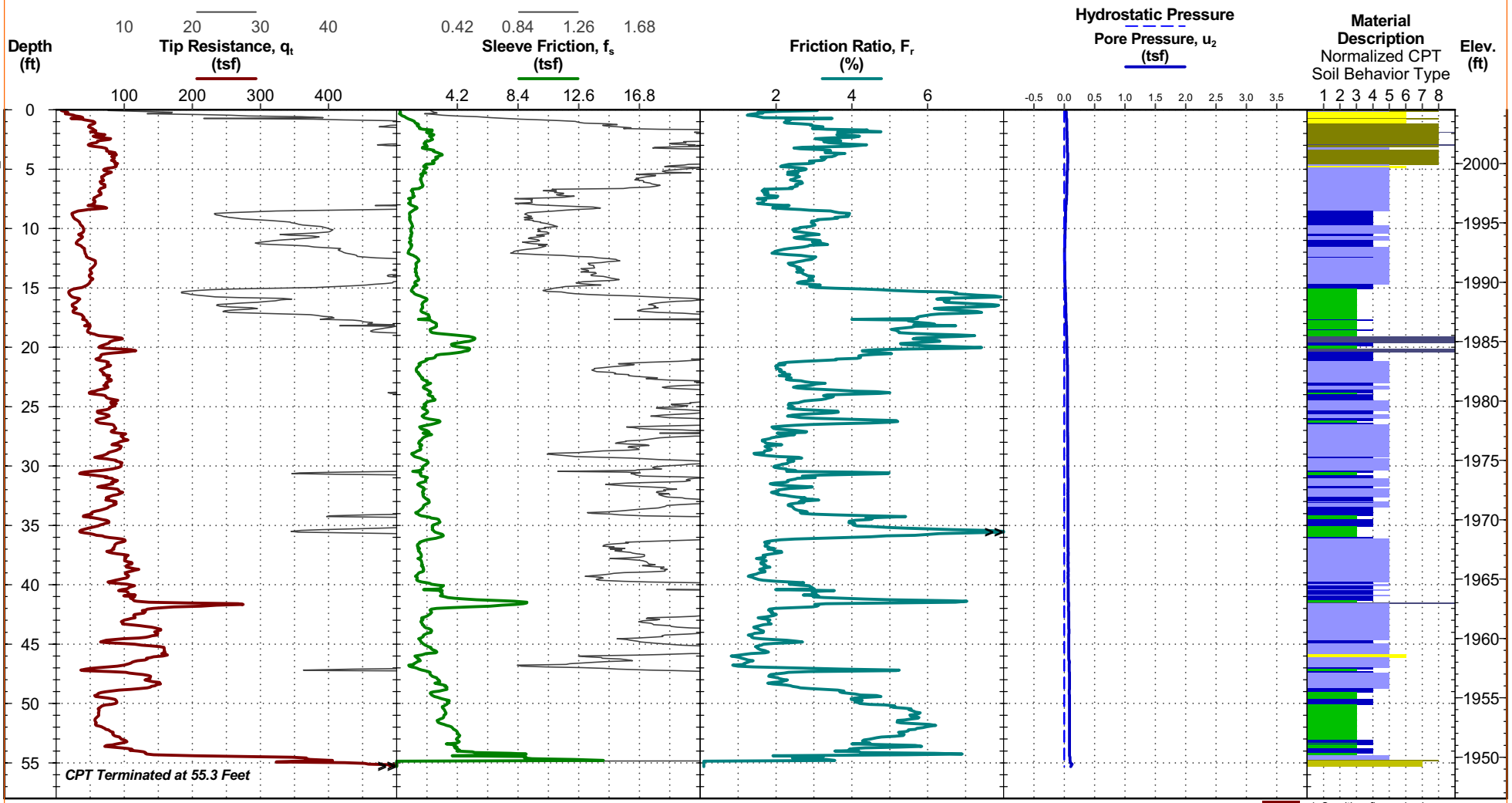
PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

TEST LOCATION: See Exploration Plan

Surface Elev.: 2004.522 ft
Latitude: 47.06551834°
Longitude: -101.21885°

SITE: 3401 24th Street SW
Center, ND



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

WATER LEVEL OBSERVATION

60 ft estimated water depth
(used in normalizations and correlations; See Supporting Information)

Probe no. DDG1555 with net area ratio of .807
U2 pore pressure transducer location
Manufactured by Vertek; calibrated 9/17/2020
Tip and sleeve areas of 15 cm^2 and 225 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

CPT Started: 10/1/2020
CPT Completed: 10/1/2020
Rig:
Operator: Michael
Project No.: M2205062

EXHIBIT 12

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT REPORT M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/13/20

CPT LOG NO. C - 4

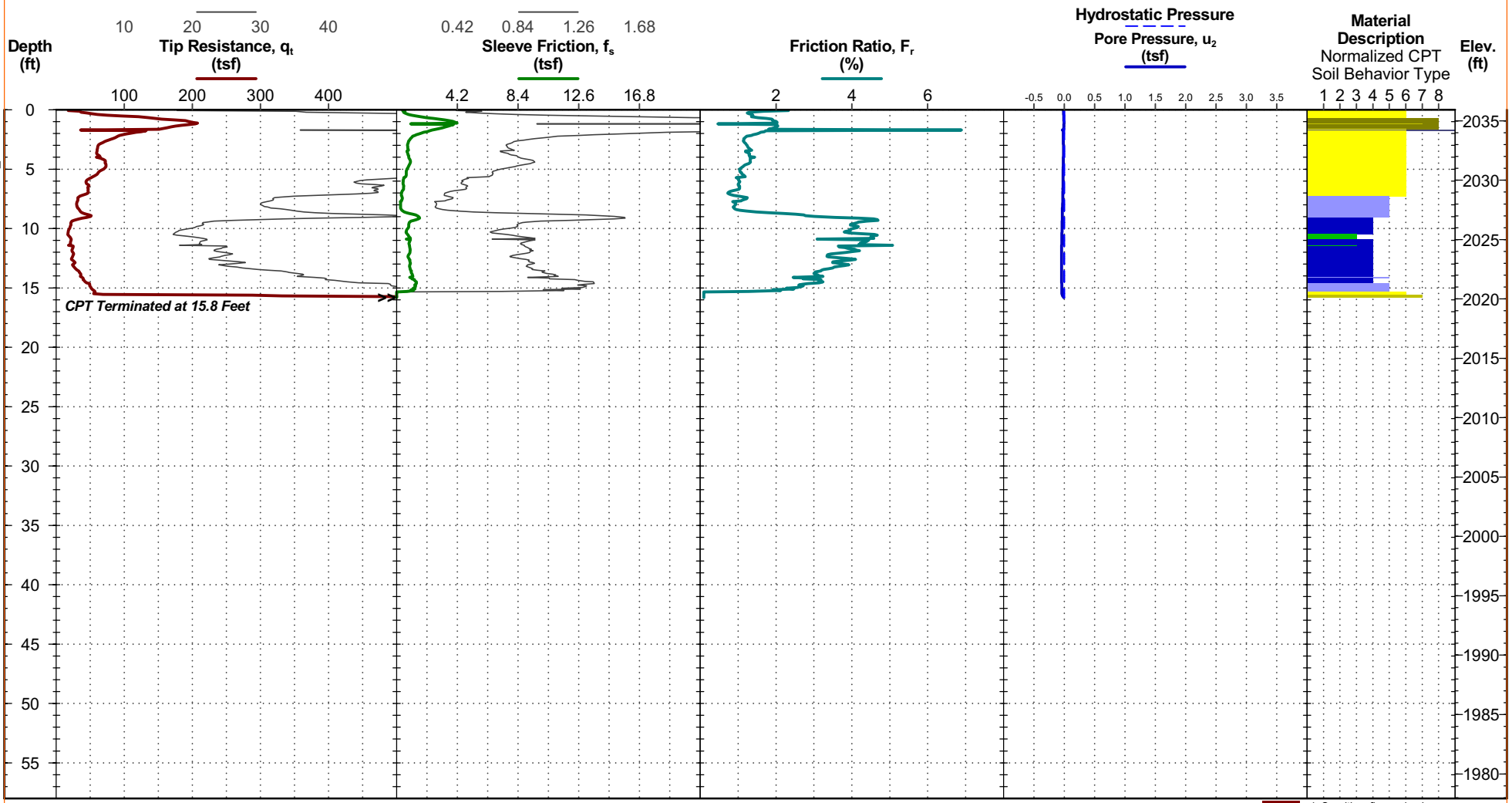
PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

TEST LOCATION: See Exploration Plan

Surface Elev.: 2035.932 ft
Latitude: 47.06378869°
Longitude: -101.2195669°

SITE: 3401 24th Street SW
Center, ND



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

WATER LEVEL OBSERVATION

▼ 60 ft estimated water depth
(used in normalizations and correlations; See Supporting Information)

Probe no. DDG1555 with net area ratio of .807
U2 pore pressure transducer location
Manufactured by Vertek; calibrated 9/17/2020
Tip and sleeve areas of 15 cm^2 and 225 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

CPT Started: 10/1/2020
CPT Completed: 10/1/2020
Rig:
Operator: Michael
Project No.: M2205062

EXHIBIT 13A

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT REPORT M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/13/20

CPT LOG NO. C - 4A

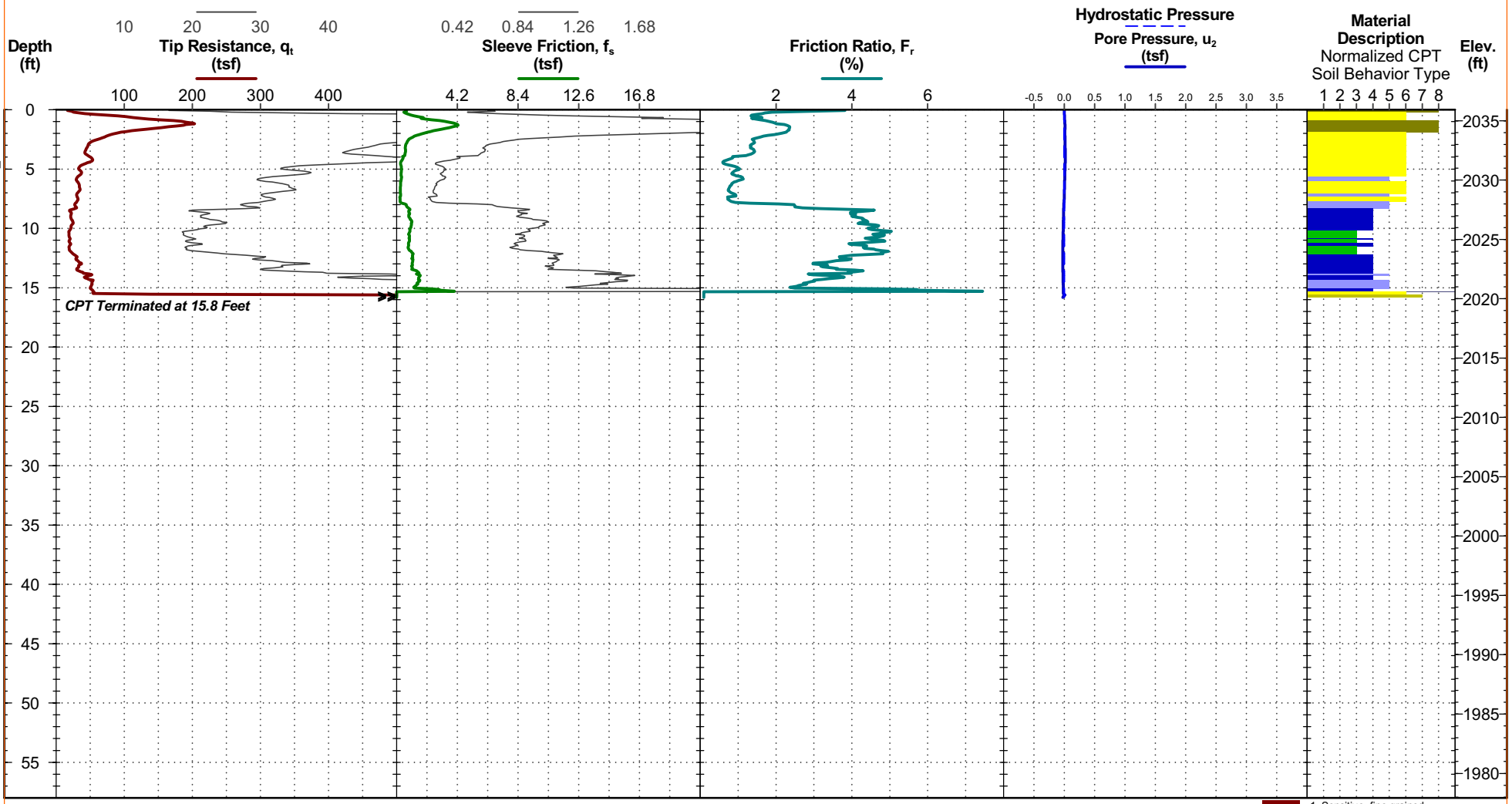
PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

TEST LOCATION: See Exploration Plan

Surface Elev.: 2035.932 ft
Latitude: 47.06378869°
Longitude: -101.2195669°

SITE: 3401 24th Street SW
Center, ND



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

WATER LEVEL OBSERVATION

60 ft estimated water depth
(used in normalizations and correlations; See Supporting Information)

Probe no. DDG1555 with net area ratio of .807
U2 pore pressure transducer location
Manufactured by Vertek; calibrated 9/17/2020
Tip and sleeve areas of 15 cm^2 and 225 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

CPT Started: 10/1/2020
CPT Completed: 10/1/2020
Rig:
Operator: Michael
Project No.: M2205062

EXHIBIT 13B

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT REPORT M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/13/20

CPT LOG NO. C - 5

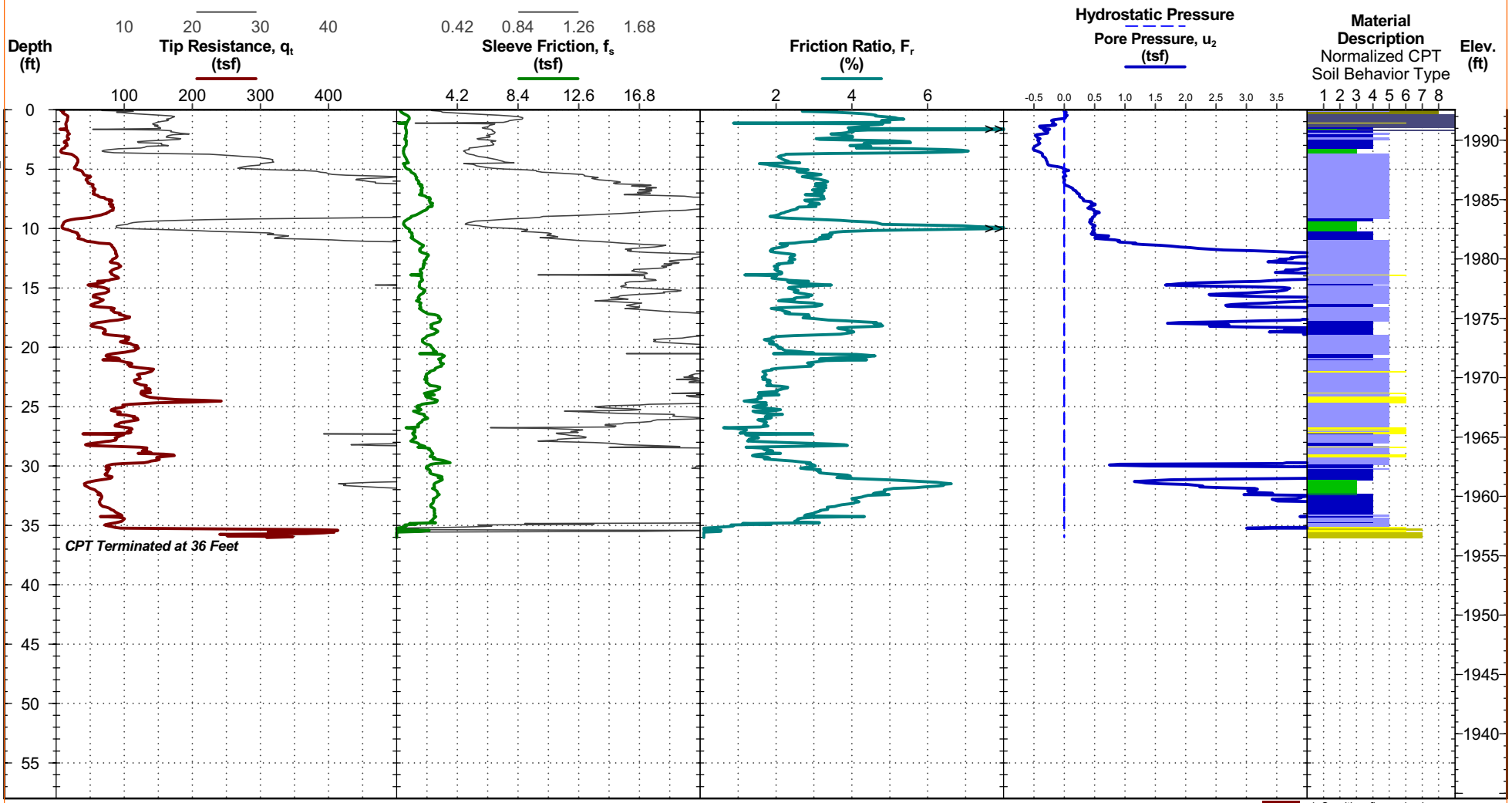
PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

TEST LOCATION: See Exploration Plan

Surface Elev.: 1992.562 ft
Latitude: 47.06460057°
Longitude: -101.2185218°

SITE: 3401 24th Street SW
Center, ND



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

WATER LEVEL OBSERVATION

▼ 60 ft estimated water depth
(used in normalizations and correlations; See Supporting Information)

Probe no. DDG1555 with net area ratio of .807
U2 pore pressure transducer location
Manufactured by Vertek; calibrated 9/17/2020
Tip and sleeve areas of 15 cm^2 and 225 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

CPT Started: 9/30/2020
CPT Completed: 9/30/2020
Rig:
Operator: Michael
Project No.: M2205062

EXHIBIT 14

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT REPORT M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/13/20

CPT LOG NO. C - 6

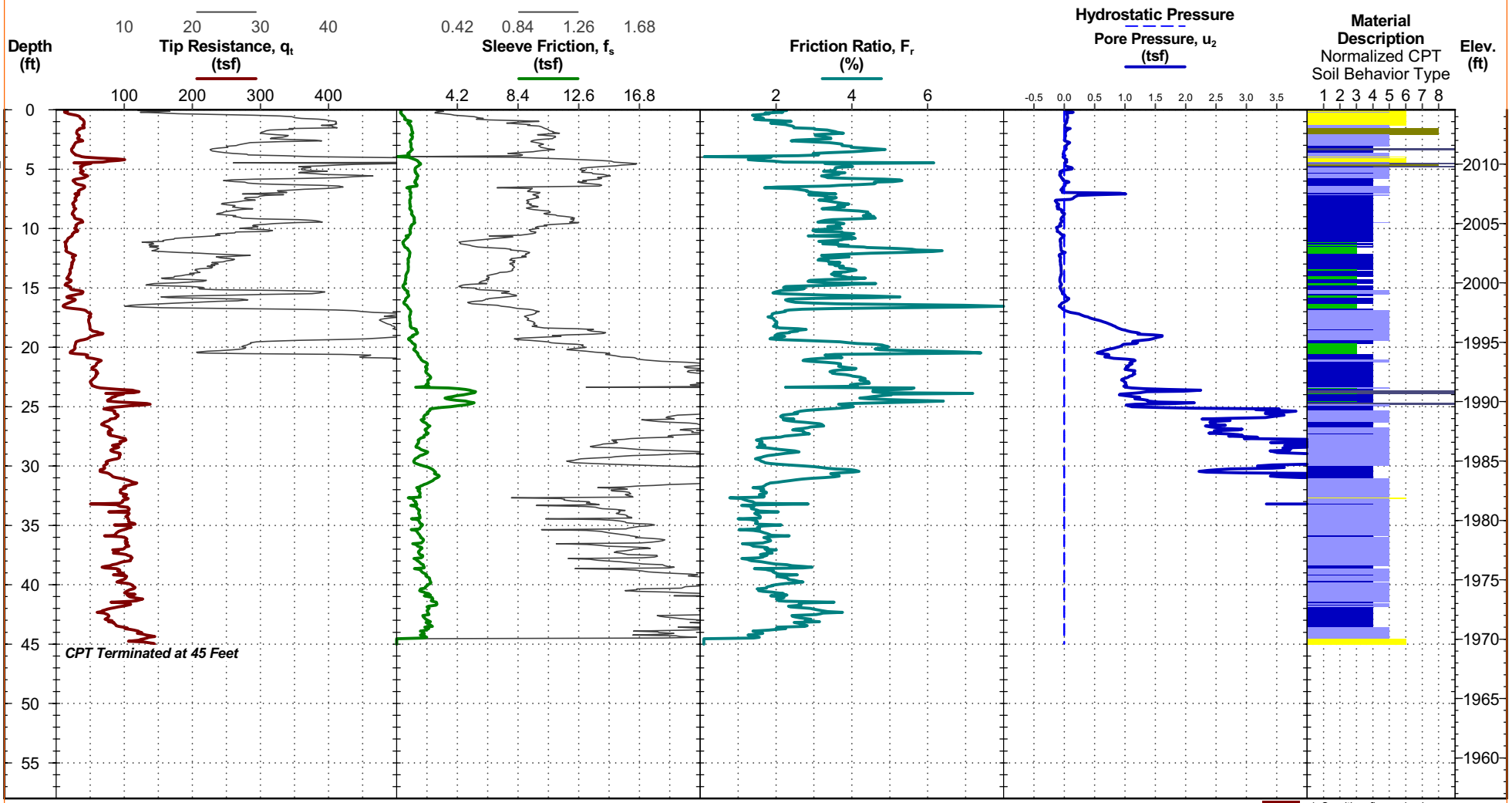
PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

TEST LOCATION: See Exploration Plan

Surface Elev.: 2014.582 ft
Latitude: 47.06408873°
Longitude: -101.2184441°

SITE: 3401 24th Street SW
Center, ND



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

WATER LEVEL OBSERVATION

60 ft estimated water depth
(used in normalizations and correlations; See Supporting Information)

Probe no. DDG1555 with net area ratio of .807
U2 pore pressure transducer location
Manufactured by Vertek; calibrated 9/17/2020
Tip and sleeve areas of 15 cm^2 and 225 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

CPT Started: 9/30/2020
CPT Completed: 9/30/2020
Rig:
Operator: Michael
Project No.: M2205062

EXHIBIT 15

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT REPORT M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/13/20

CPT LOG NO. C - 7

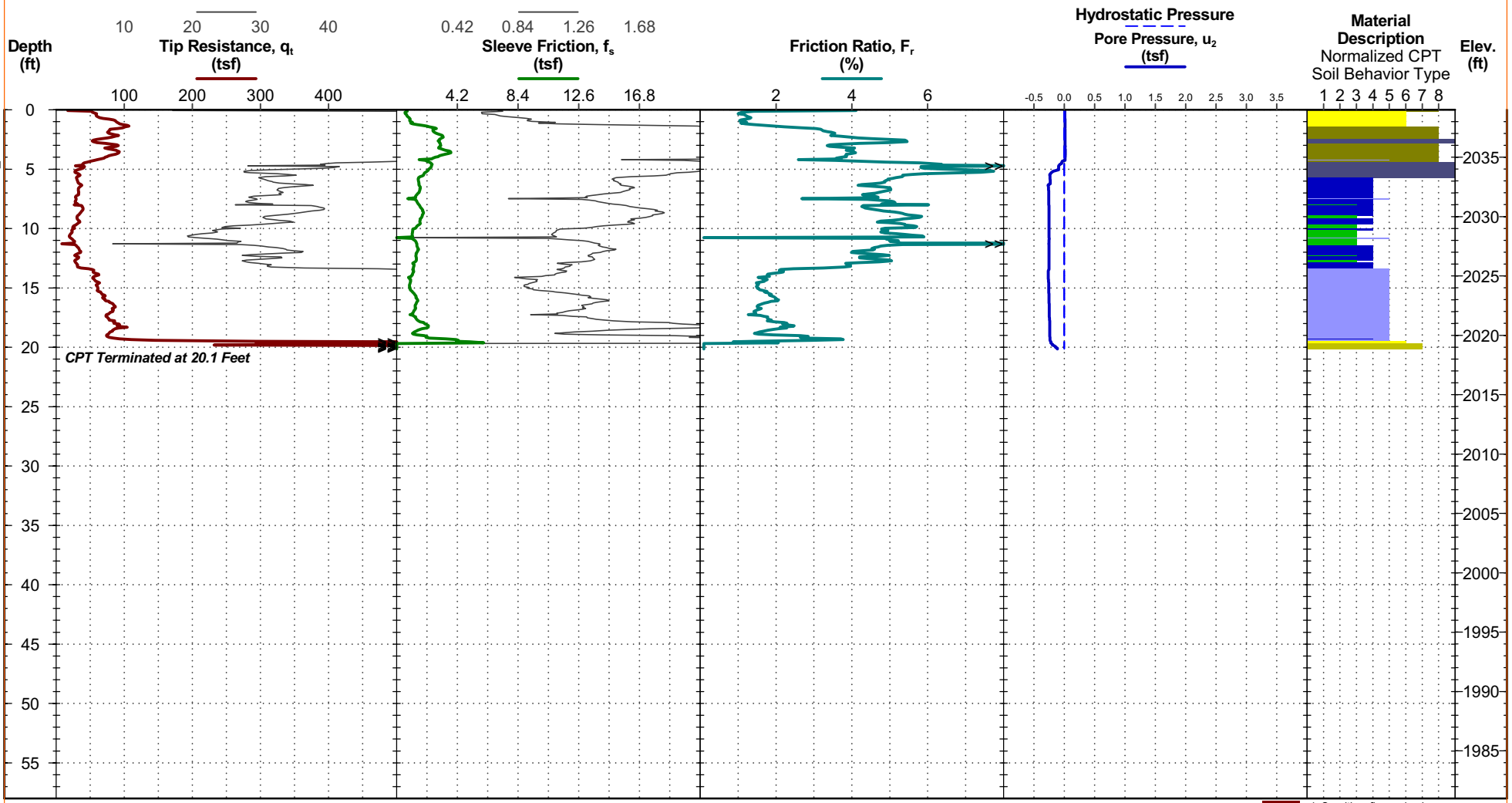
PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

TEST LOCATION: See Exploration Plan

Surface Elev.: 2038.992 ft
Latitude: 47.06300621°
Longitude: -101.2185391°

SITE: 3401 24th Street SW
Center, ND



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

WATER LEVEL OBSERVATION

60 ft estimated water depth
(used in normalizations and correlations; See Supporting Information)

Probe no. DDG1555 with net area ratio of .807
U2 pore pressure transducer location
Manufactured by Vertek; calibrated 9/17/2020
Tip and sleeve areas of 15 cm^2 and 225 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

CPT Started: 10/1/2020
CPT Completed: 10/1/2020
Rig:
Operator: Michael
Project No.: M2205062

EXHIBIT 16

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT REPORT M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/13/20

CPT LOG NO. C - 8

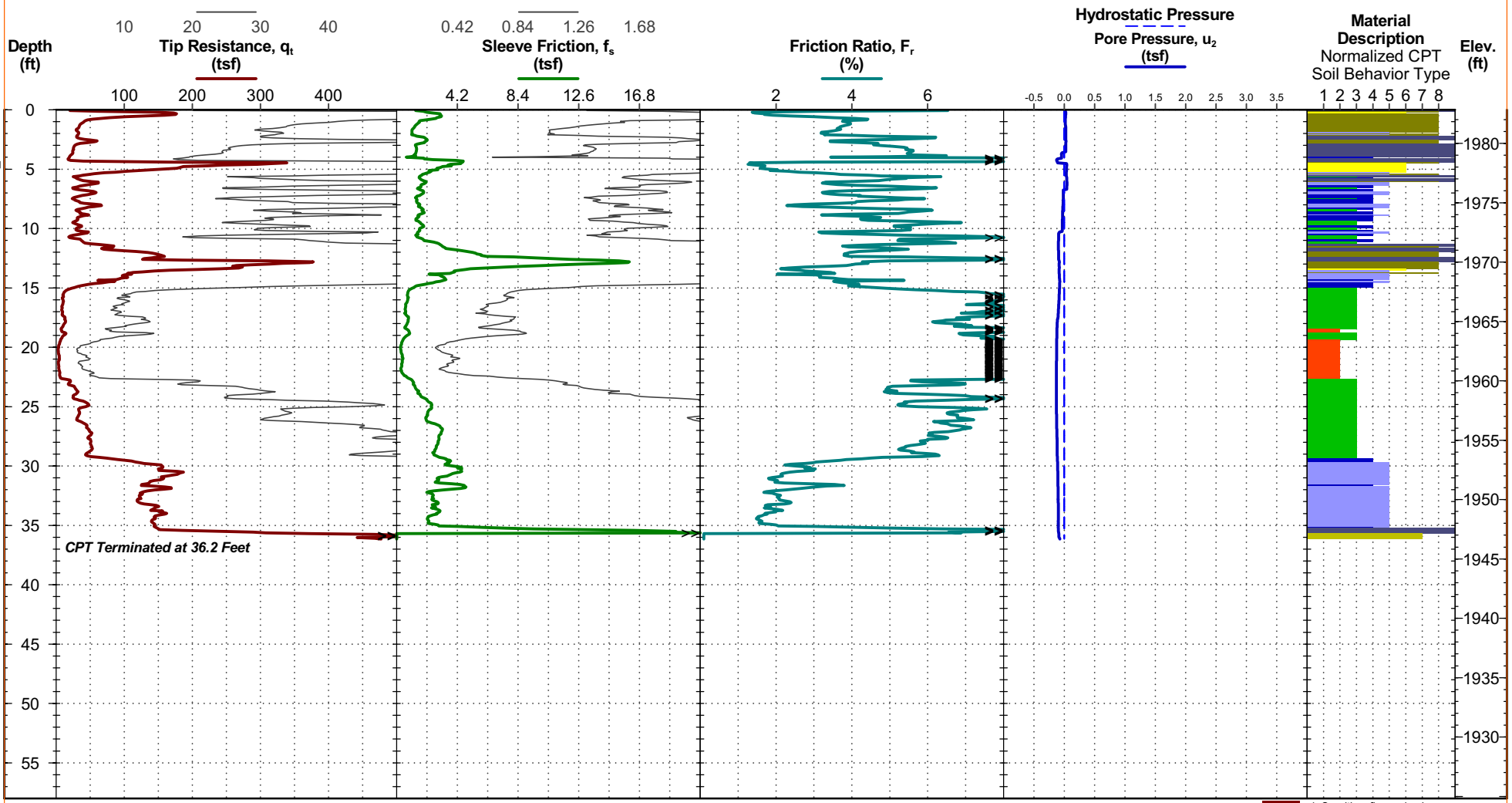
PROJECT: Project Tundra

CLIENT: Fluor Enterprises Inc
Greenville, SC

TEST LOCATION: See Exploration Plan

Surface Elev.: 1982.827 ft
Latitude: 47.06606547°
Longitude: -101.2162071°

SITE: 3401 24th Street SW
Center, ND



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

CPT sensor calibration reports available upon request.

WATER LEVEL OBSERVATION

▼ 60 ft estimated water depth
(used in normalizations and correlations; See Supporting Information)

Probe no. DDG1555 with net area ratio of .807
U2 pore pressure transducer location
Manufactured by Vertek; calibrated 9/17/2020
Tip and sleeve areas of 15 cm^2 and 225 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

CPT Started: 10/1/2020
CPT Completed: 10/1/2020
Rig:
Operator: Michael
Project No.: M2205062

EXHIBIT 17

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT REPORT M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/13/20

N

S

APPROXIMATE STATIONING

ELEVATION (feet)

2,020
2,000
1,980
1,960
1,940
1,920
1,900
1,880
1,860

C - 8
Tip Resistance, q_t (tsf) SBT Friction Ratio (%)
400 300 200 100 0 0 8 16 24 32 40
CPTT-36

B-1
BT-121

C - 3
Tip Resistance, q_t (tsf) SBT Friction Ratio (%)
400 300 200 100 0 0 8 16 24 32 40
CPTT-55

B-2
BT-121

C - 2
Tip Resistance, q_t (tsf) SBT Friction Ratio (%)
400 300 200 100 0 0 8 16 24 32 40
CPTT-37

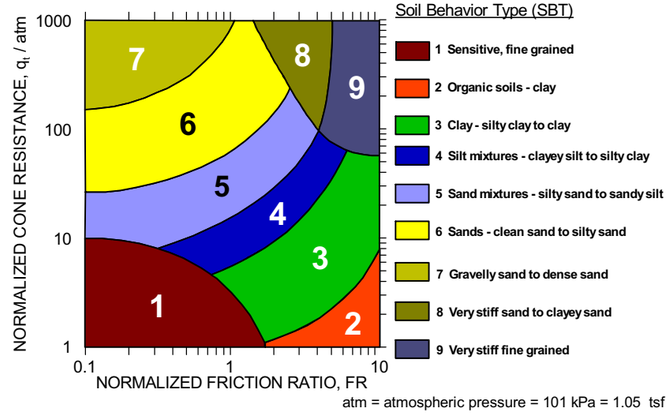
C - 5
Tip Resistance, q_t (tsf) SBT Friction Ratio (%)
400 300 200 100 0 0 8 16 24 32 40
CPTT-36

C - 1
Tip Resistance, q_t (tsf) SBT Friction Ratio (%)
400 300 200 100 0 0 8 16 24 32 40
CPTT-39

Legend for USCS Classification Graphic Symbols

- Topsoil
- Coal
- Sandstone
- Silty Sand
- Lean Clay with Sand
- Fat Clay
- Fat Clay with Sand
- Fill
- Silt
- Lean Clay
- Sandy Fat Clay

CPT Soil Classification Graphic Symbols



atm = atmospheric pressure = 101 kPa = 1.05 tsf

Water Level Reading at time of drilling.

Water Level Reading after drilling.

NOTES:
See Exhibit for orientation of soil profile.
See General Notes in Appendix for symbols and soil classifications.
Soils profile provided for illustration purposes only.
Soils between borings may differ.
For presentation purposes, some locations are offset to allow display of both borings and CPTs.
BT - Boring Termination (Ft)
CPTT - CPT Termination (Ft)

Project Manager: Chad Crowley	Project No.: M2205062
Drawn by: RK	Scale: N.T.S.
Approved by: SRG	File Name:
Date: 11/02/20	

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND
PH. 701-258-2833 FAX. 701-258-2857

SUBSURFACE PROFILE

NORTH-SOUTH SECTION VIEW
PROJECT TUNDRA
3401 24TH STREET SW
CENTER, ND

EXHIBIT

18A

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT FENCE W/COMPANION BORING M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/15/20

N

S

APPROXIMATE STATIONING

ELEVATION (feet)

2,050
2,040
2,030
2,020
2,010
2,000
1,990
1,980
1,970
1,960
1,950
1,940
1,930

B-4
BT-81
DH-1
BT-101
B-3
BT-61

C - 6
Tip Resistance, q_t (tsf) SBT Friction Ratio (%)
400 300 200 100 0 0 8 16 24 32 40
CPTT-45

C - 4
Tip Resistance, q_t (tsf) SBT Friction Ratio (%)
400 300 200 100 0 0 8 16 24 32 40
CPTT-16

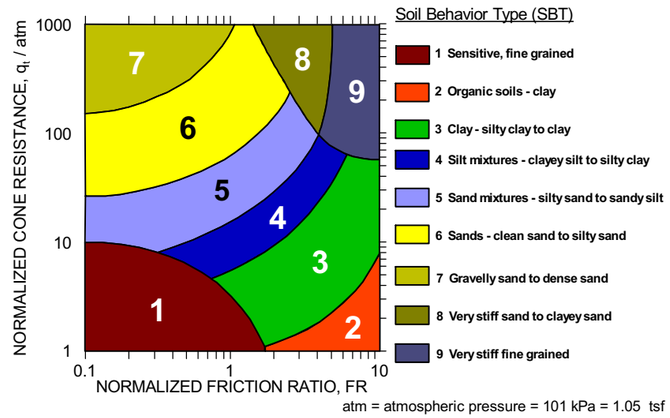
C - 4A
Tip Resistance, q_t (tsf) SBT Friction Ratio (%)
400 300 200 100 0 0 8 16 24 32 40
CPTT-16

C - 7
Tip Resistance, q_t (tsf) SBT Friction Ratio (%)
400 300 200 100 0 0 8 16 24 32 40
CPTT-20

Legend for USCS Classification Graphic Symbols

- Topsoil
- Fill
- Clayey Sand
- Fat Clay
- Silty Sand
- Sandy Fat Clay
- Coal
- Poorly-graded Sand
- Silty Clay
- Sandy Lean Clay
- Silty Clayey Sand
- Silty Clay with Sand

CPT Soil Classification Graphic Symbols



atm = atmospheric pressure = 101 kPa = 1.05 tsf

▽ Water Level Reading at time of drilling.

▼ Water Level Reading after drilling.

NOTES:
See Exhibit for orientation of soil profile.
See General Notes in Appendix for symbols and soil classifications.
Soils profile provided for illustration purposes only.
Soils between borings may differ.
For presentation purposes, some locations are offset to allow display of both borings and CPTs.
BT - Boring Termination (Ft)
CPTT - CPT Termination (Ft)

Project Manager: Chad Crowley	Project No.: M2205062
Drawn by: RK	Scale: N.T.S.
Approved by: SRG	File Name:
Date: 11/02/20	

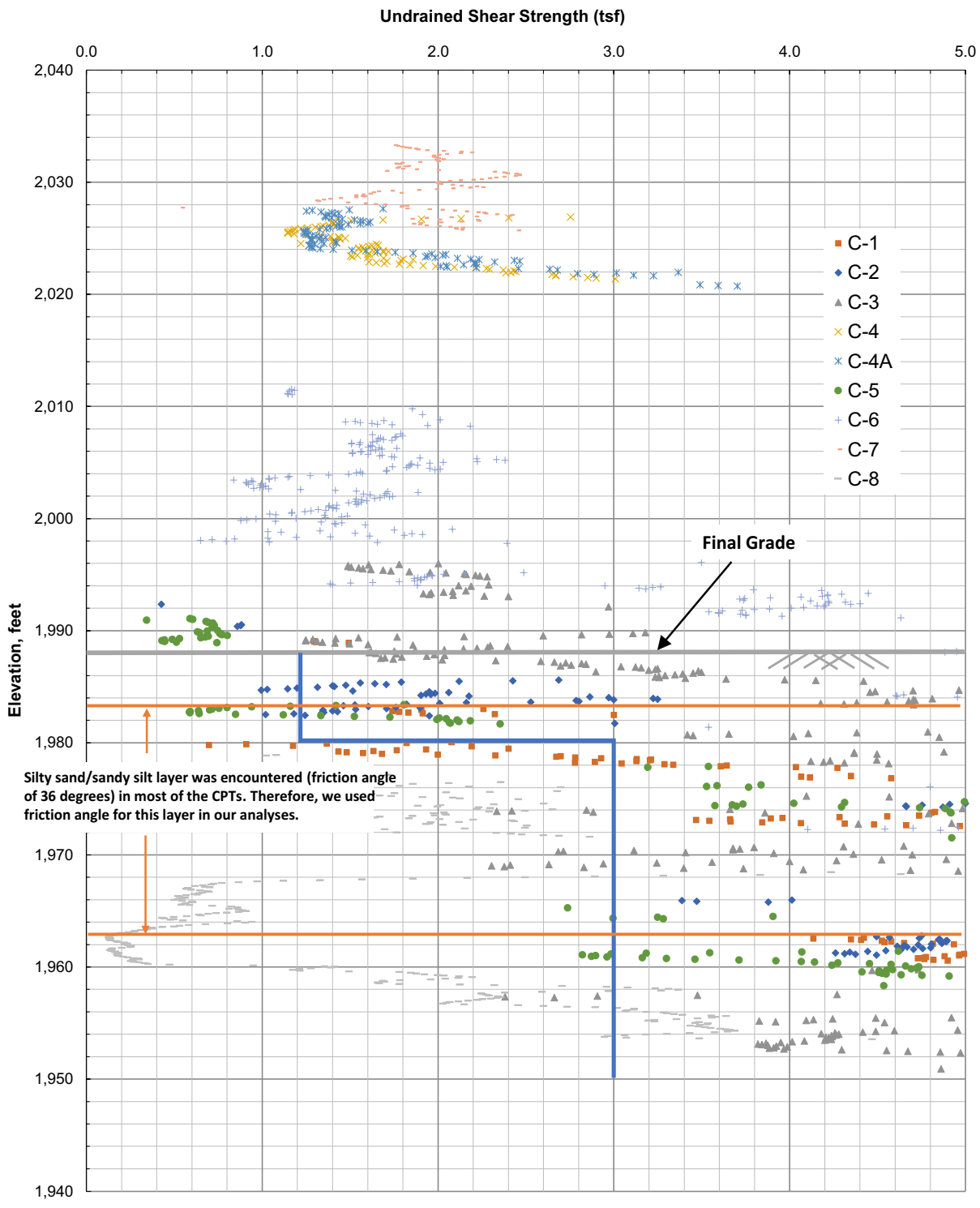
Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND
PH. 701-258-2833 FAX. 701-258-2857

SUBSURFACE PROFILE

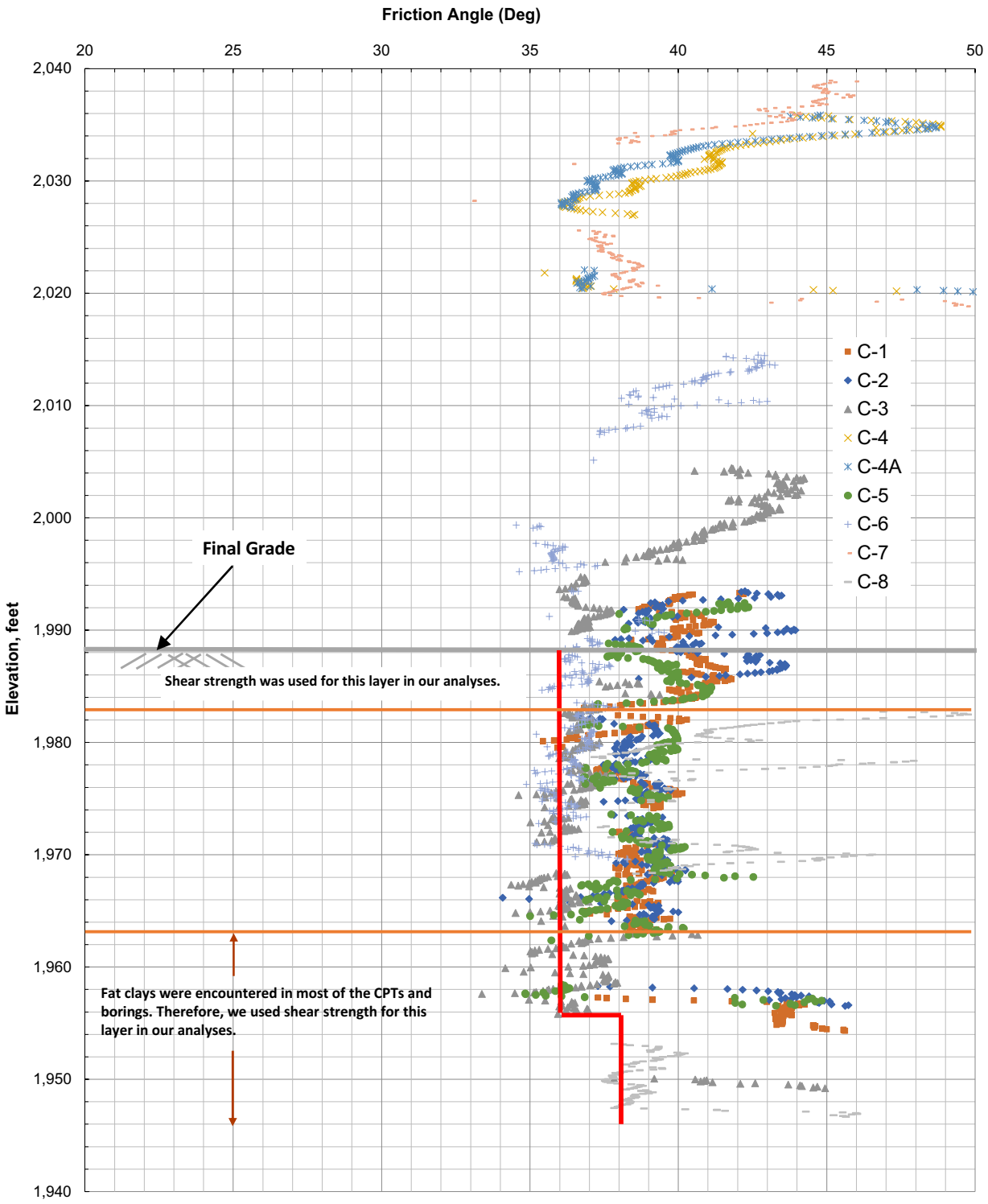
NORTH-SOUTH SECTION VIEW
PROJECT TUNDRA
3401 24TH STREET SW
CENTER, ND

EXHIBIT 18B

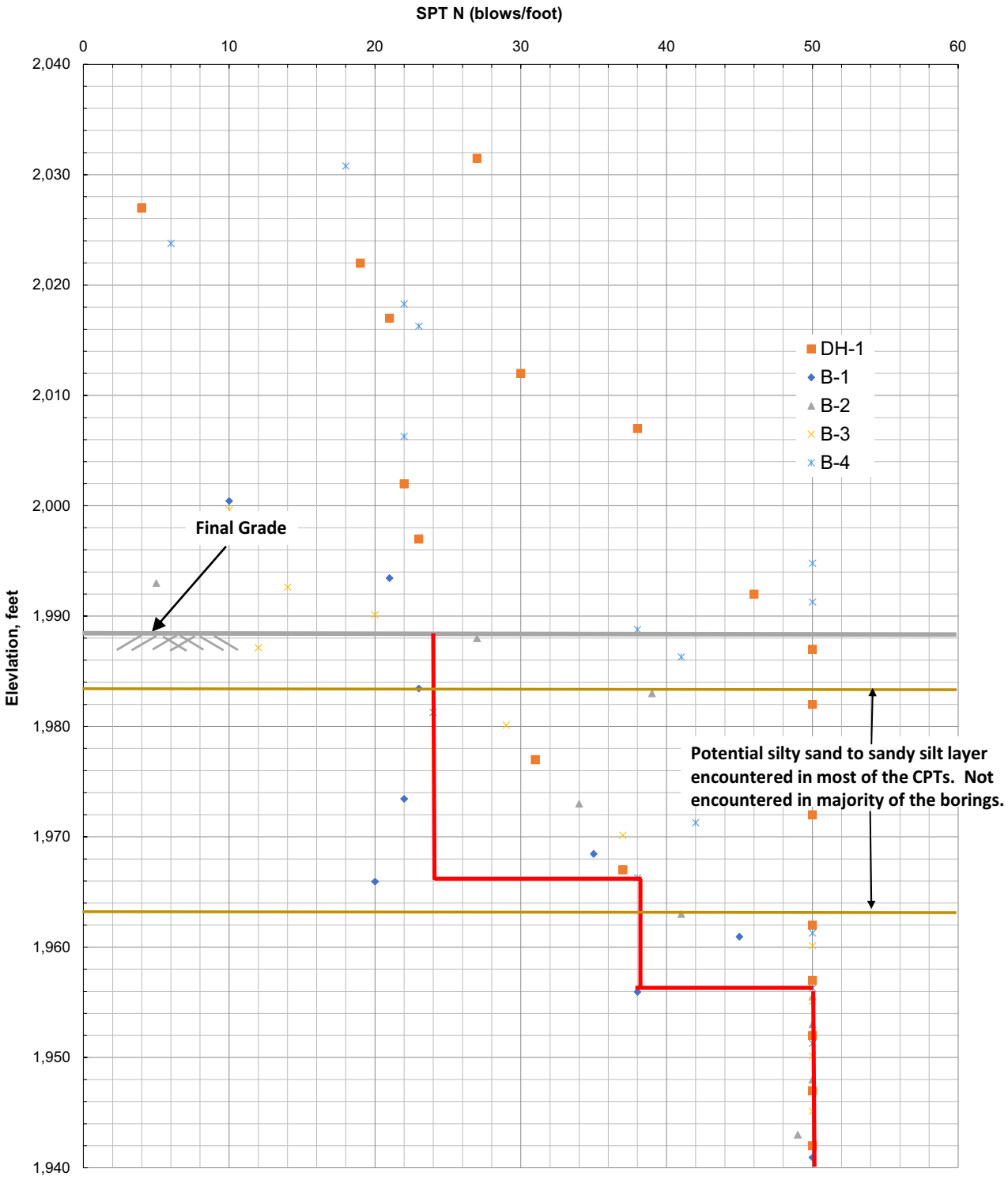
THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT FENCE W/COMPANION BORING M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/15/20



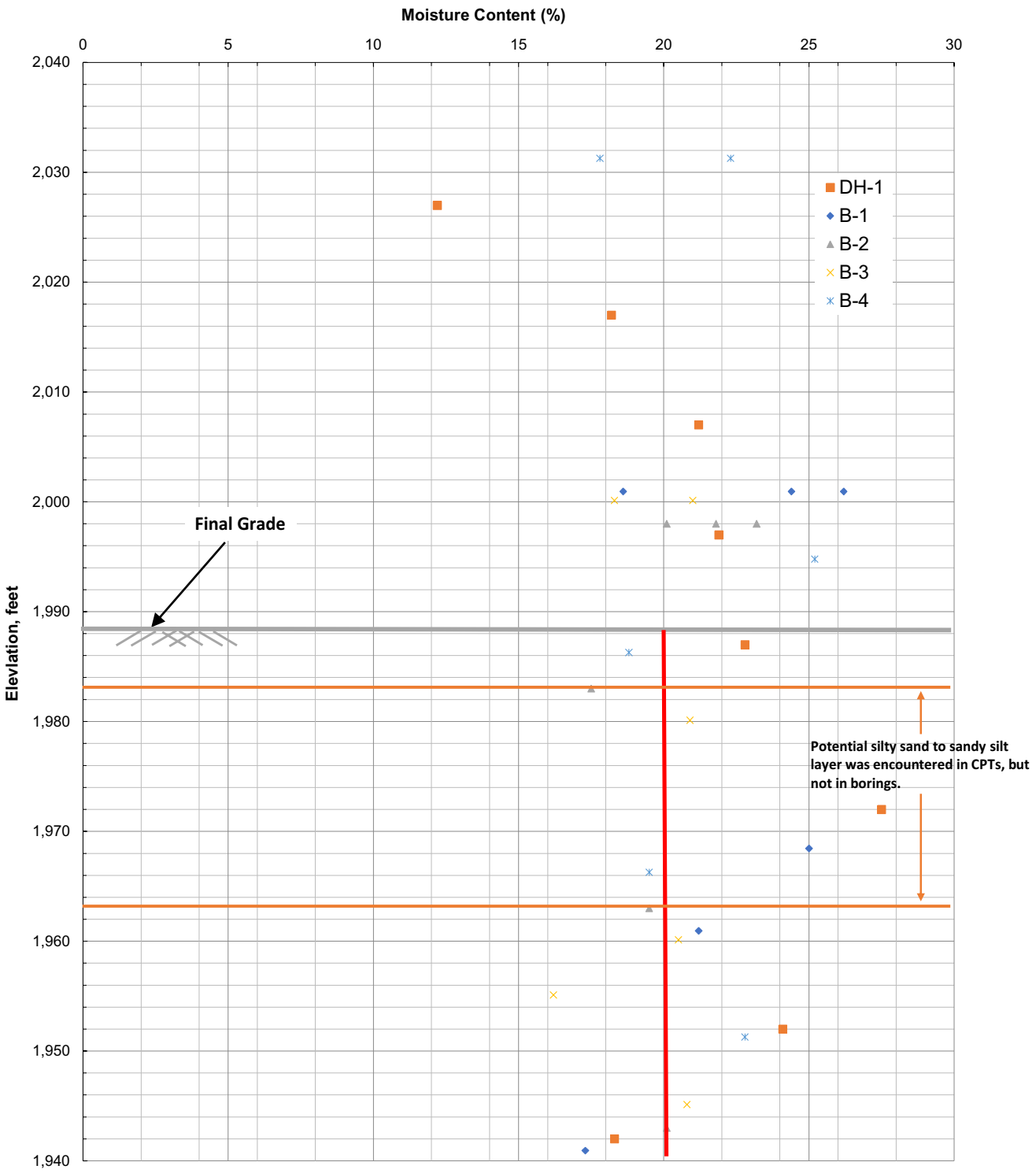
Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	UNDRAINED SHEAR STRENGTH VS. DEPTH FROM CPT DATA MINNKOTA PROJECT TUNDRA CCS PROJECT CENTER, NORTH DAKOTA	EXHIBIT 19
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/02/2020			
Approved by:	SRG					



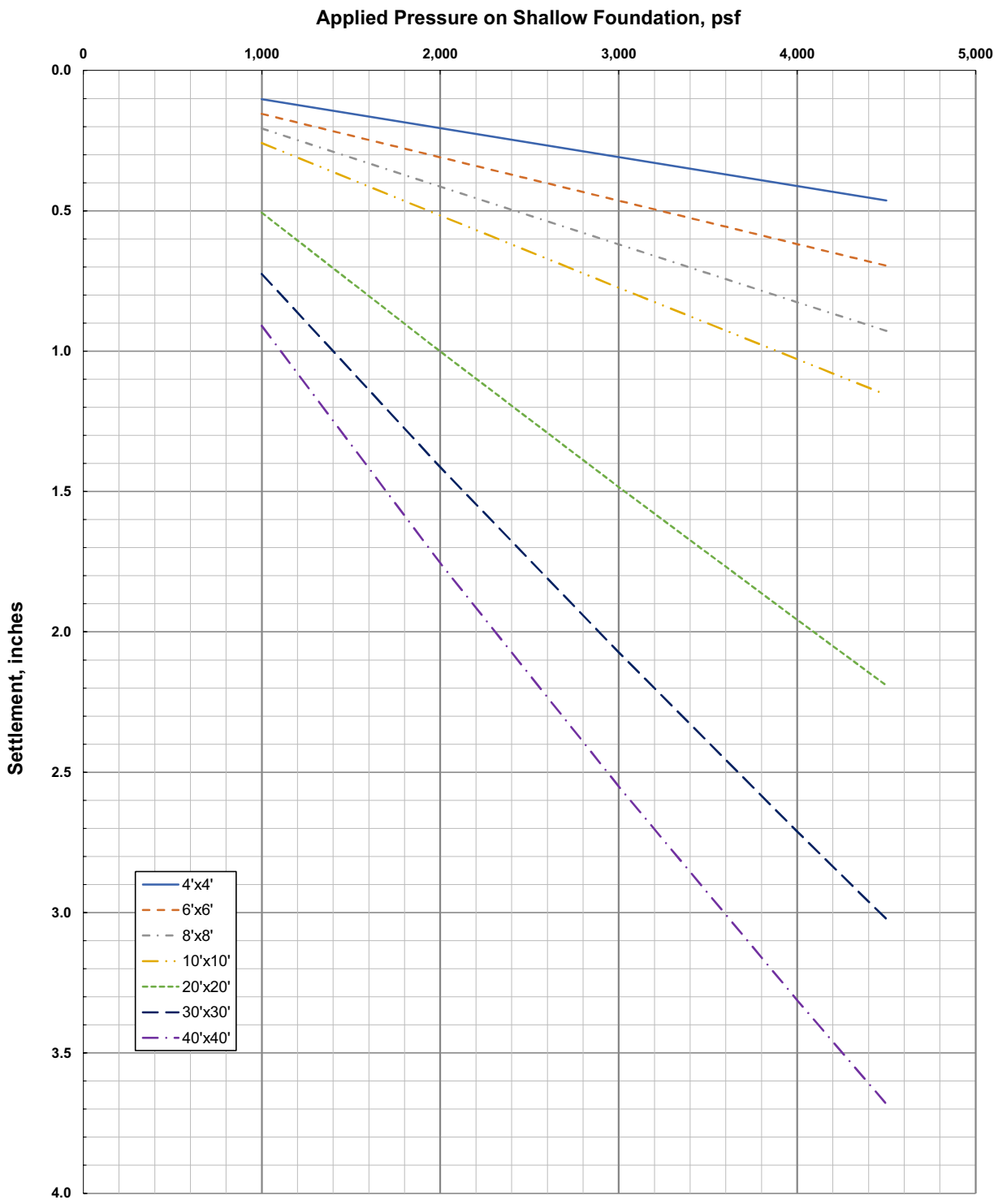
Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	UNDRAINED SHEAR STRENGTH VS. DEPTH FROM CPT DATA MINNKOTA PROJECT TUNDRA CCS PROJECT CENTER, NORTH DAKOTA	EXHIBIT 21
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/02/2020			
Approved by:	SRG					



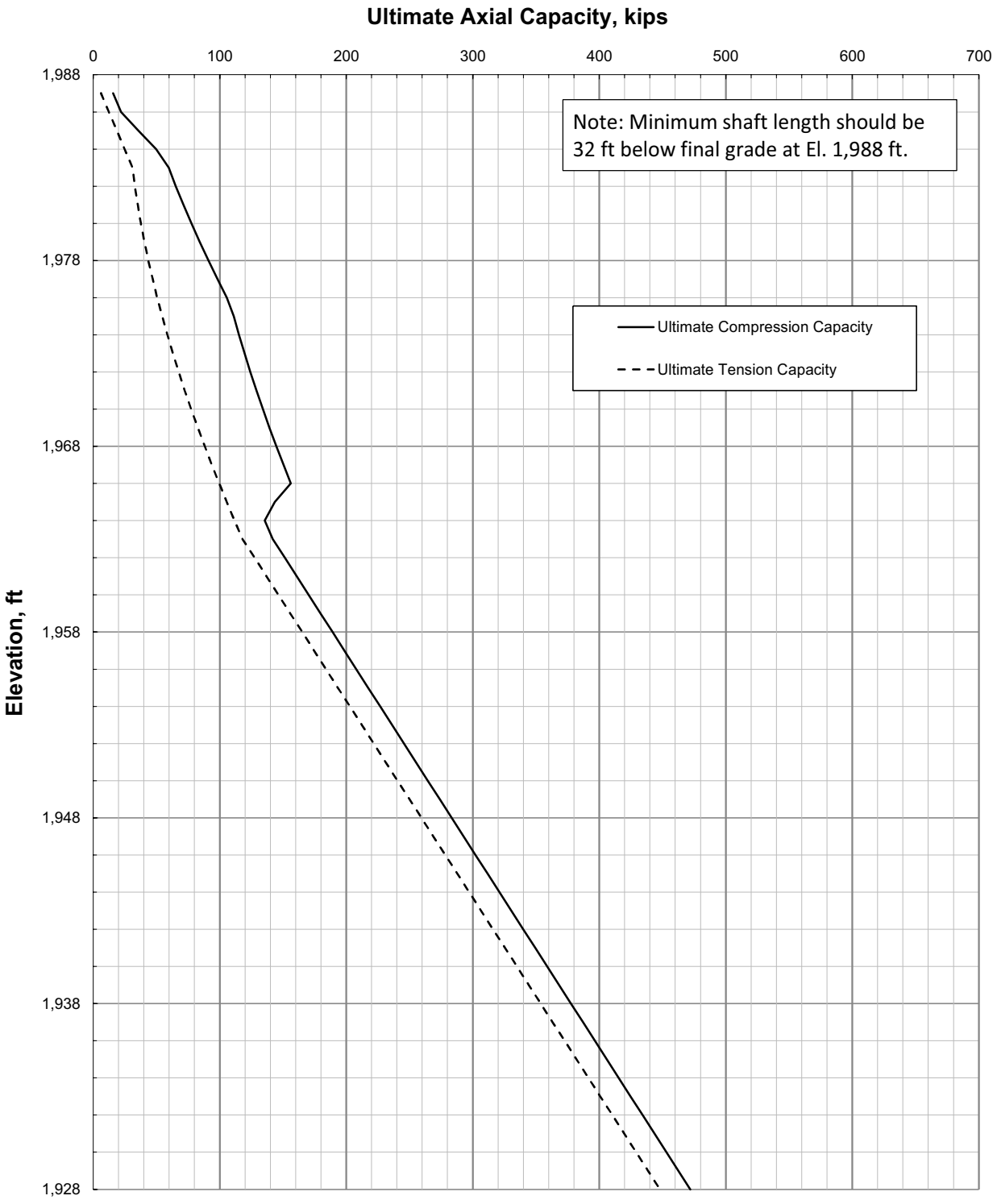
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Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/02/2020			
Approved by:	SRG					



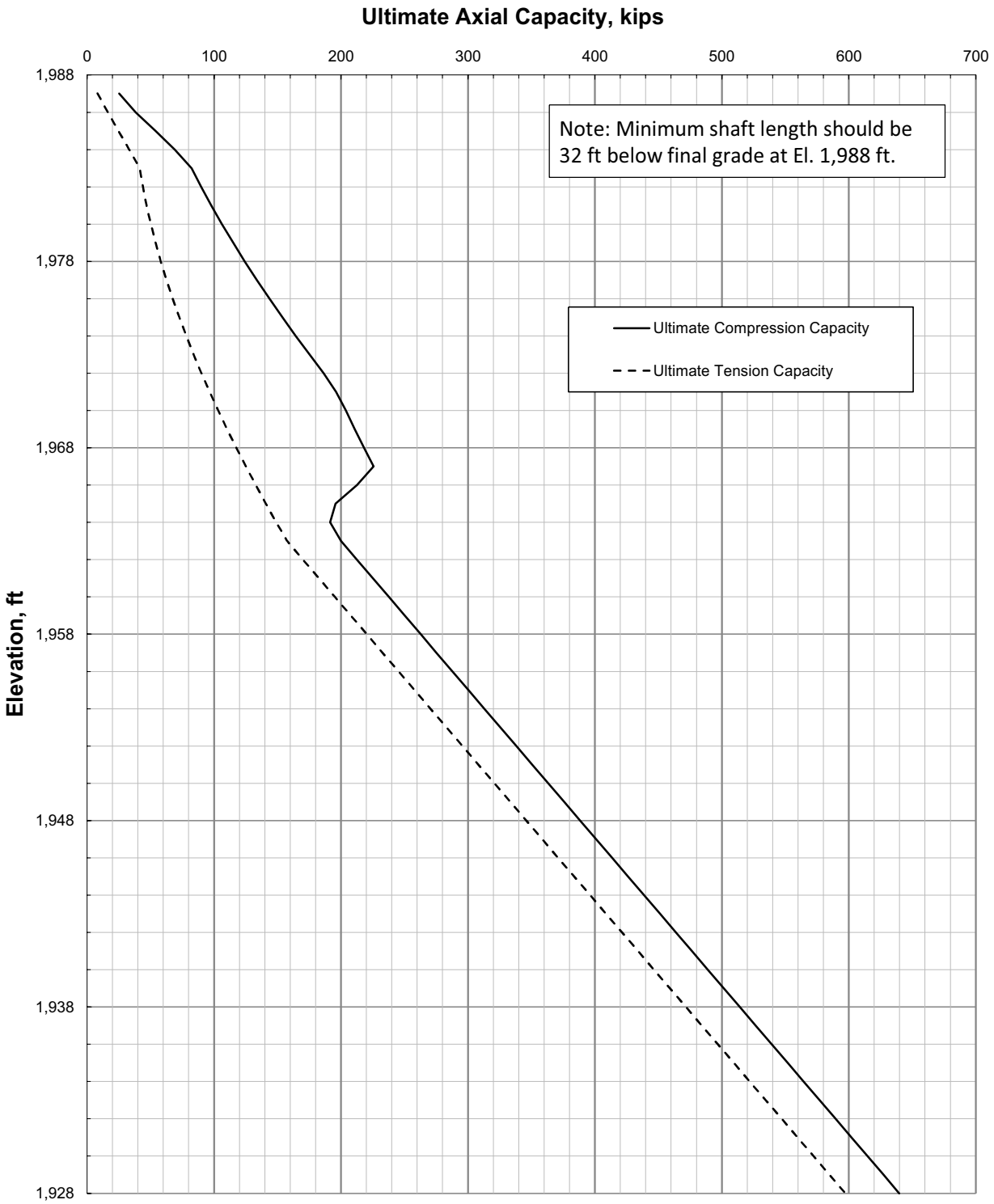
Project Mgr:	CAC	Project No.		MOISTURE CONTENT VS. DEPTH FROM SPT DATA MINNKOTA PROJECT TUNDRA CCS PROJECT CENTER, NORTH DAKOTA	EXHIBIT
Prepared by:	RK	M2205062	Terracon Consulting Engineers & Scientists Texas Registration 3272		22
Checked by:	SRG	Date: 11/02/2020			
Approved by:	SRG		1805 Hancock Drive Bismarck, North Dakota 58501		



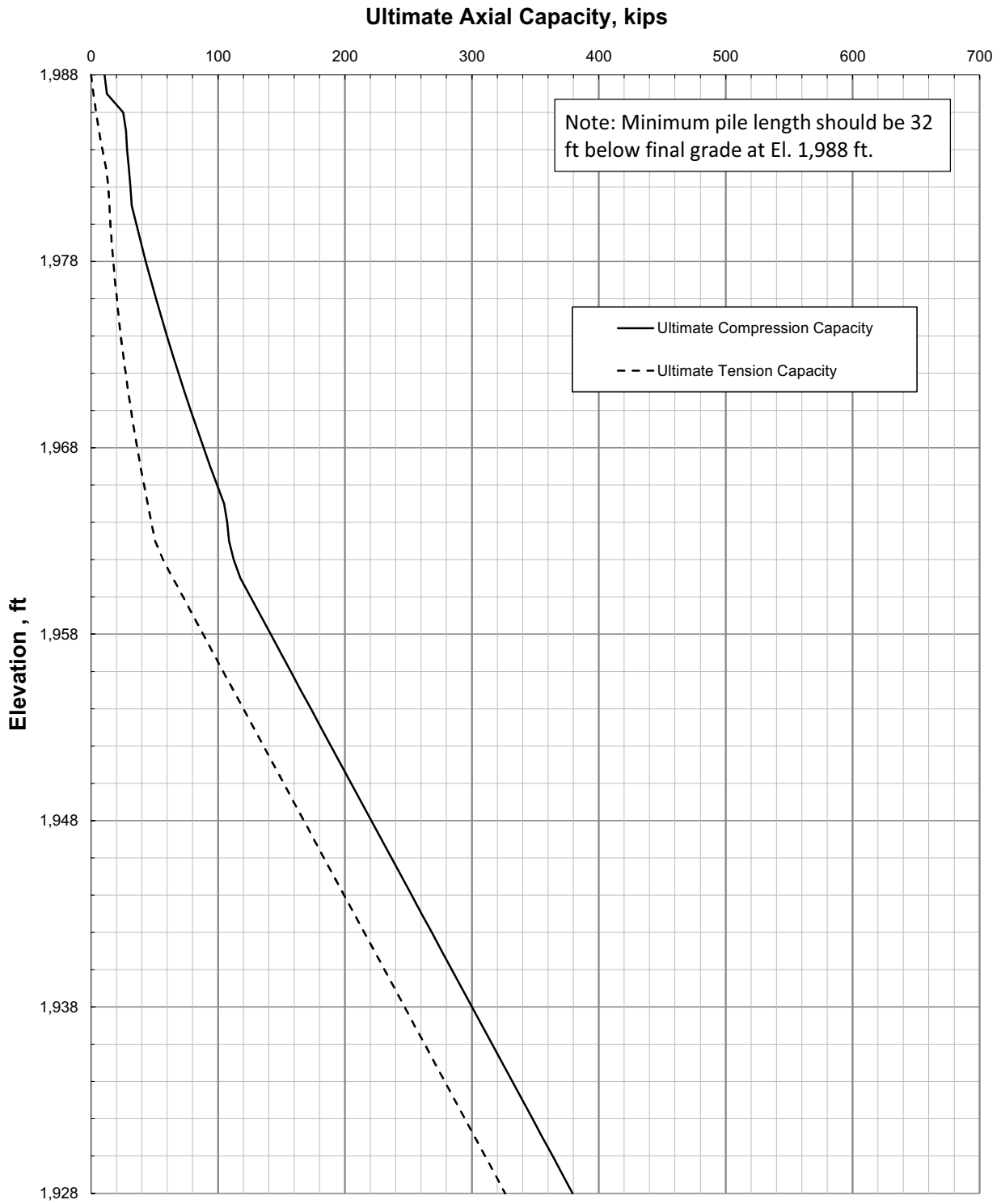
Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	SETTLEMENT - SHALLOW FOUNDATIONS PROJECT TUNDRA MINNKOTA POWER COOPERATIVE, INC. CENTER, NORTH DAKOTA	EXHIBIT 23
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/2/2020			
Approved by:	SRG					



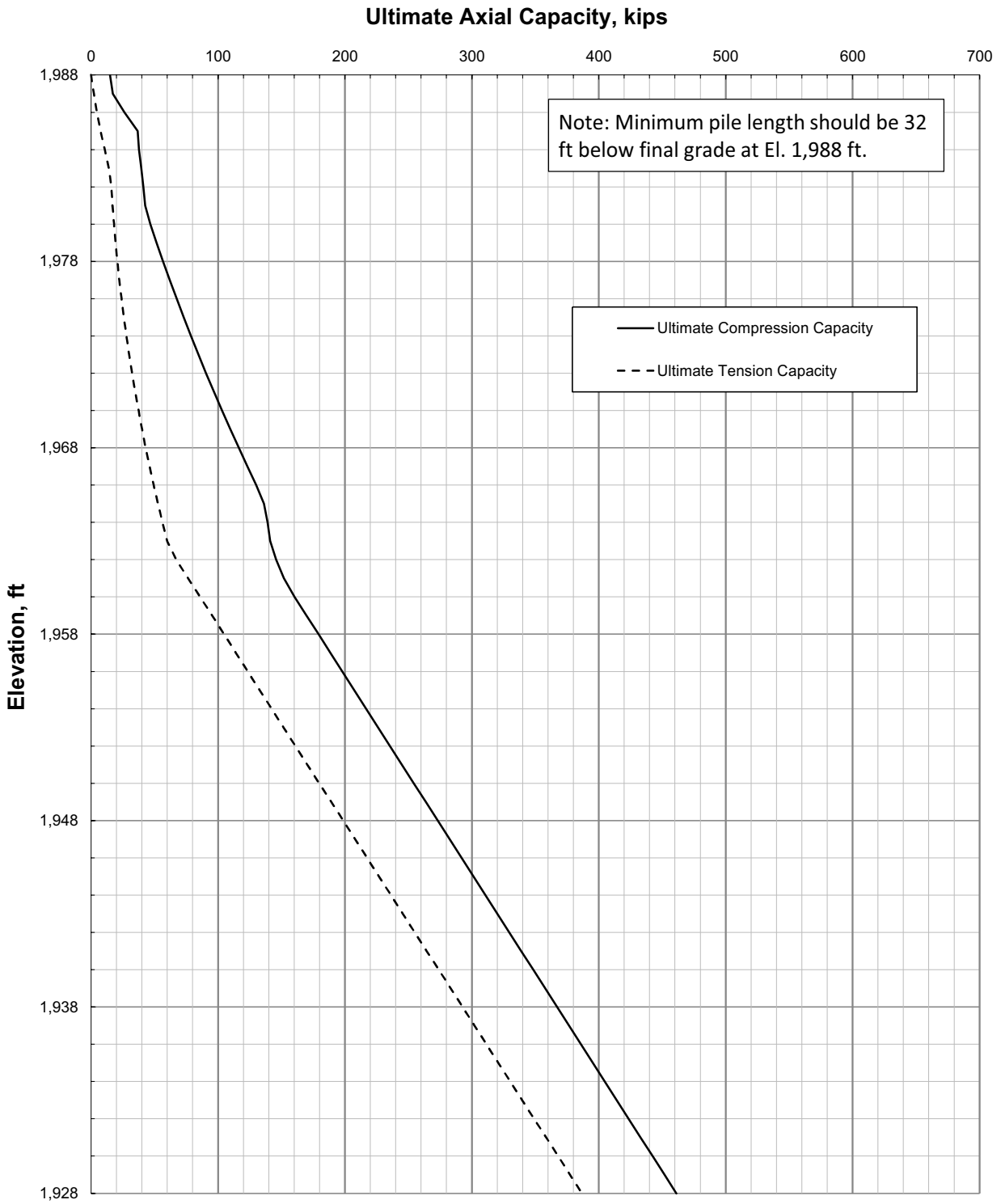
Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	**ULTIMATE AXIAL CAPACITY CURVE 18 INCH DIAMATER DRILLED SHAFT PROJECT TUNDRA MINNKOTA POWER COOPERATIVE, INC. CENTER, NORTH DAKOTA**	**EXHIBIT 24A**
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/02/2020			
Approved by:	SRG					



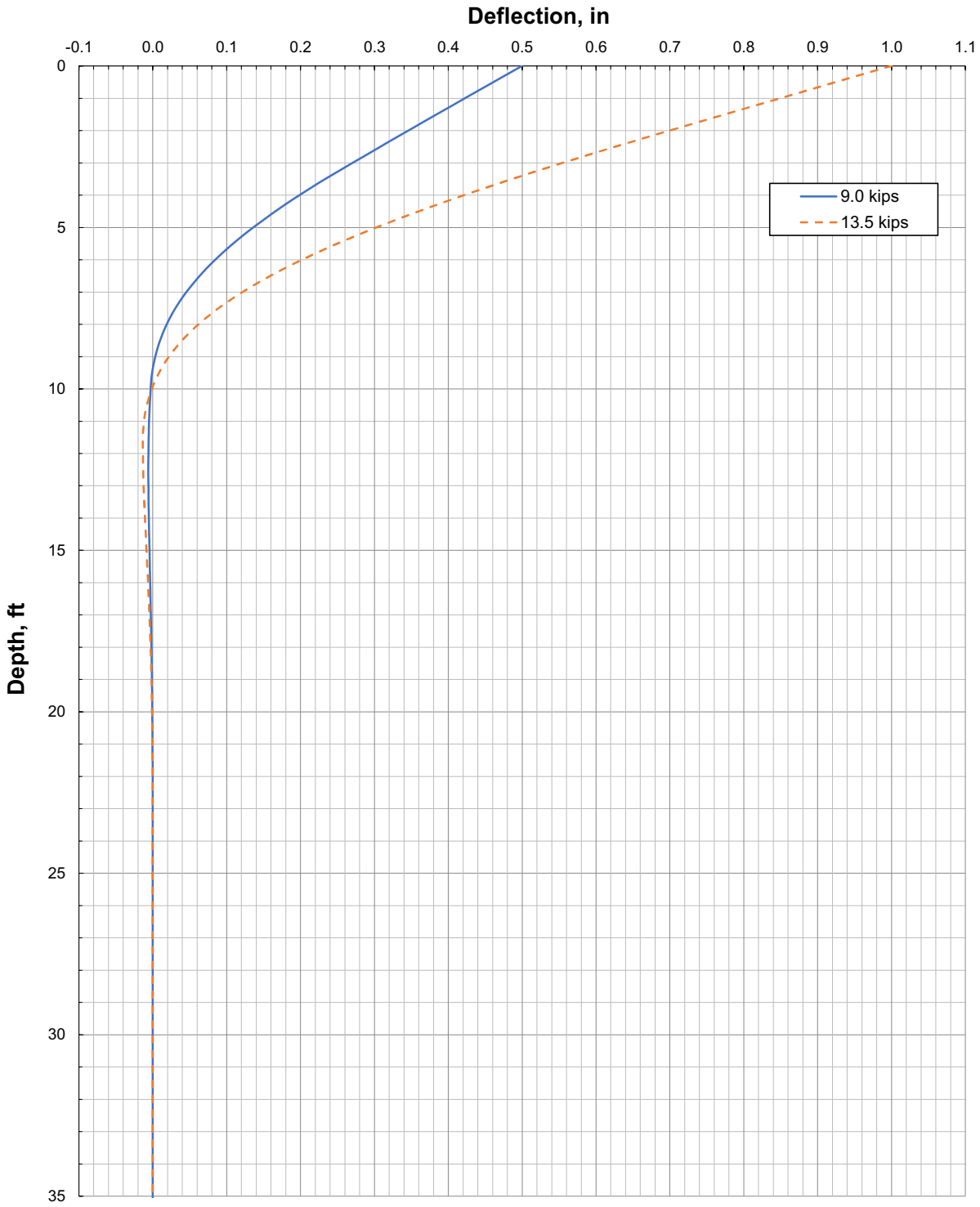
Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	**ULTIMATE AXIAL CAPACITY CURVE 24 INCH DIAMATER DRILLED SHAFT PROJECT TUNDRA MINNKOTA POWER COOPERATIVE, INC. CENTER, NORTH DAKOTA**	**EXHIBIT 24B**
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/02/2020			
Approved by:	SRG					



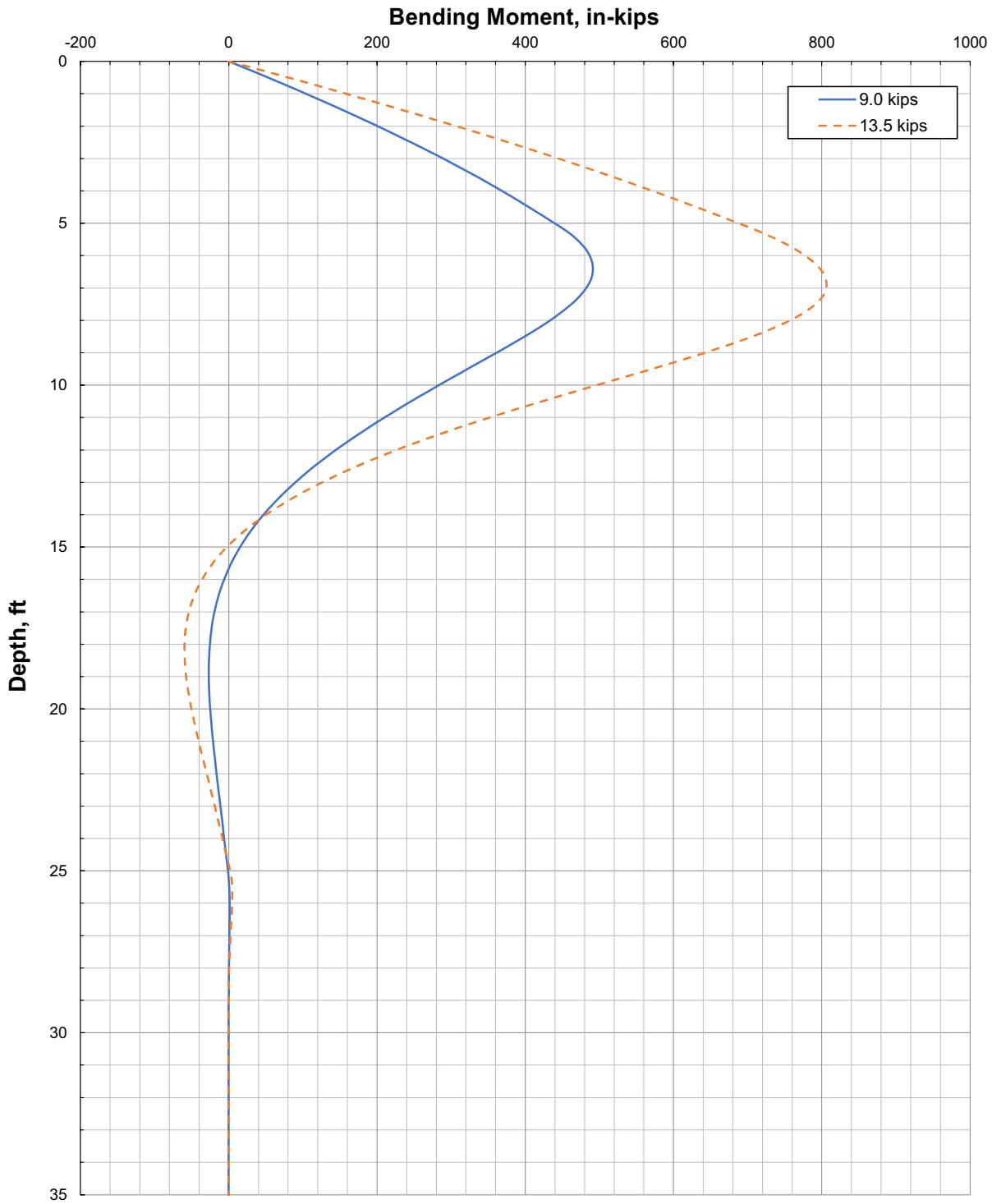
Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	**ULTIMATE AXIAL CAPACITY CURVE** **12x53 H PILE** **PROJECT TUNDRA** **MINNKOTA POWER COOPERATIVE, INC.** **CENTER, NORTH DAKOTA**	**EXHIBIT** **25A**
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/02/2020			
Approved by:	SRG					



Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	**ULTIMATE AXIAL CAPACITY CURVE** **14x73 H PILE** **PROJECT TUNDRA** **MINNKOTA POWER COOPERATIVE, INC.** **CENTER, NORTH DAKOTA**	**EXHIBIT** **25B**
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/02/2020			
Approved by:	SRG					

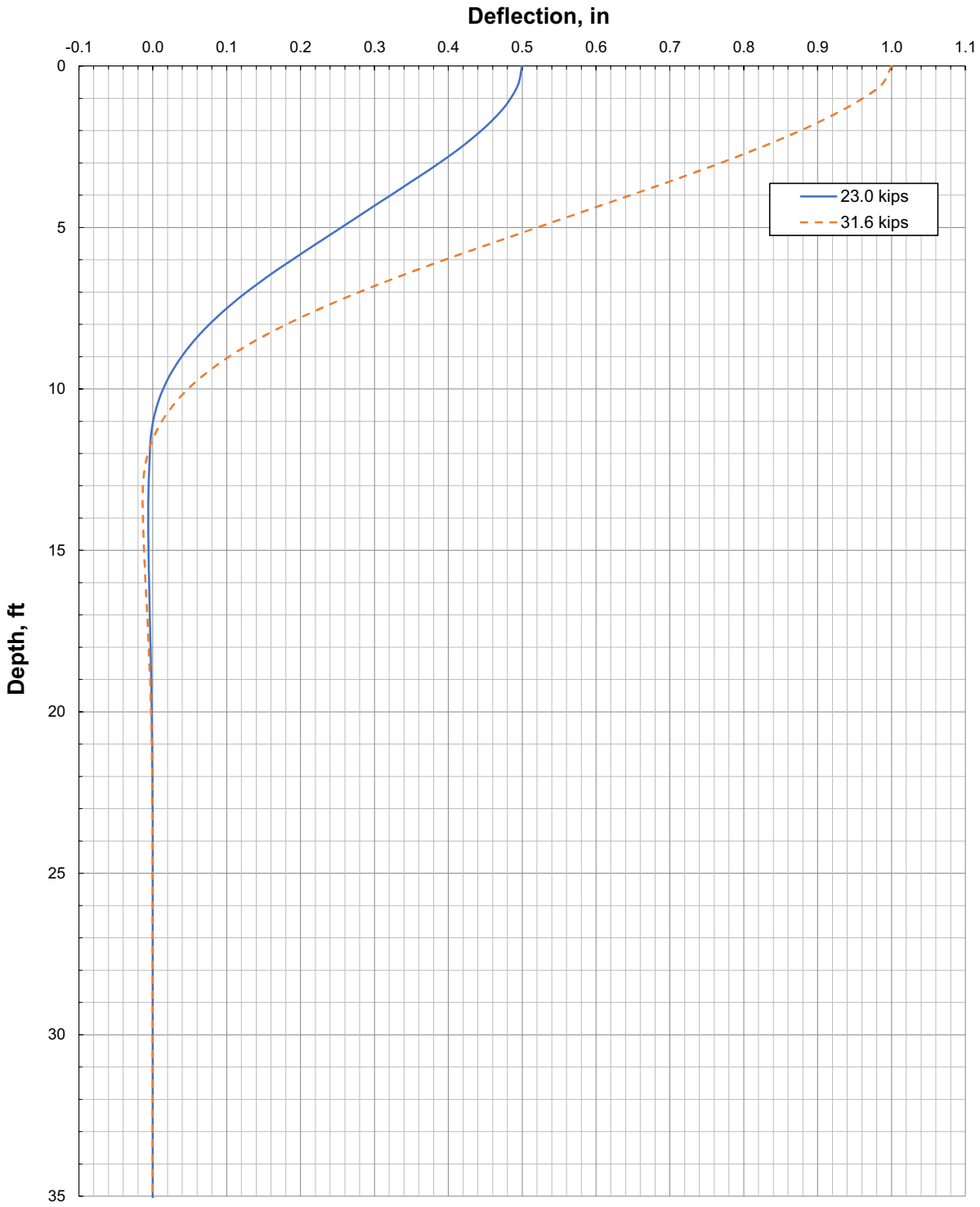


Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	LATERAL DEFLECTION VS. DEPTH CURVES 18 INCH DIAMETER DRILLED SHAFT - FREE HEAD PROJECT TUNDRA CENTER, NORTH DAKOTA	EXHIBIT 26A
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/2/2020			
Approved by:	SRG					

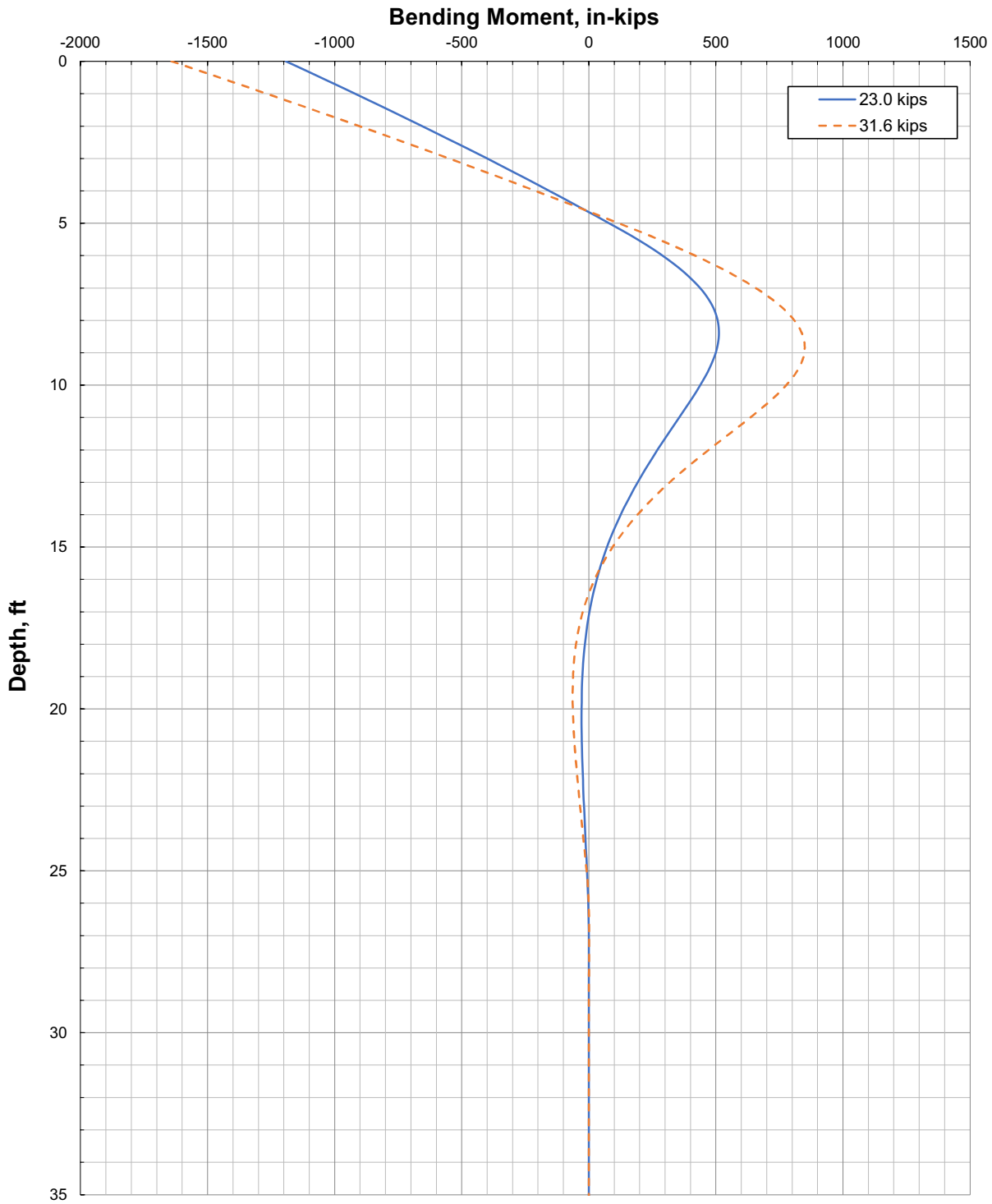


Project Mgr:	CAC	Project No.			EXHIBIT
Prepared by:	RK	M2205062		BENDING MOMENT VS. DEPTH CURVES 18 INCH DIAMETER DRILLED SHAFT - FREE HEAD PROJECT TUNDRA CENTER, NORTH DAKOTA	26B
Checked by:	SRG	Date:	11/2/2020		
Approved by:	SRG				

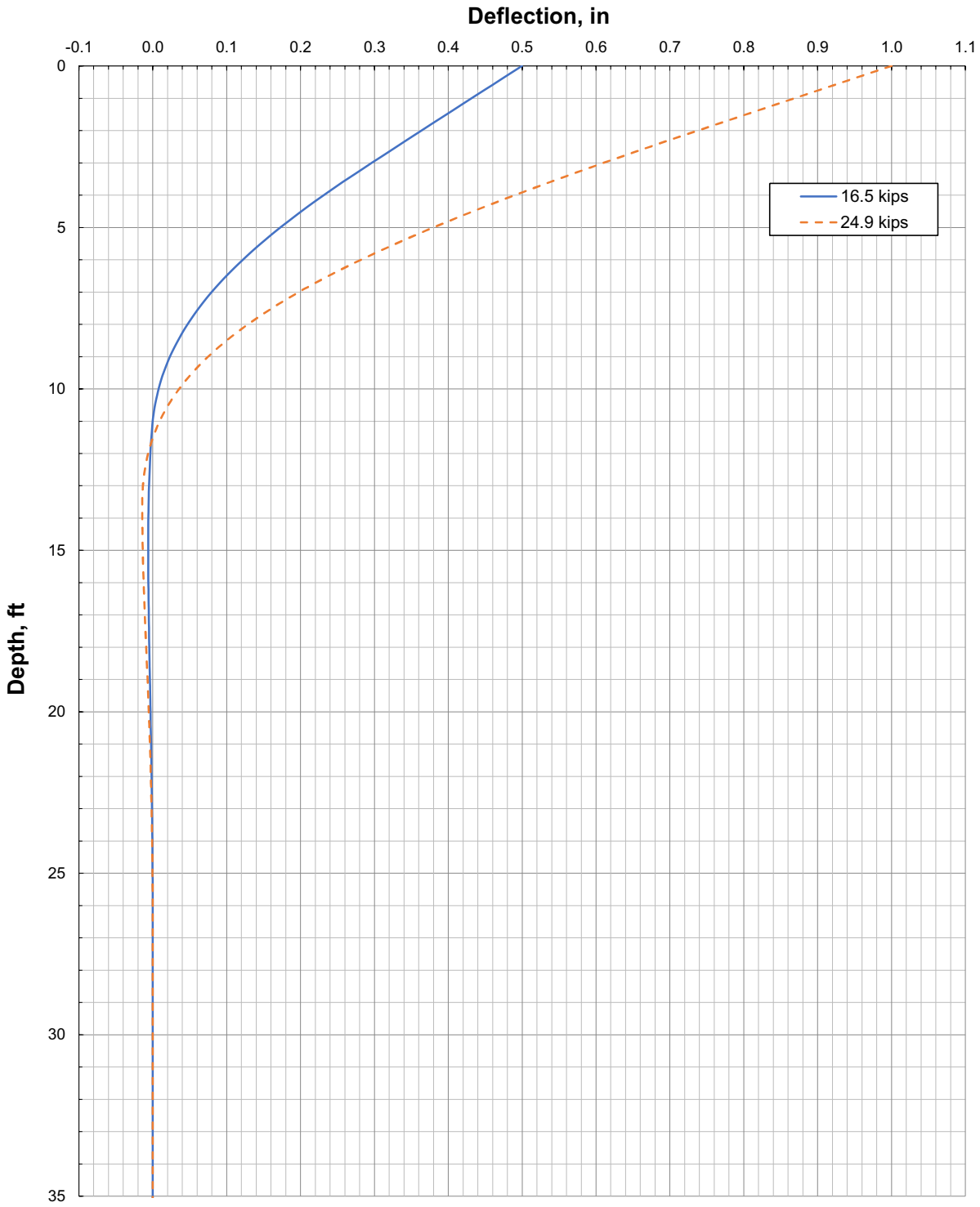
Terracon
Consulting Engineers & Scientists
Texas Registration 3272
1805 Hancock Drive Bismarck, North Dakota 58501



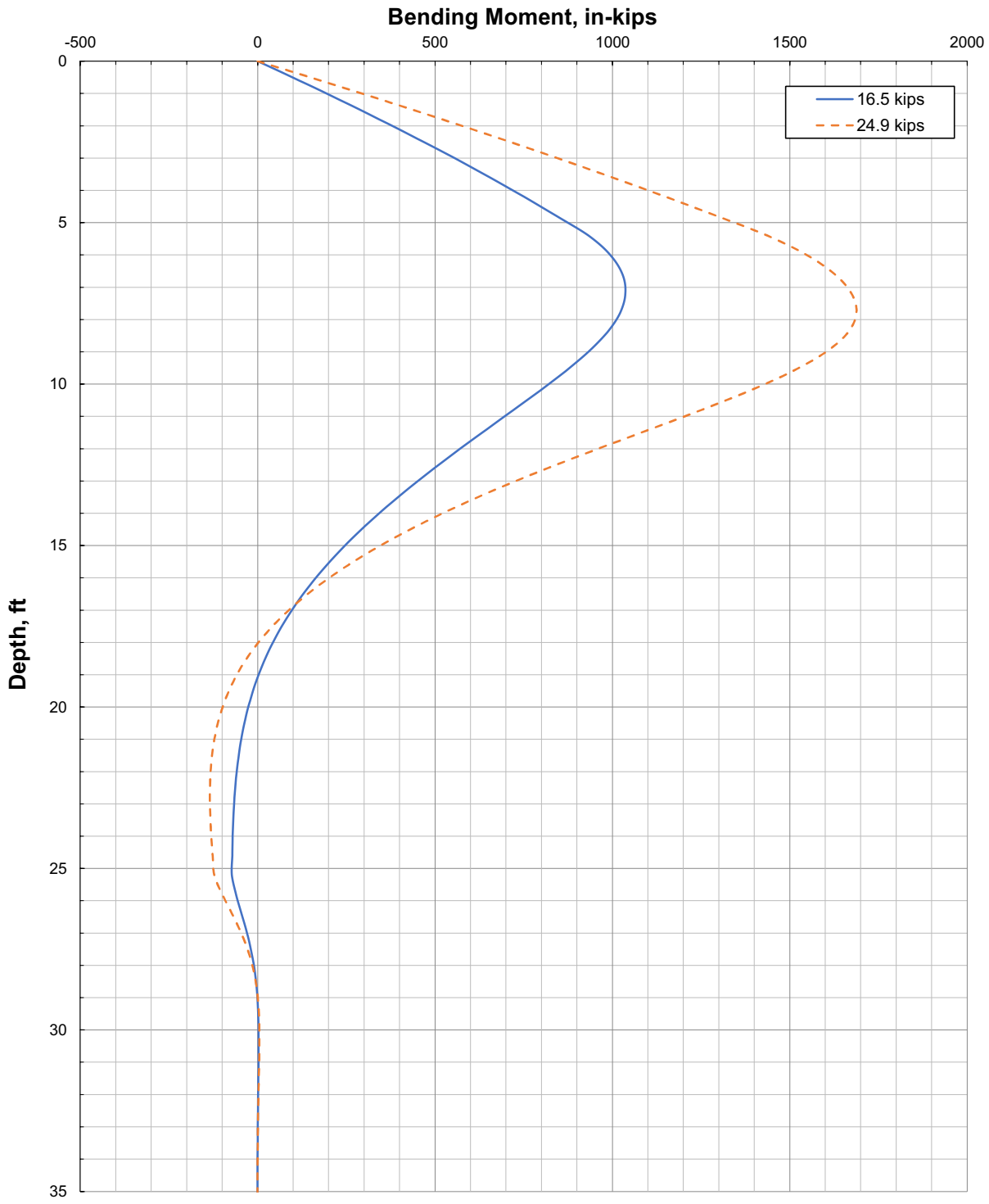
Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	**LATERAL DEFLECTION VS. DEPTH CURVES 18 INCH DIAMETER DRILLED SHAFT - FIXED HEAD PROJECT TUNDRA CENTER, NORTH DAKOTA**	**EXHIBIT 26C**
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/2/2020			
Approved by:	SRG					



Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	BENDING MOMENT VS. DEPTH CURVES 18 INCH DIAMETER DRILLED SHAFT - FIXED HEAD PROJECT TUNDRA CENTER, NORTH DAKOTA	EXHIBIT 26D
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/2/2020			
Approved by:	SRG					

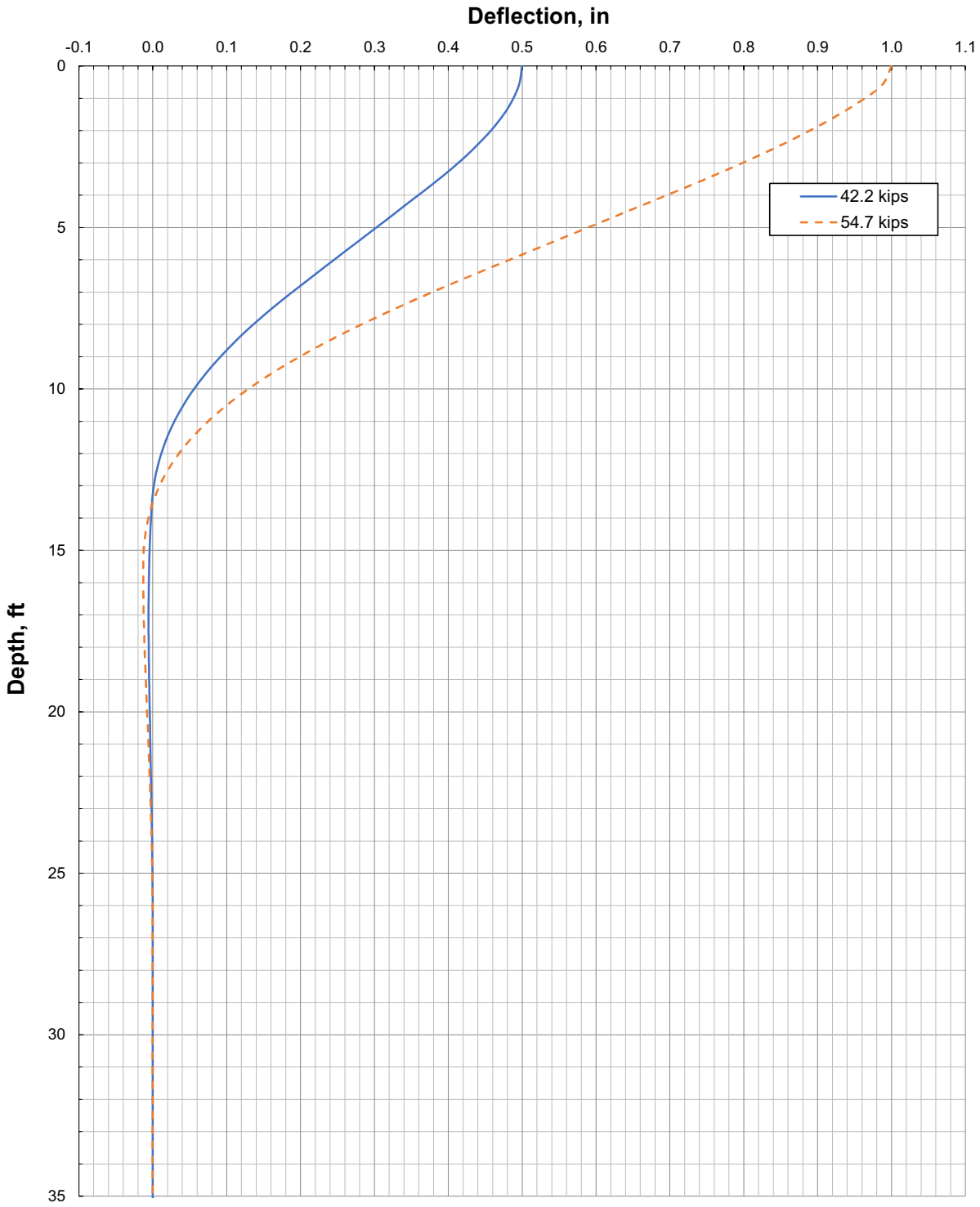


Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	**LATERAL DEFLECTION VS. DEPTH CURVES** **24 INCH DIAMETER DRILLED SHAFT - FREE HEAD** **PROJECT TUNDRA** **CENTER, NORTH DAKOTA**	**EXHIBIT** **26E**
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/2/2020			
Approved by:	SRG					

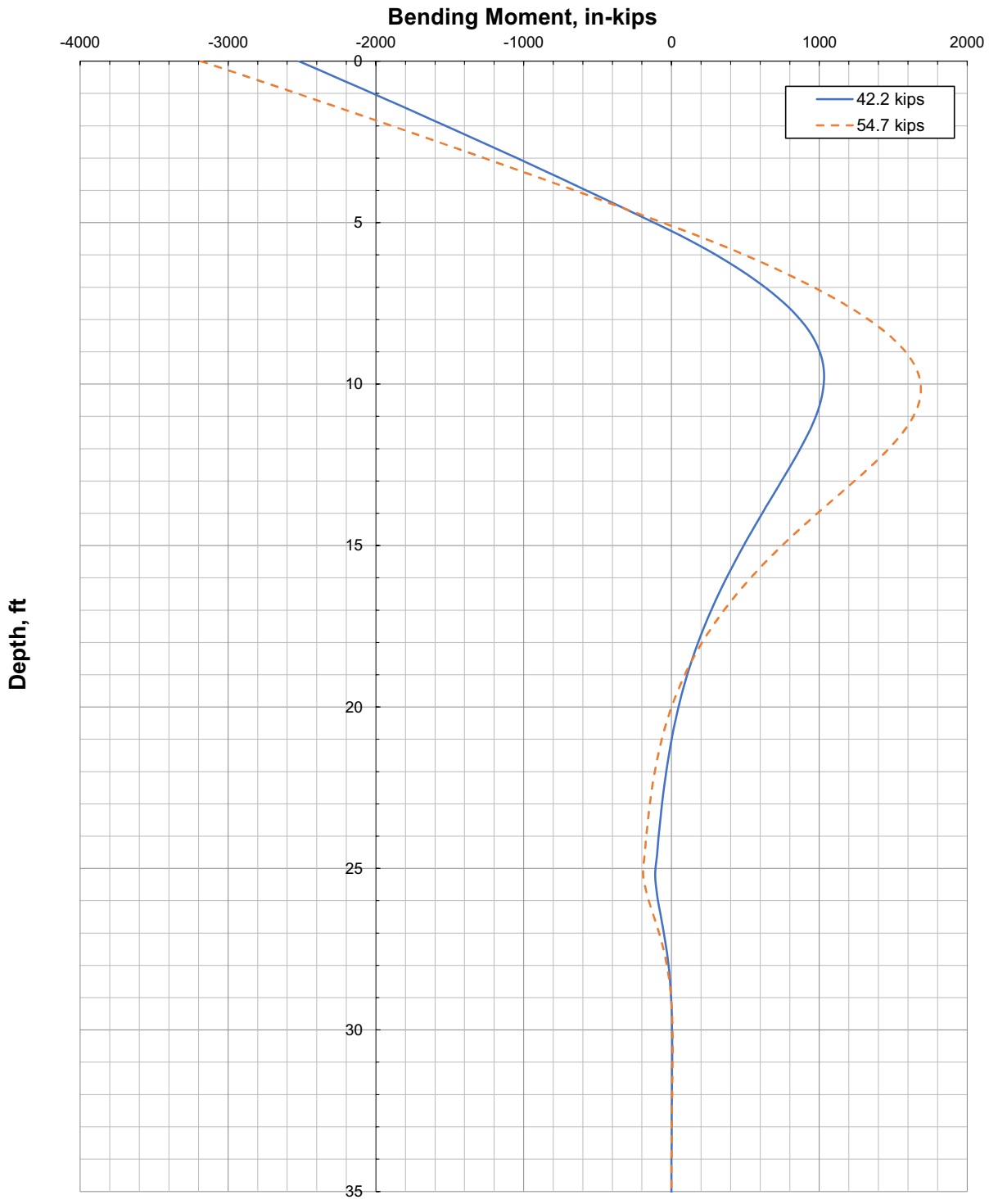


Project Mgr:	CAC	Project No.			EXHIBIT
Prepared by:	RK	M2205062		BENDING MOMENT VS. DEPTH CURVES 24 INCH DIAMETER DRILLED SHAFT - FREE HEAD PROJECT TUNDRA CENTER, NORTH DAKOTA	26F
Checked by:	SRG	Date:	11/2/2020		
Approved by:	SRG				

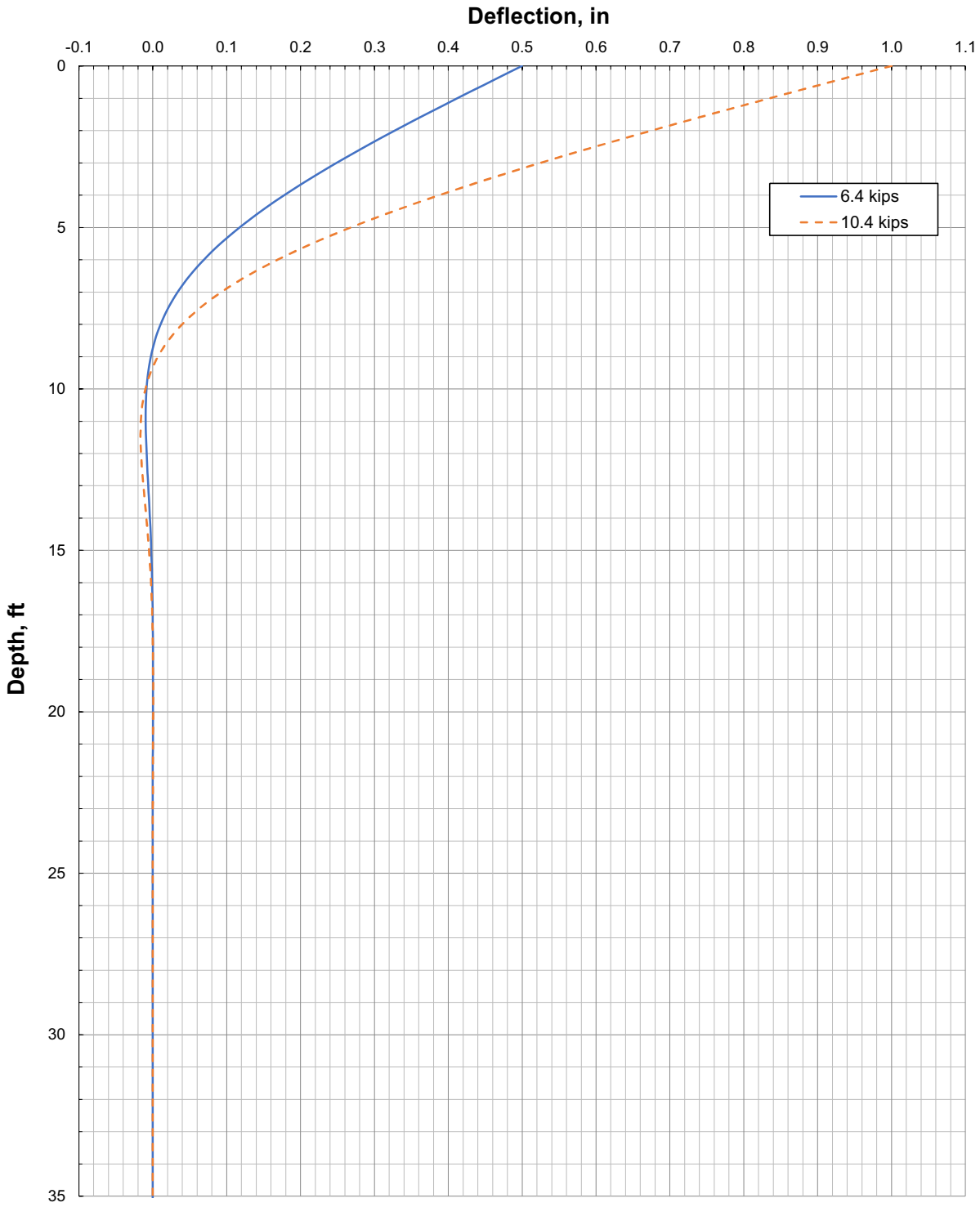
Terracon
Consulting Engineers & Scientists
Texas Registration 3272
1805 Hancock Drive Bismarck, North Dakota 58501



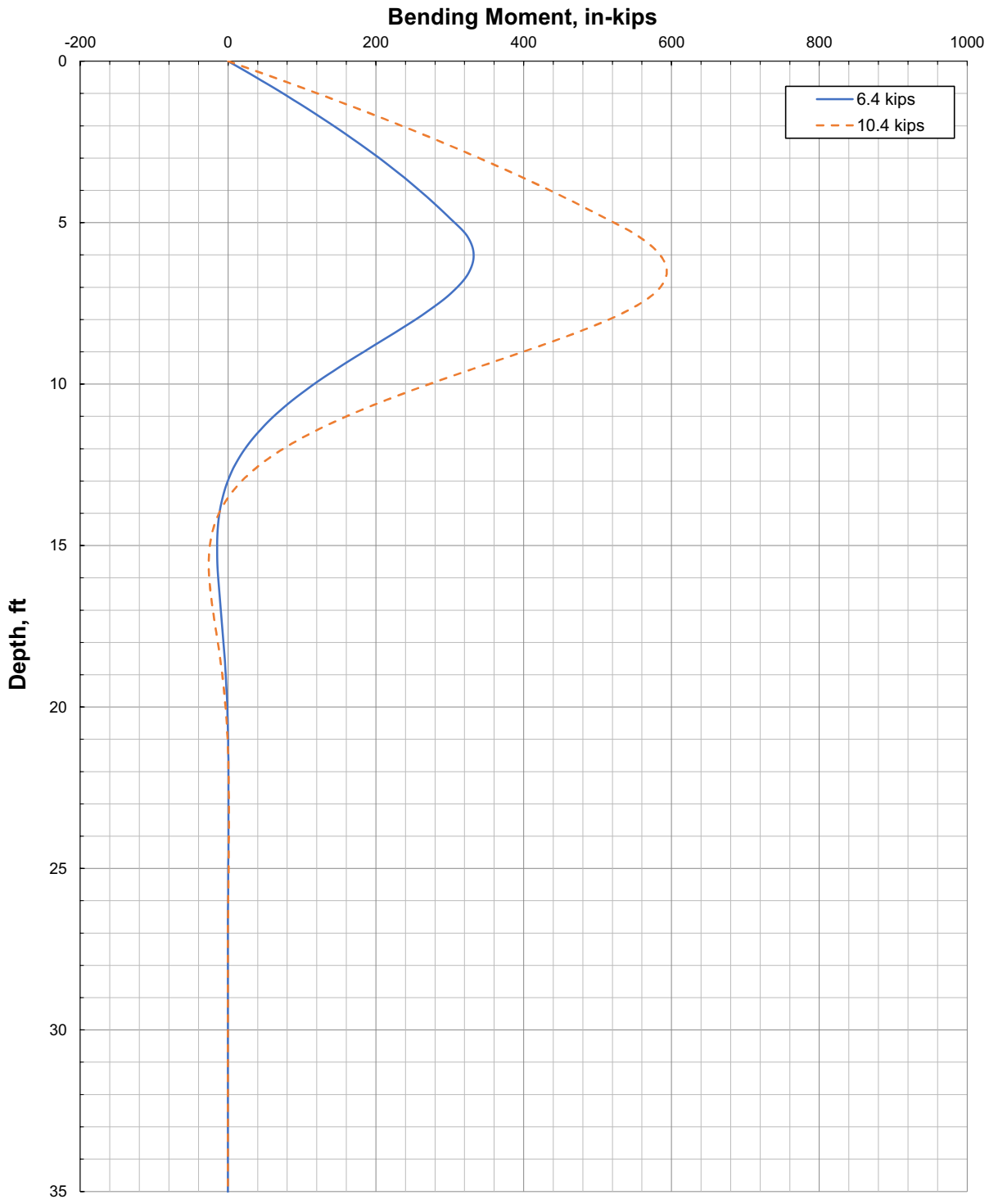
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Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/2/2020			
Approved by:	SRG					



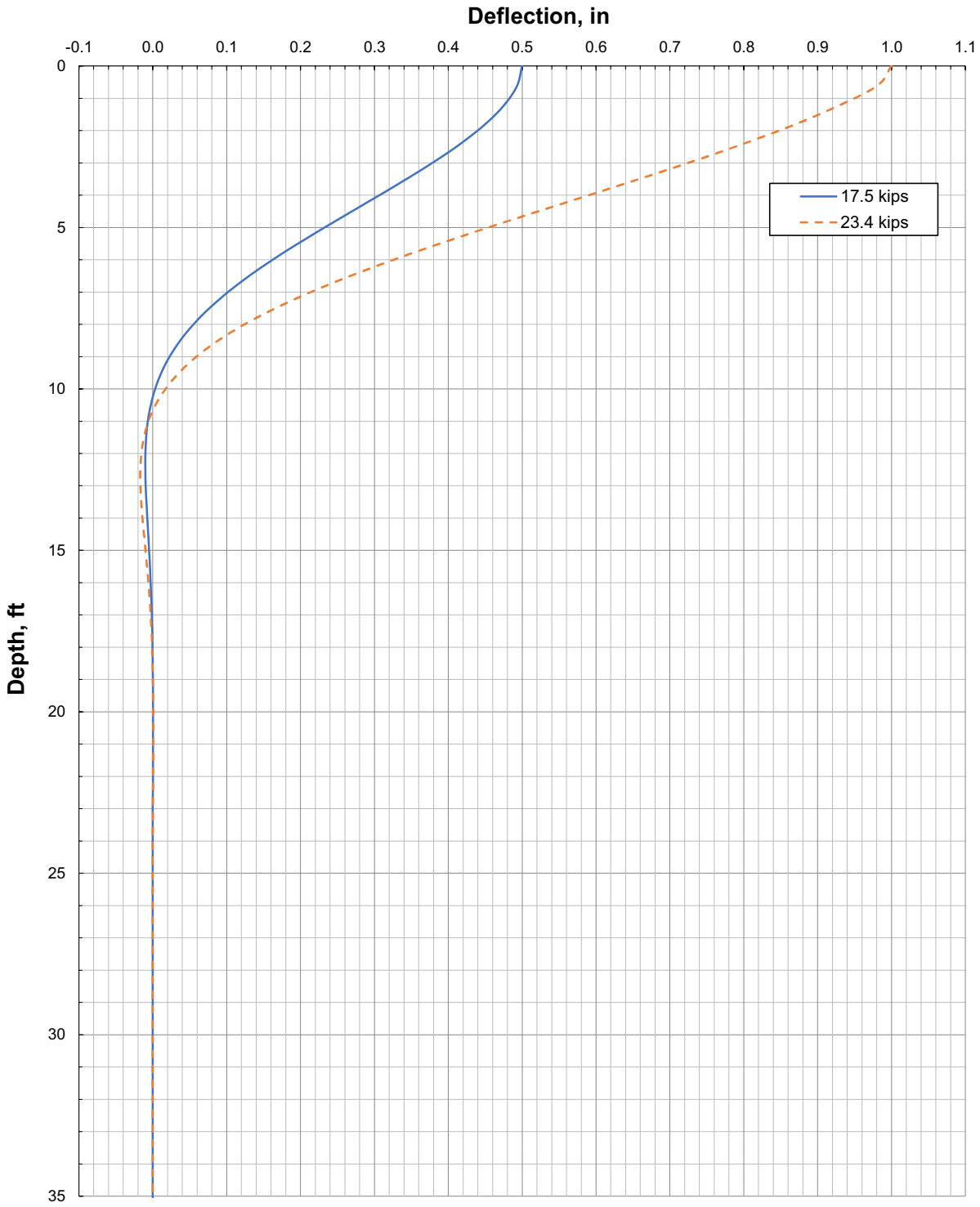
Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	**BENDING MOMENT VS. DEPTH CURVES** **24 INCH DIAMETER DRILLED SHAFT - FIXED HEAD** **PROJECT TUNDRA** **CENTER, NORTH DAKOTA**	**EXHIBIT** **26H**
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/2/2020			
Approved by:	SRG					



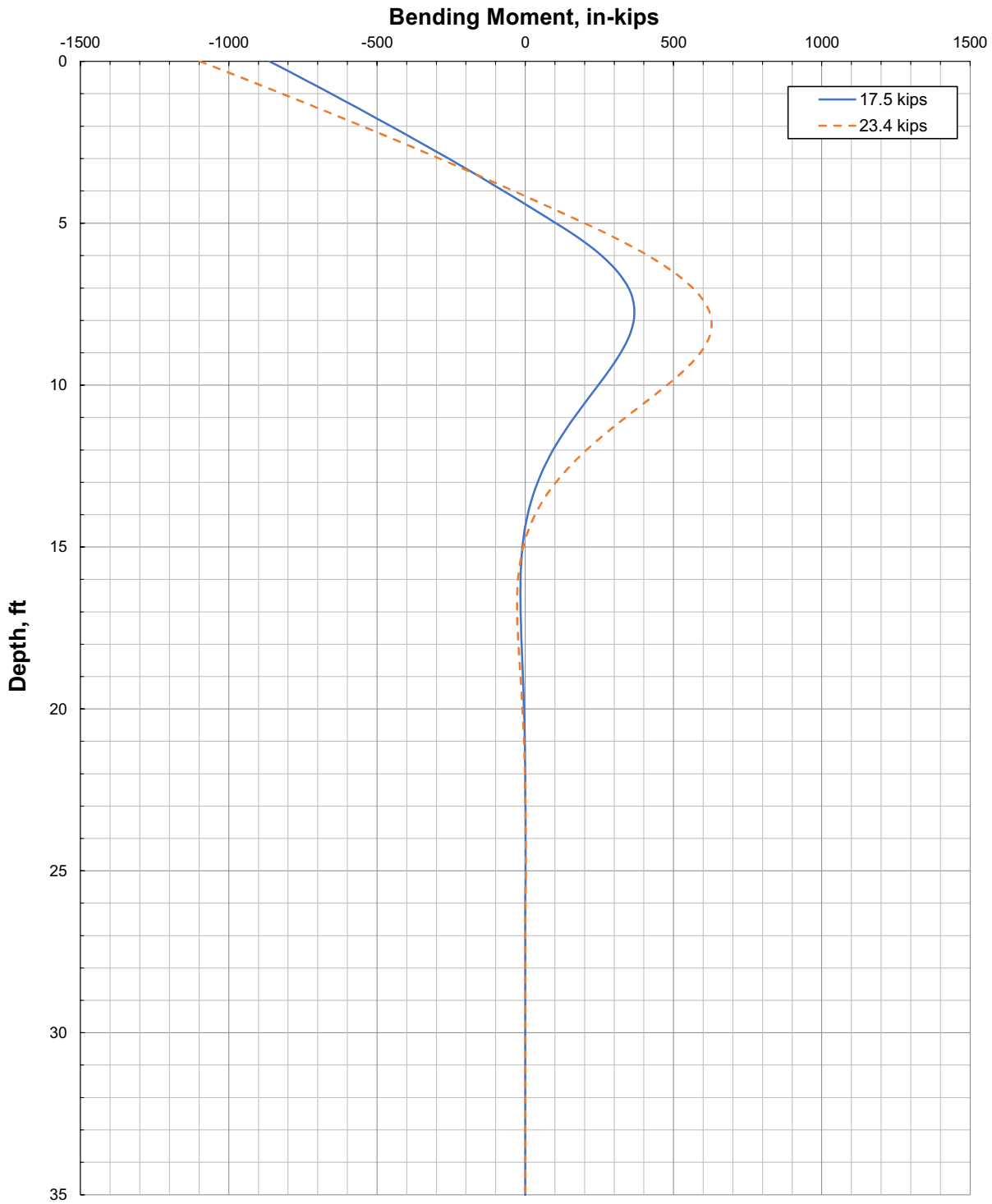
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Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/2/2020			
Approved by:	SRG					



Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	**BENDING MOMENT VS. DEPTH CURVES** **12x53 H PILE - FREE HEAD** **PROJECT TUNDRA** **CENTER, NORTH DAKOTA**	**EXHIBIT** **27B**
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/2/2020			
Approved by:	SRG					

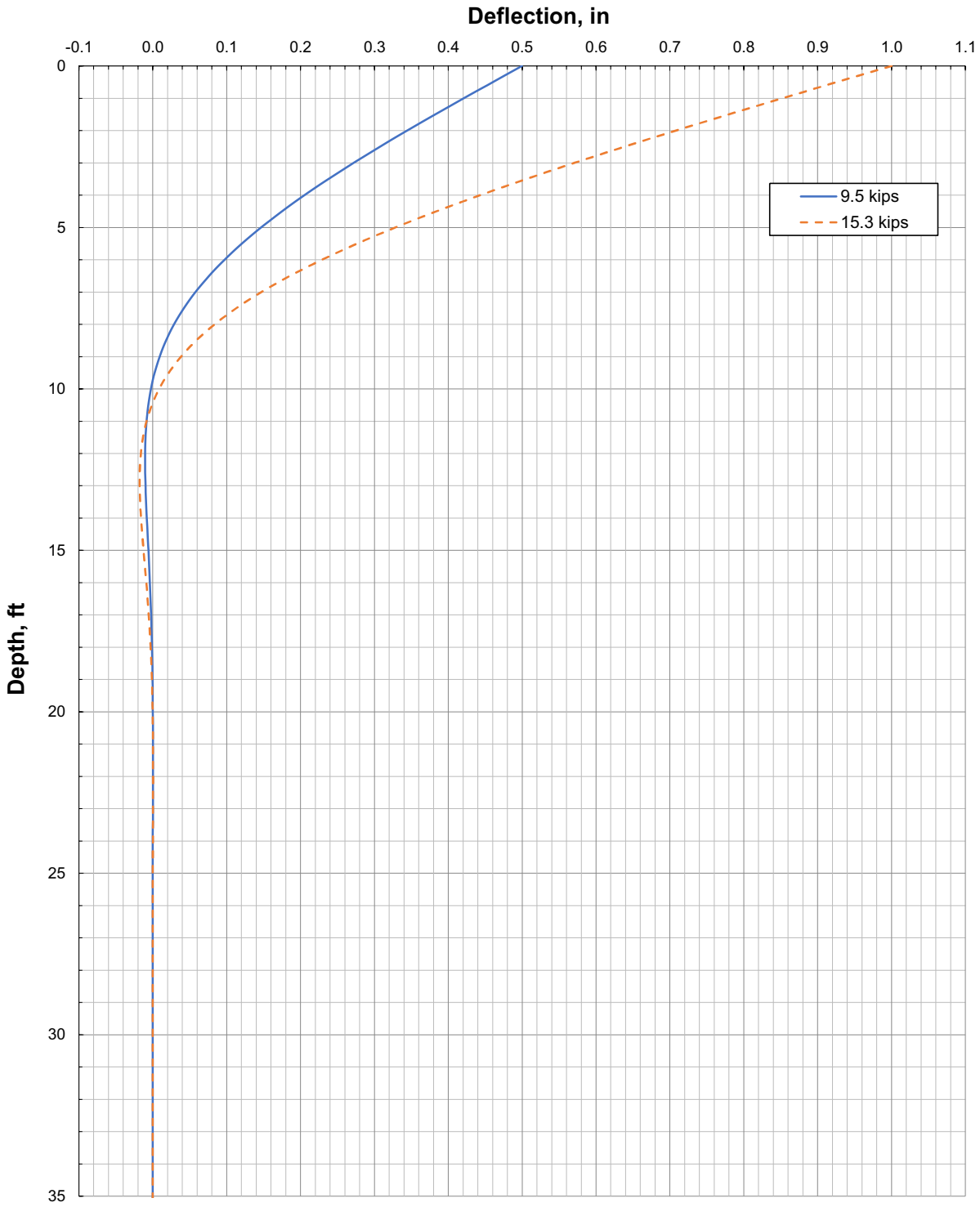


Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	**LATERAL DEFLECTION VS. DEPTH CURVES** **12x53 H PILE - FIXED HEAD** **PROJECT TUNDRA** **CENTER, NORTH DAKOTA**	**EXHIBIT** **27C**
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/2/2020			
Approved by:	SRG					

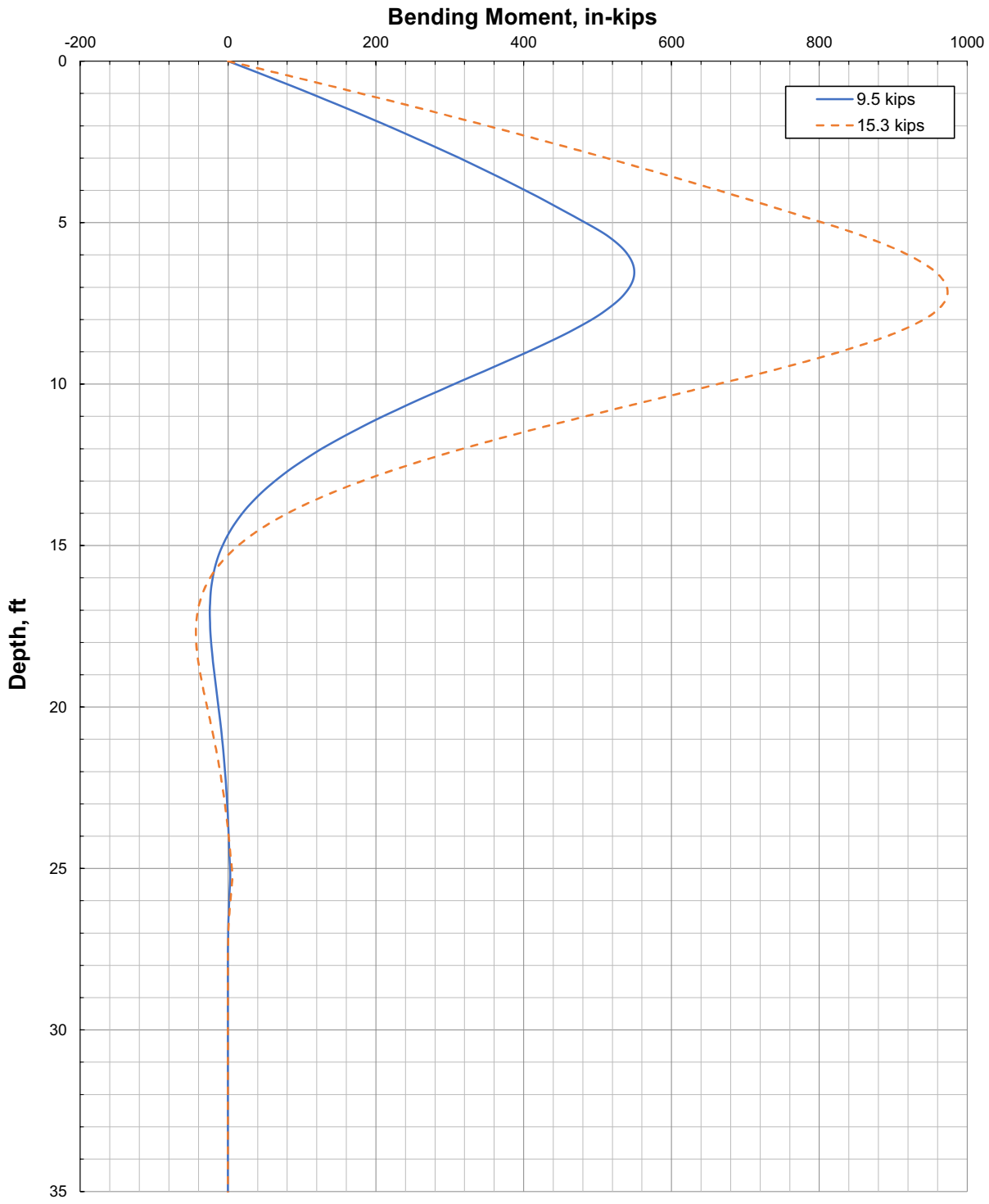


Project Mgr:	CAC	Project No.			EXHIBIT
Prepared by:	RK	M2205062		BENDING MOMENT VS. DEPTH CURVES 12x53 H PILE - FIXED HEAD PROJECT TUNDRA CENTER, NORTH DAKOTA	27D
Checked by:	SRG	Date:	11/2/2020		
Approved by:	SRG				

Terracon
Consulting Engineers & Scientists
Texas Registration 3272
1805 Hancock Drive Bismarck, North Dakota 58501

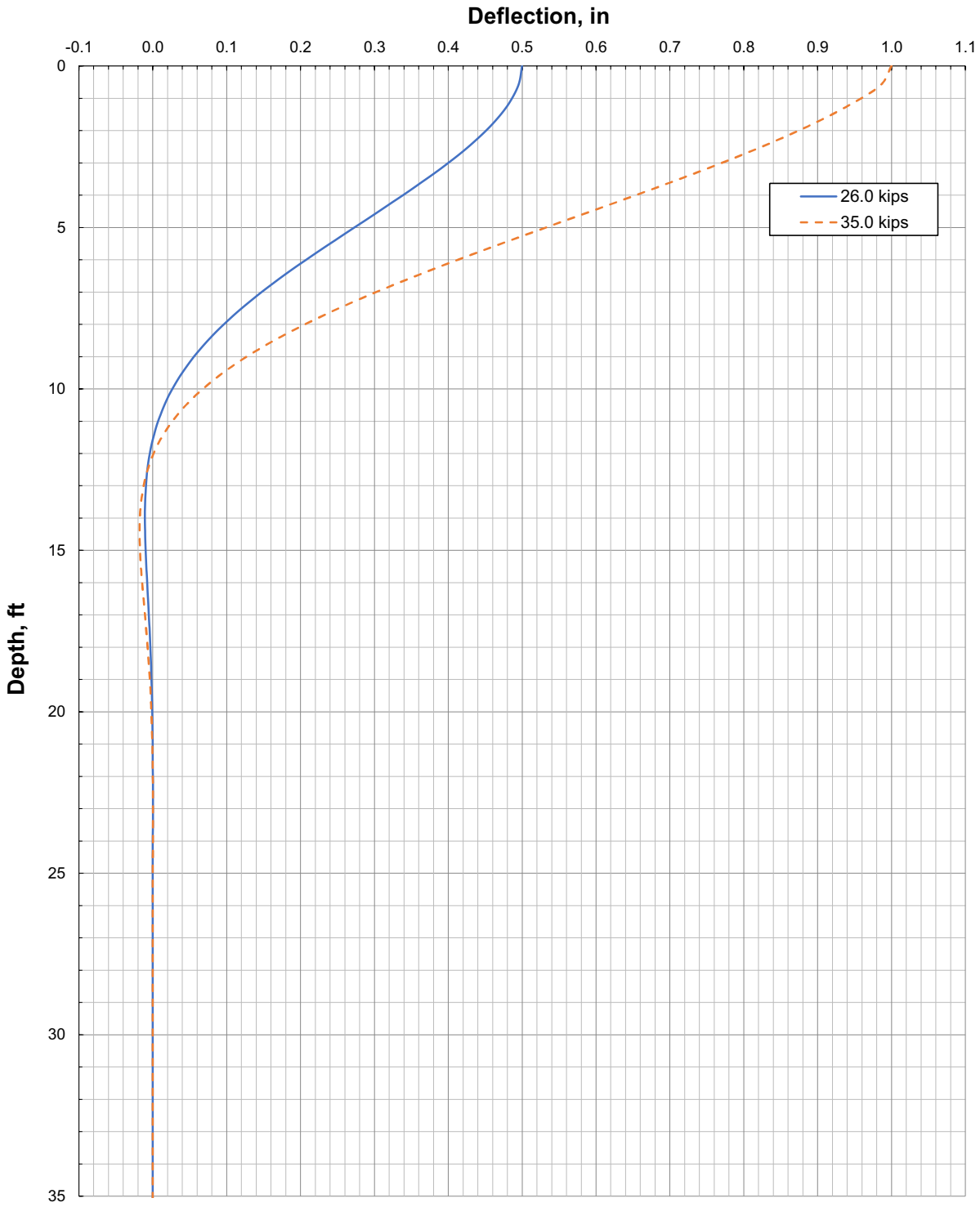


Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	**LATERAL DEFLECTION VS. DEPTH CURVES** **14x73 H PILE - FREE HEAD** **PROJECT TUNDRA** **CENTER, NORTH DAKOTA**	**EXHIBIT** **27E**
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/2/2020			
Approved by:	SRG					

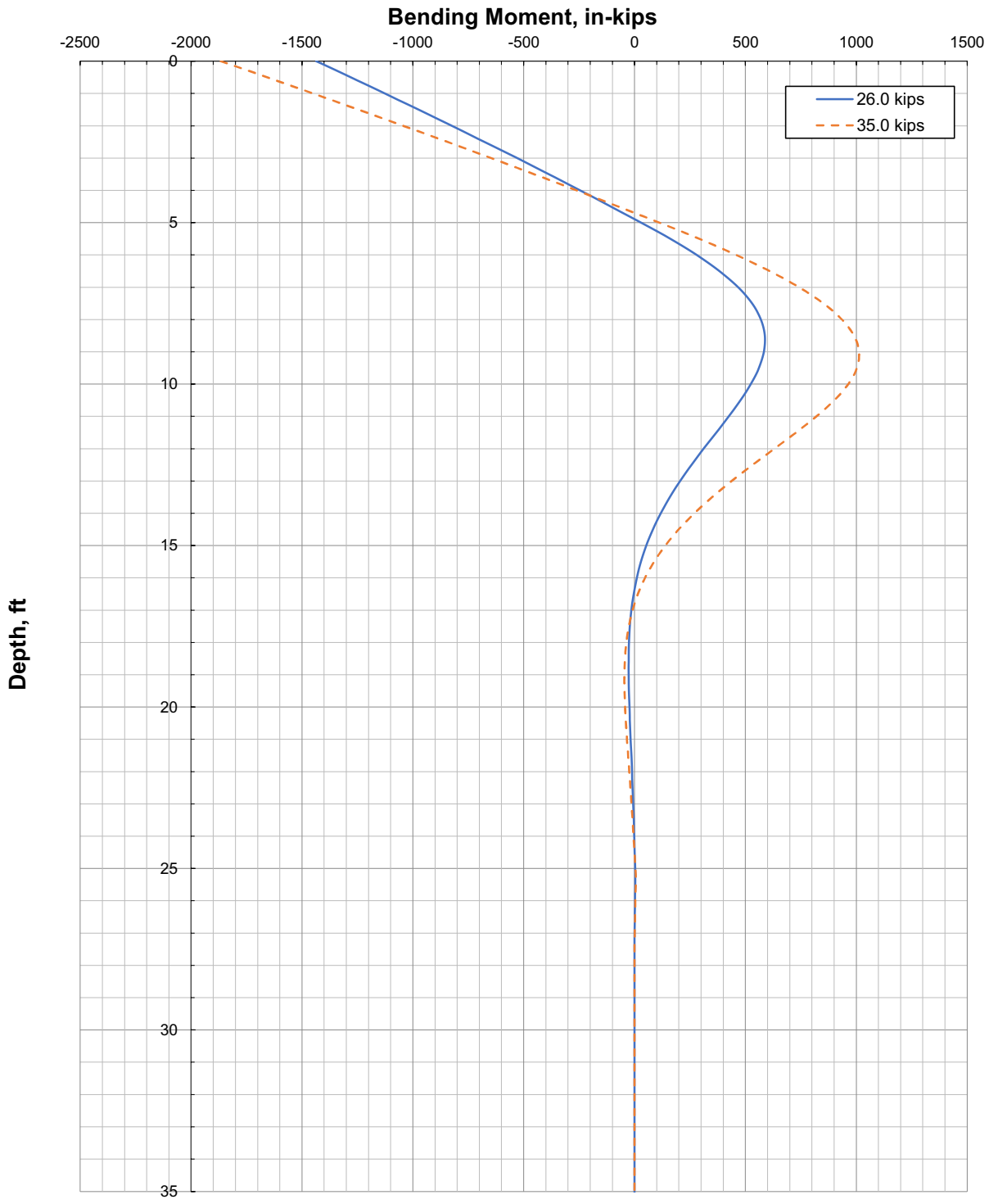


Project Mgr:	CAC	Project No.		BENDING MOMENT VS. DEPTH CURVES 14x73 H PILE - FREE HEAD PROJECT TUNDRA CENTER, NORTH DAKOTA	EXHIBIT 27F
Prepared by:	RK	M2205062			
Checked by:	SRG	Date:	11/2/2020		
Approved by:	SRG				

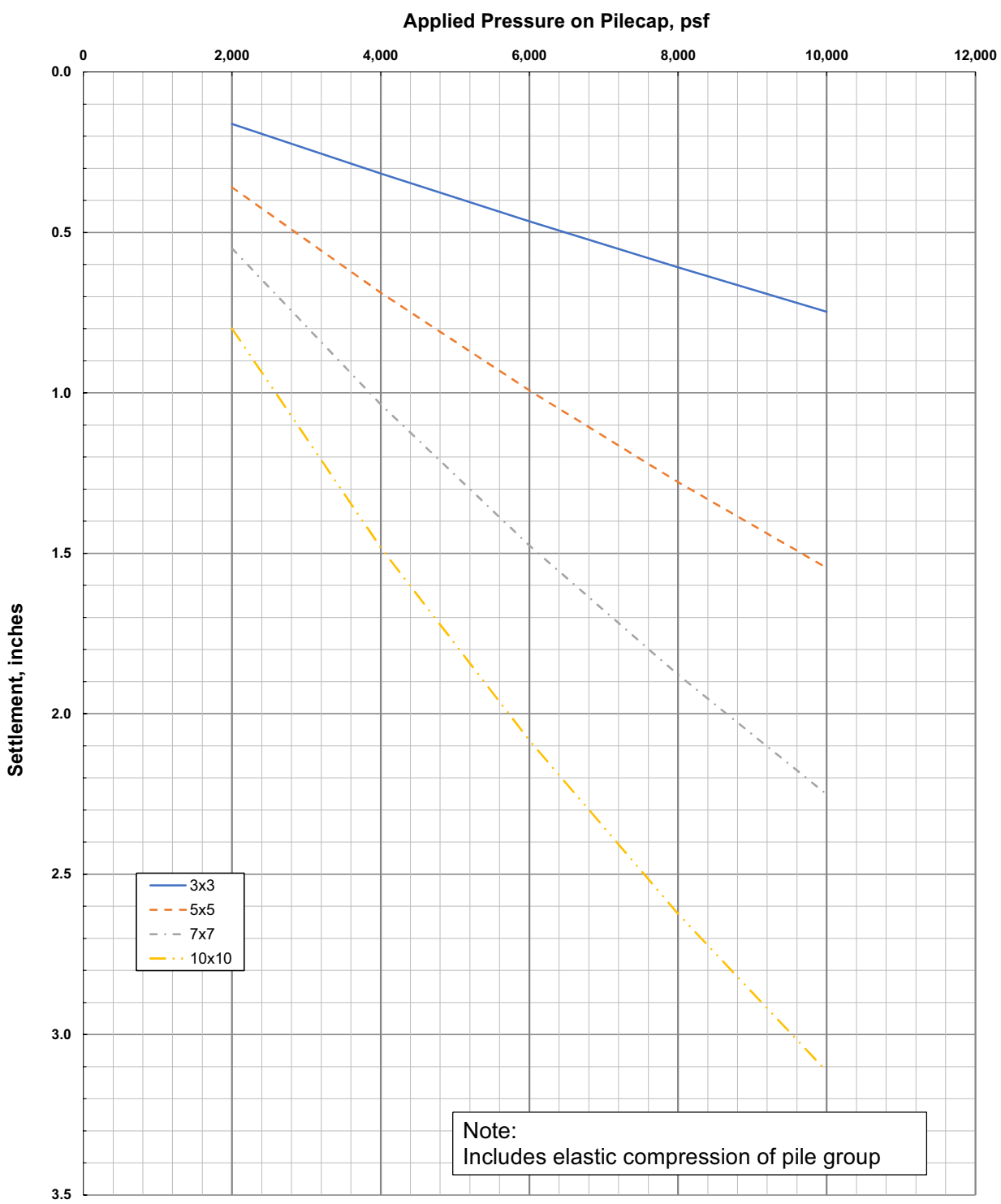
Terracon
Consulting Engineers & Scientists
Texas Registration 3272
1805 Hancock Drive Bismarck, North Dakota 58501



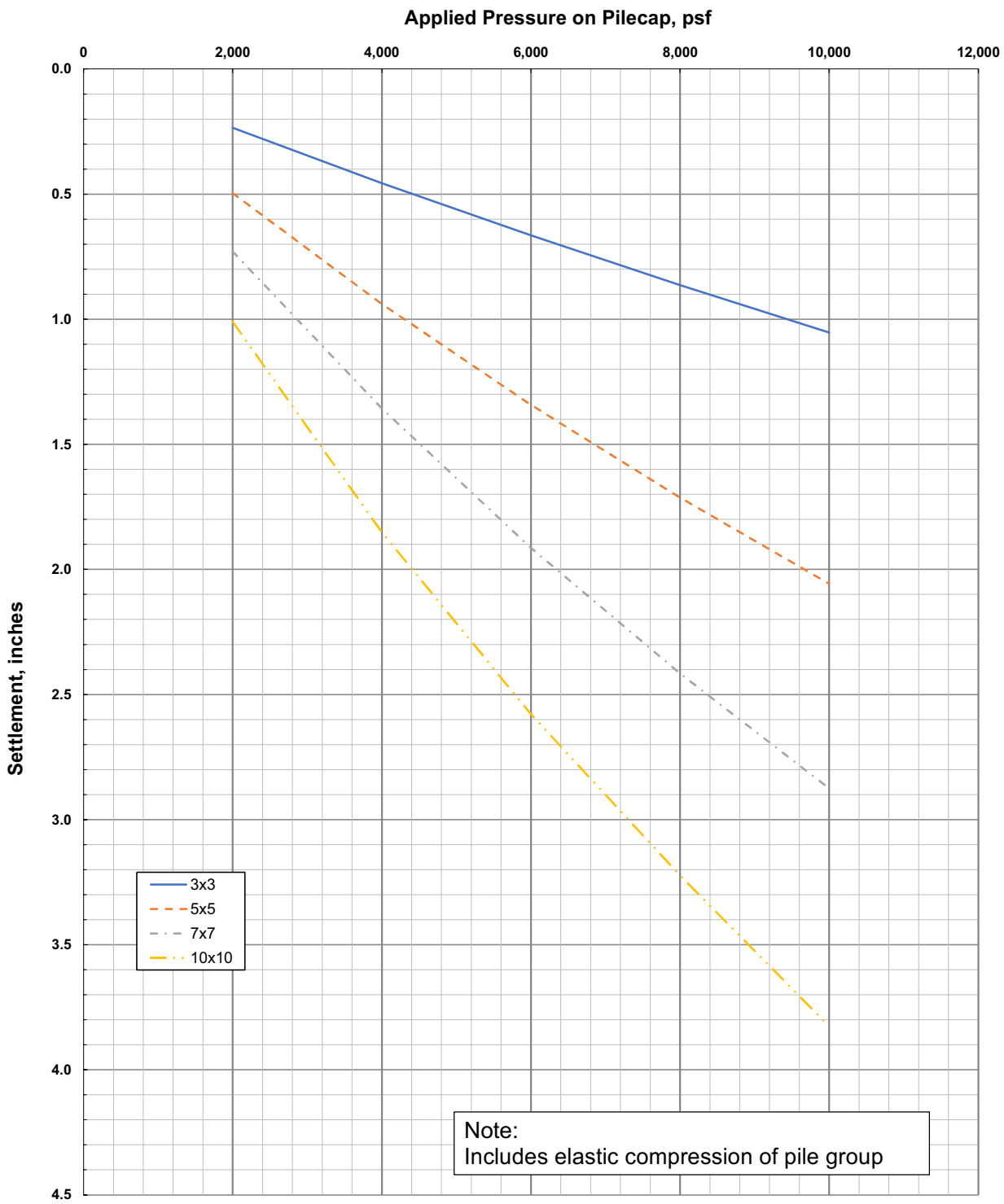
Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	LATERAL DEFLECTION VS. DEPTH CURVES 14x73 H PILE - FIXED HEAD PROJECT TUNDRA CENTER, NORTH DAKOTA	EXHIBIT 27G
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/2/2020			
Approved by:	SRG					



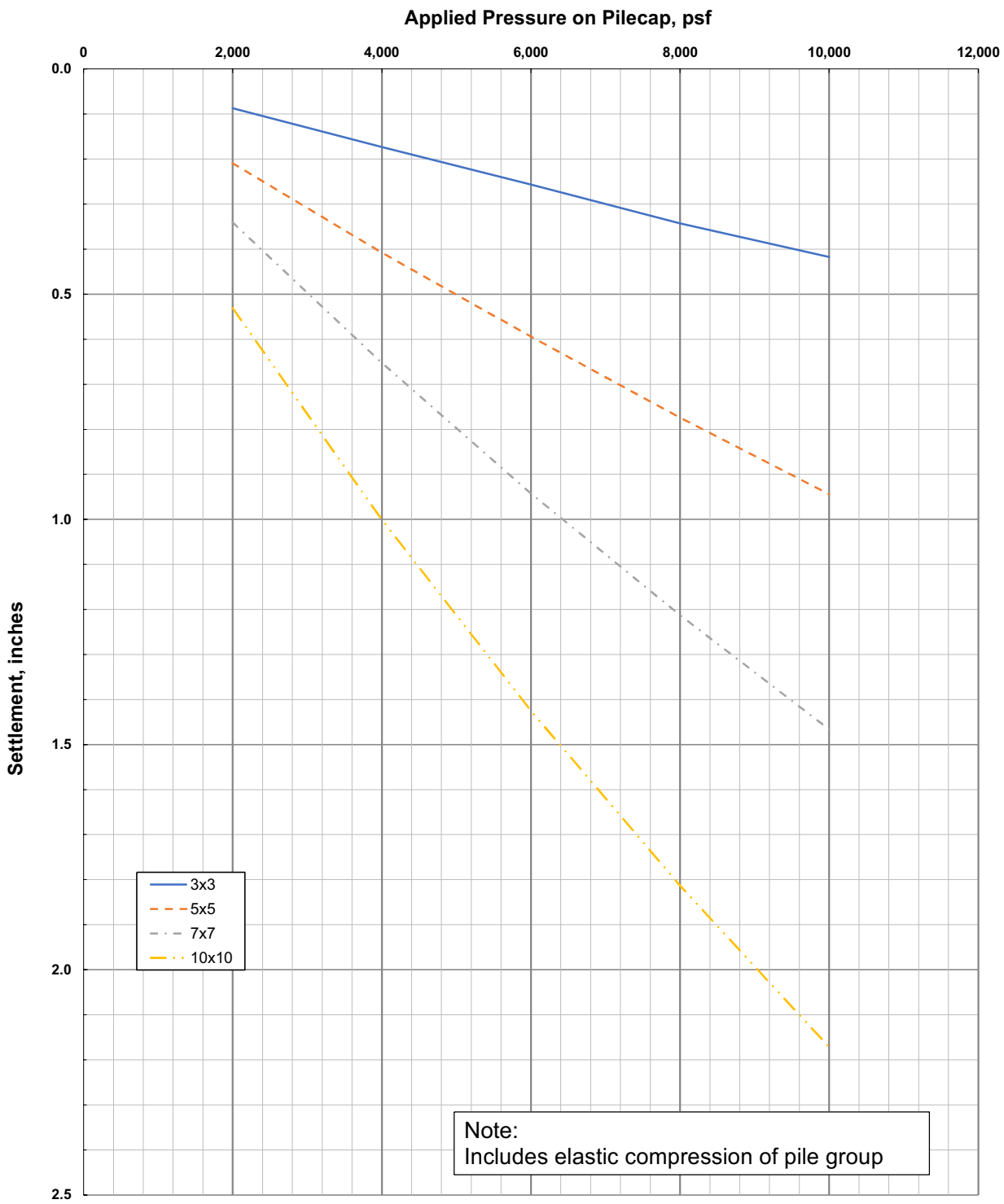
Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	**BENDING MOMENT VS. DEPTH CURVES 14x73 H PILE - FIXED HEAD PROJECT TUNDRA CENTER, NORTH DAKOTA**	**EXHIBIT 27H**
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/2/2020			
Approved by:	SRG					



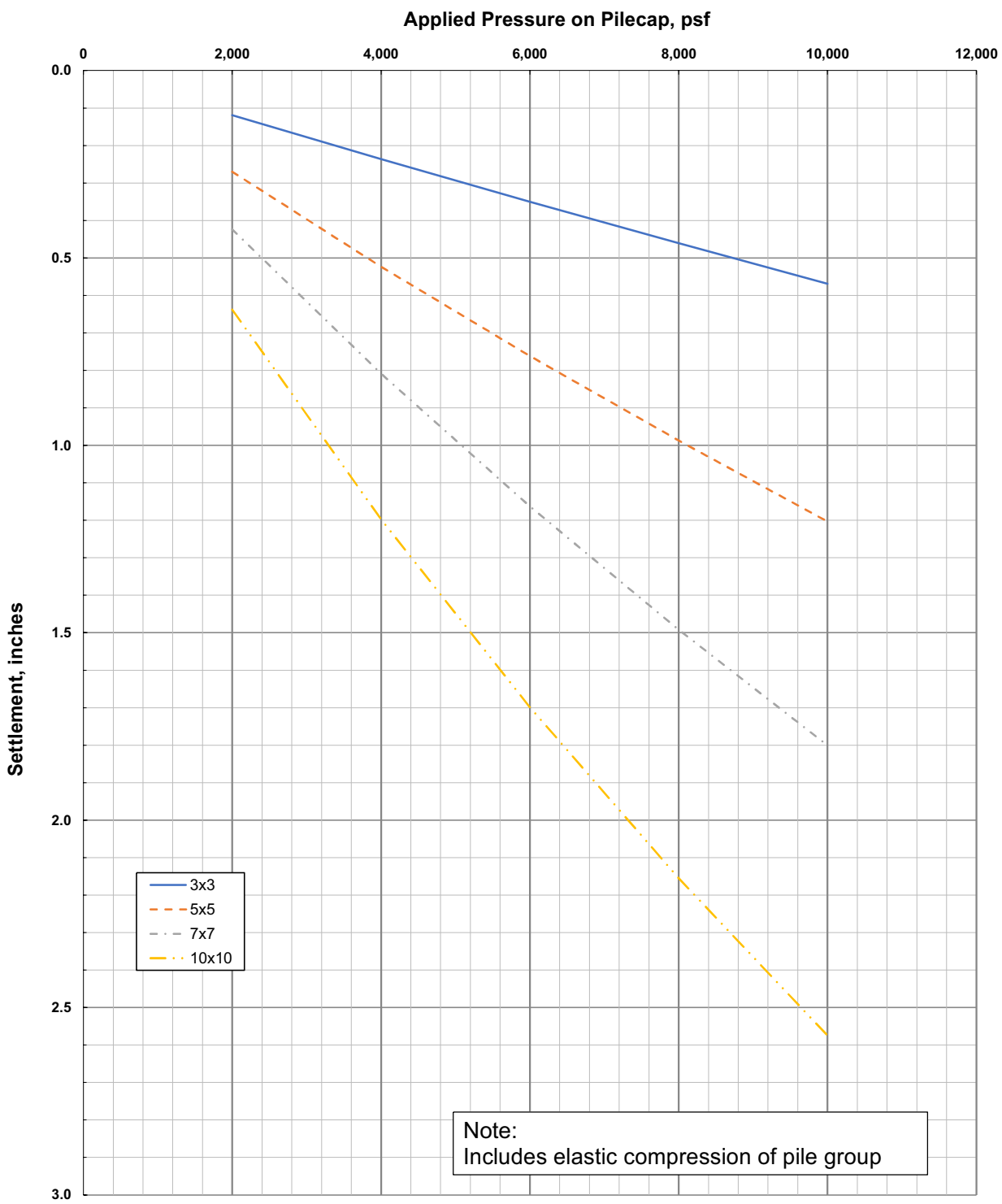
Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	SETTLEMENT - 3D SPACED PILE GROUPS 18 INCH DIAMETER DRILLED SHAFT PROJECT TUNDRA MINNKOTA POWER COOPERATIVE, INC. CENTER, NORTH DAKOTA	EXHIBIT 28A
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/2/2020			
Approved by:	SRG					



Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	SETTLEMENT - 3D SPACED PILE GROUPS 24 INCH DIAMETER DRILLED SHAFT PROJECT TUNDRA MINNKOTA POWER COOPERATIVE, INC. CENTER, NORTH DAKOTA	EXHIBIT 28B
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/2/2020			
Approved by:	SRG					

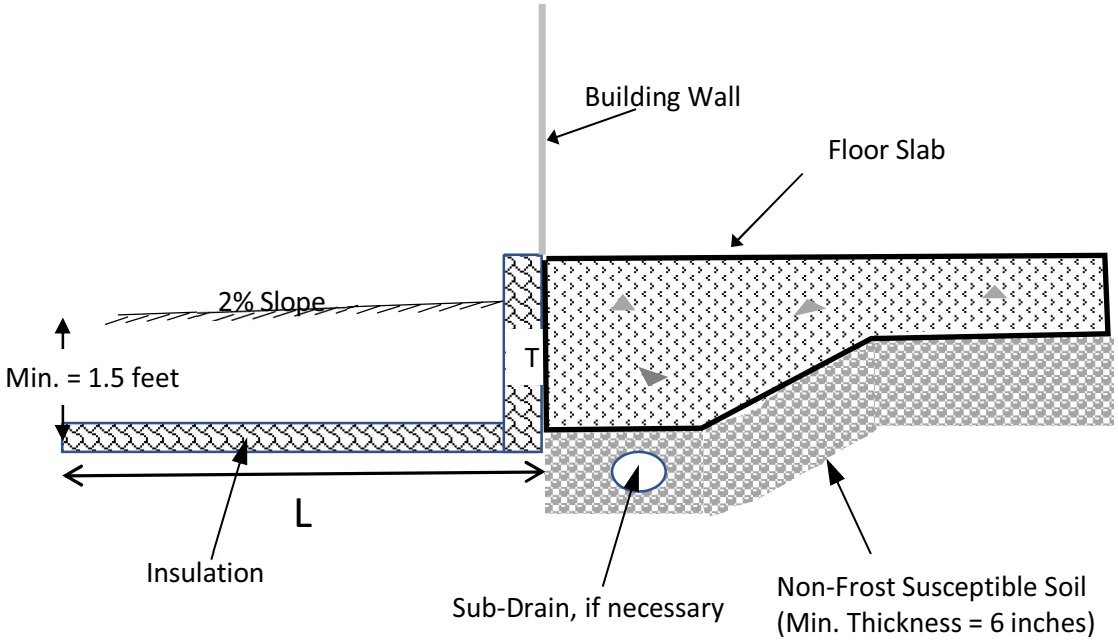


Project Mgr:	CAC	Project No.		Terracon Consulting Engineers & Scientists Texas Registration 3272 1805 Hancock Drive Bismarck, North Dakota 58501	SETTLEMENT - 3D SPACED PILE GROUPS 12x53 H PILE PROJECT TUNDRA MINNKOTA POWER COOPERATIVE, INC. CENTER, NORTH DAKOTA	EXHIBIT 28C
Prepared by:	RK	M2205062				
Checked by:	SRG	Date:	11/2/2020			
Approved by:	SRG					



Project Mgr:	CAC	Project No.		**SETTLEMENT - 3D SPACED PILE GROUPS** **14x73 H PILE** **PROJECT TUNDRA** **MINNKOTA POWER COOPERATIVE, INC.** **CENTER, NORTH DAKOTA**	**EXHIBIT** **28D**
Prepared by:	RK	M2205062			
Checked by:	SRG	Date:	11/2/2020		
Approved by:	SRG				

Terracon
Consulting Engineers & Scientists
Texas Registration 3272
1805 Hancock Drive Bismarck, North Dakota 58501

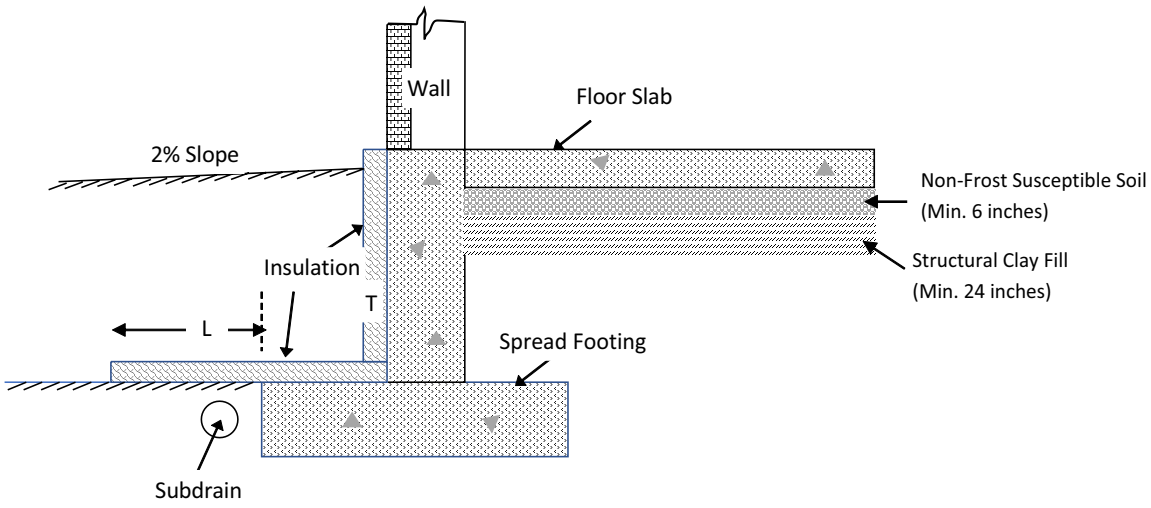


Minimum Building Temperature, °F	Recommended	
	Rigid Insulation Thickness, (T), inches	Minimum Distance (L), feet
64	2	3
45	4	5

Note 1: Heated building should cover the entire concrete floor area to prevent frost penetration
Note 2: Subdrain is recommended in case of high groundwater levels.
Note 3:We recommend a vapor barrier between the floor slab and the Non-Frost Susceptible soil.
Note 4: If the slab can't tolerate more than 1 inch of settlement, we recommend additional 24 inches of structural clay fill below the Non-Frost Susceptible soil.

TYPICAL FLOOR SLAB FOUNDATION - HEATED BUILDING
TUNDRA CARBON CAPTURE & SEQUESTRATION (CCS) PROJECT
MINNKOTA POWER COOPERATIVE, INC.
CENTER, NORTH DAKOTA

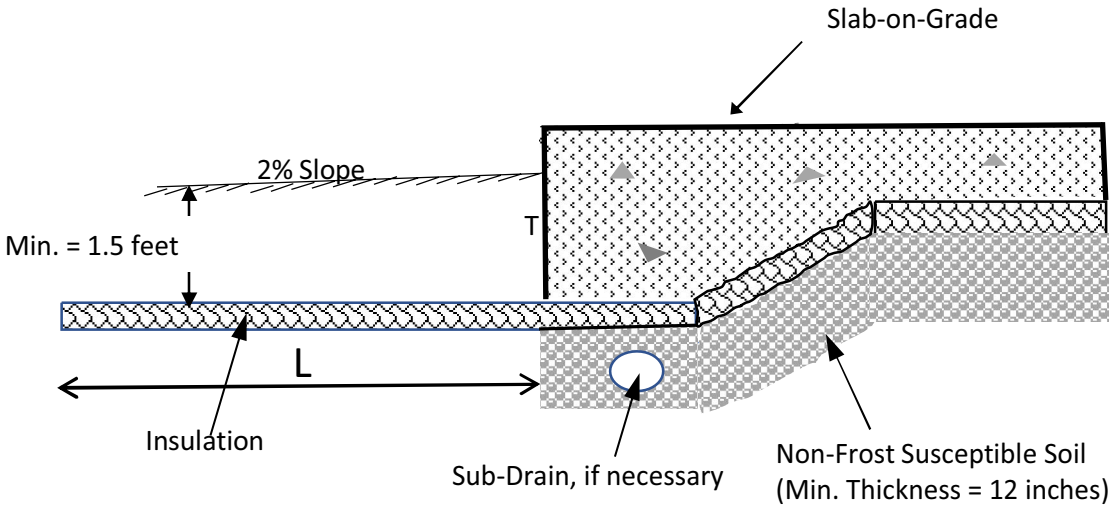
EXHIBIT 29



Minimum Building Temperature, °F	Recommended	
	Rigid Insulation Thickness (T), inches	Minimum Distance (L), feet
64	2	3
45	4	5

Note 1: Impervious Asphalt surface or 12-inch thick compacted clay with 2% slope is recommended to prevent infiltration, which can have adverse effect on the foundation performance.
Note 2: Subdrain is recommended in case of high groundwater levels.
Note 3: Recommended a vapor barrier between the Non-Frost Susceptible (NFS) soil and the floor slab.

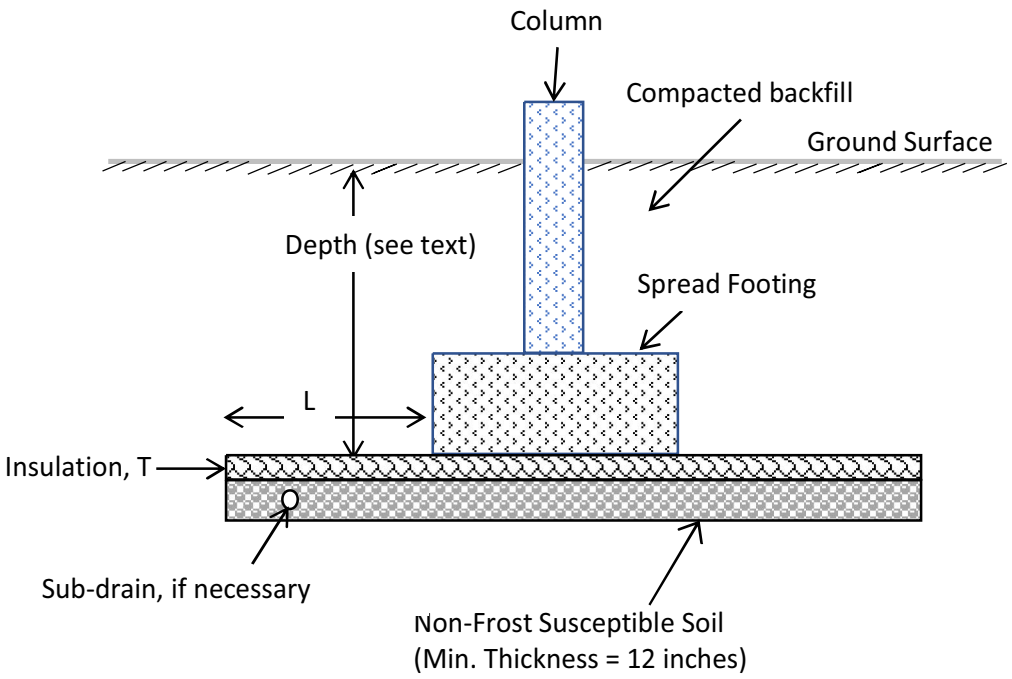
TYPICAL SPREAD FOOTING - HEATED BUILDING
TUNDRA CARBON CAPTURE & SEQUESTRATION (CCS) PROJECT
MINNKOTA POWER COOPERATIVE, INC.
CENTER, NORTH DAKOTA



Note 1: Subdrain is recommended in case of high groundwater levels.
Note 2: Recommended minimum thickness of insulation is 9 inches.
Note 3: Minimum "L" is 4.5 feet.

SLAB-ON-GRADE FOUNDATION WITH INSULATION - UNHEATED AREAS
TUNDRA CARBON CAPTURE & SEQUESTRATION (CCS) PROJECT
MINNKOTA POWER COOPERATIVE, INC. CENTER,
NORTH DAKOTA

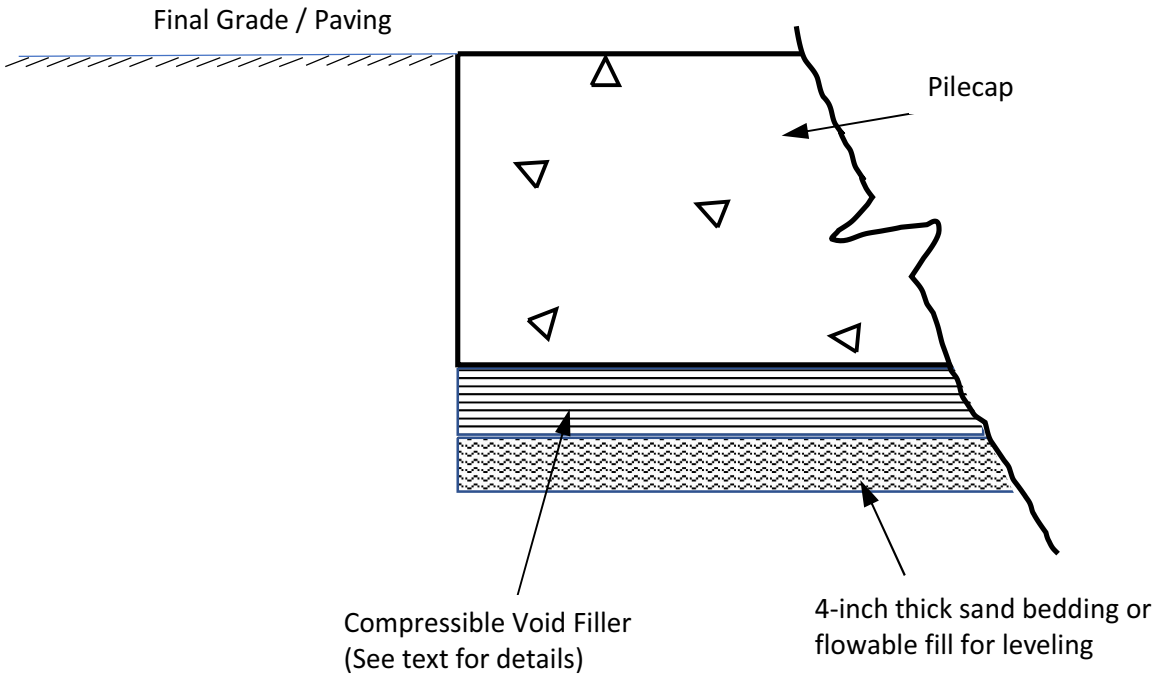
EXHIBIT 31



Note 1: See text for additional details.
Note 2: Subdrain is recommended to lower the groundwater to bottom of the foundation.
Note 3: Recommended minimum thickness (T) of insulation is 9 inches.
Note 4: Recommended minimum length (L) is 3 feet

TYPICAL INSULATED SPREAD FOOTING - UNHEATED AREAS
TUNDRA CARBON CAPTURE & SEQUESTRATION (CCS) PROJECT
MINNKOTA POWER COOPERATIVE, INC.
CENTER, NORTH DAKOTA

EXHIBIT 32



TYPICAL PILECAP WITH VOID FORM - UNHEATED AREAS
TUNDRA CARBON CAPTURE & SEQUESTRATION (CCS) PROJECT
MINNKOTA POWER COOPERATIVE, INC.
CENTER, NORTH DAKOTA

APPENDIX A
SUPPORTING INFORMATION

GENERAL NOTES

Terracon

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

- No Recovery
- Shelby Tube
- Standard Penetration Test

WATER LEVEL

- **Water Initially Encountered**
- **Water Level After a Specified Period of Time**
- **Water Level After a Specified Period of Time**

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

N	**Standard Penetration Test Resistance (Blows/Ft.)**
(HP)	**Hand Penetrometer**
(T)	**Torvane**
(DCP)	**Dynamic Cone Penetrometer**
(PID)	**Photo-Ionization Detector**
(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines Classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]		CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

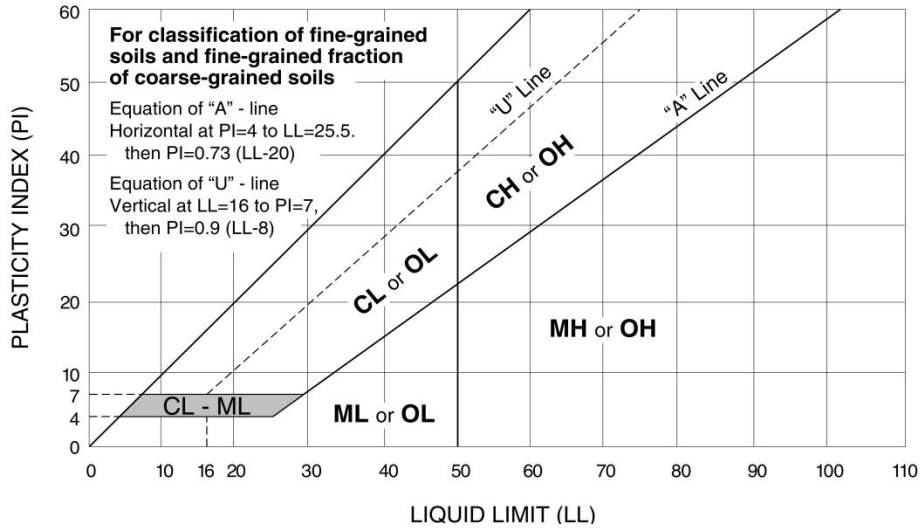
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



APPENDIX B
GEOPHYSICAL REPORT

October 15, 2020

Fluor Enterprises, Inc.
100 Fluor Daniel Dr
Greenville, SC. 29607

Attn: Mr. David Alewine
E: david.alewine@fluor.com
M: 864.517.1940

Re: Geophysical Exploration Services
Project Tundra
Center, North Dakota
Terracon Project No. M2205062

Dear Mr. Alewine:

On September 9, 10 and 22, 2020, a representative of Terracon Consultants, Inc. (Terracon) performed geophysical exploration services at the above referenced site.

1.0 PROJECT DESCRIPTION

The purpose of this geophysical exploration was to gather information to aid in identifying possible anomalies with Ground Penetrating Radar (GPR) in traverses pre-determined by the client and downhole seismic velocities in one borehole.

2.0 EXPLORATION METHODS

Terracon used a GPR system consisting of a 350 HS MHz antenna made by Geophysical Survey Systems, Inc. (GSSI) to perform an upper profile geophysical survey. In general, field data collection was accomplished as referenced in ASTM D 6432, and more information on both the general method and collection procedures can be found in the standard.

GPR utilizes radio waves to detect changes in the subsurface of the area being scanned. Changes in the signal generally indicate material property changes such as but not limited to electromagnetic conductivity and dielectric constant, which in some cases can be qualitatively linked to other material properties such as density, moisture, or material type, and can be effective in identifying the presence and location of items such as voids, buried concrete, tanks, underground utilities, and embedded reinforcing steel in concrete and masonry structures, among other things. The instrument is capable of both producing real-time images and recording images for later interpretation. Data was collected using a free scan method in which data was collected and interpreted while on-site.

The GPR system was outfitted with a GPS to track where data was collected.

Terracon also used a seismograph and geophone to collect downhole seismic data. The system consisted of a Geometrics ES3000 seismograph with a triaxial geophone and both S-wave and P-wave data was collected.

Seismic source shots were taken at 5-foot depth intervals using an instrumented sledge hammer and metal plate/timber. When the sledgehammer makes contact with the plate/timber it triggers the seismograph to collect data. The data was recorded on a laptop using SeisModule Controller software and returned to the office for analysis. The seismic surveys provided compression wave and shear wave travel times for each interval. Using Seisimager, developed by Geometrics, the first-arrival travel times were picked and recorded and converted velocities using the depth of the geophone and travel path from the source for each interval. The resulting plots contain the travel times and velocity for each interval along with Poisson's Ratio calculated from the velocities. A weighted average for the shear wave velocity is also attached.

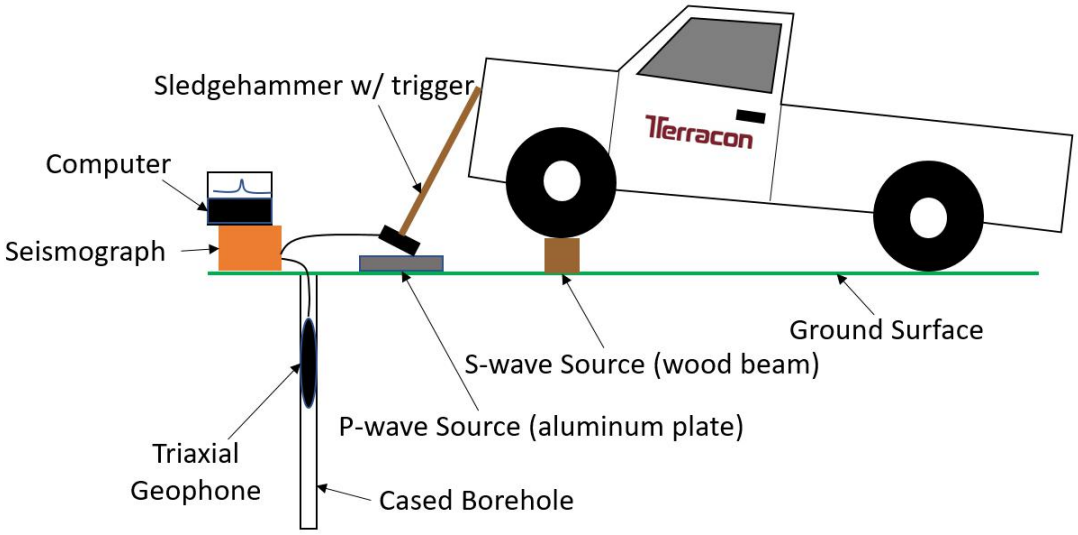


Figure 1: Schematic of downhole seismic acquisition

3.0 FINDINGS AND CONCLUSIONS

A Terracon representative visited the site and scanned in client selected areas. Multiple anomalies were detected under the survey lines which could be consistent with utilities and/or possible buried debris. Several anomalies were also observed to have reinforced concrete either at the surface or buried. Aerial photos with locations of the anomalies and a table with anomalies and geographic location/approximate depth are attached in Appendix A.

Downhole seismic velocities and travel times are attached as Appendix B.

4.0 LIMITATIONS

It should be noted the process relies on instrument signals to indicate physical conditions in the field. Signal information can be affected by on-site conditions beyond the control of the operator, such as, but not limited to, cultural features, concrete/soil types, concrete/soil moisture, groundwater table depth, and/or reinforcing steel spacing. Interpretation of those signals is based on a combination of known factors combined with the experience of the operator and geophysical scientist evaluating the results. Utilizing conventional observation, sampling, and testing of select areas are recommended to confirm the results from the geophysical surveys. As with all geophysical methods, the geophysical results provide a level of confidence, but should not be considered absolute. We cannot be responsible for the interpretation of geophysical results by others.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geophysical practices. No warranties, either express or implied, are intended or made.

The results presented in this report are based upon the data obtained from the geophysical surveys and from other information discussed in this report. This report does not reflect variations that may occur in areas inaccessible to the geophysical equipment, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction.

We appreciate the opportunity to work with you on this project. Please do not hesitate to contact the undersigned if you have any questions regarding this information or if we can be of further service to you.

Sincerely,
Terracon Consultants, Inc.

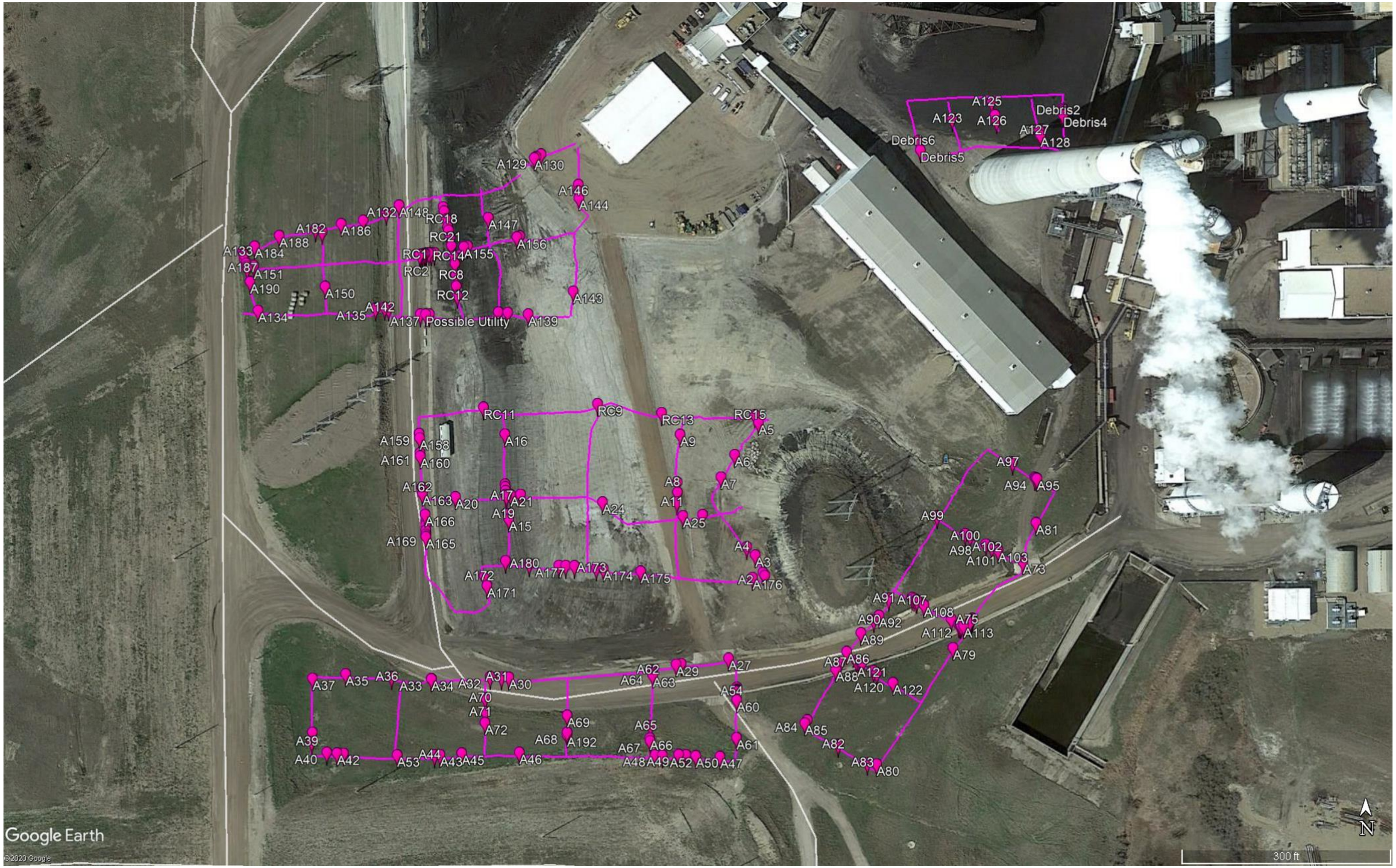
Ryan M. Korth, G.I.
Senior Staff Geophysicist

Rob A. Kramer
Project Geophysicist

Distribution: Addressee (pdf)

Attachment: Appendix A – GPR Results
Appendix B – Downhole Seismic Results

Appendix A
GPR Results



Legend

- GPR Anomaly
- GPR Traverse

Project Manager:	CAC
Drawn by:	RMK
Checked by:	RAK
Approved by:	SRG

Project No.	M2205062
Scale:	N.T.S.
File Name:	
Date:	OCT 2020

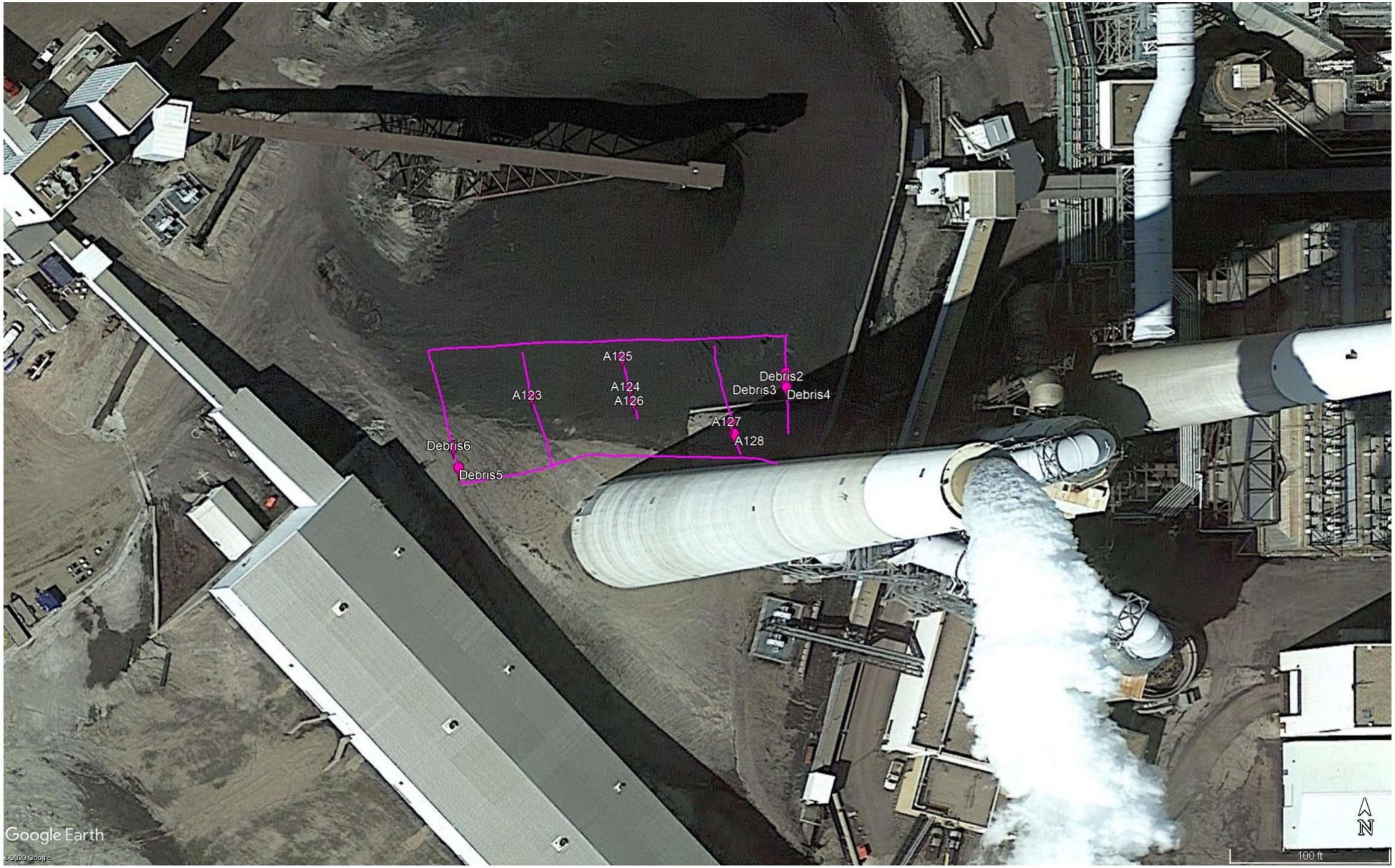
Terracon
Consulting Engineers & Scientists
15080 A Circle Omaha, NE 68144
PH. (402) 330-2202 terracon.com

GROUND PENETRATING RADAR

Project Tundra
Center, North Dakota

Exhibit

A1



Legend

- GPR Anomaly
- GPR Traverse

Project Manager:	CAC
Drawn by:	RMK
Checked by:	RAK
Approved by:	SRG

Project No.	M2205062
Scale:	N.T.S.
File Name:	
Date:	OCT 2020

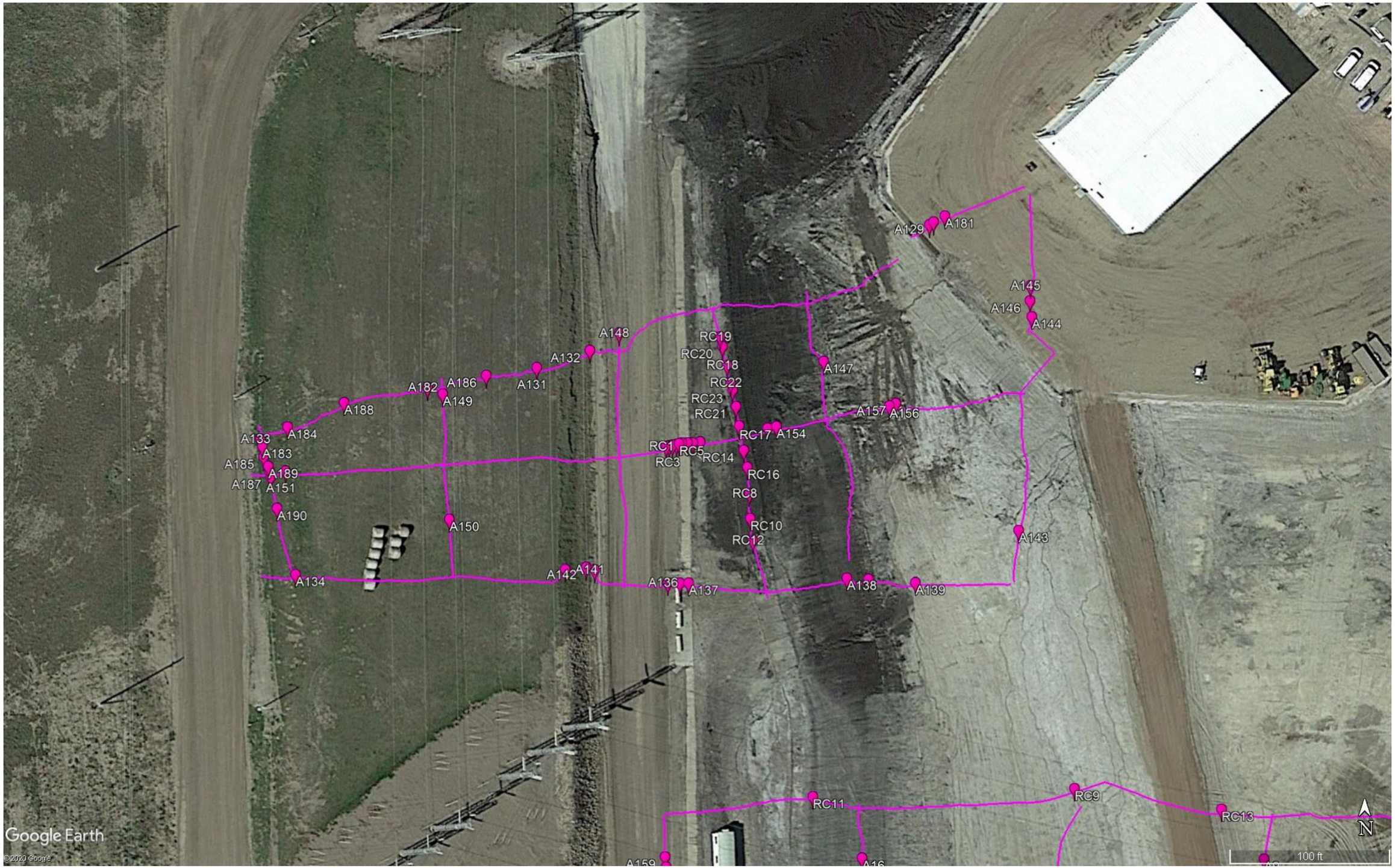
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Consulting Engineers & Scientists
15080 A Circle Omaha, NE 68144
PH. (402) 330-2202 terracon.com

GROUND PENETRATING RADAR

Project Tundra
Center, North Dakota

Exhibit

A2



Legend

- GPR Anomaly
- GPR Traverse

Project Manager:	CAC
Drawn by:	RMK
Checked by:	RAK
Approved by:	SRG

Project No.	M2205062
Scale:	N.T.S.
File Name:	
Date:	OCT 2020

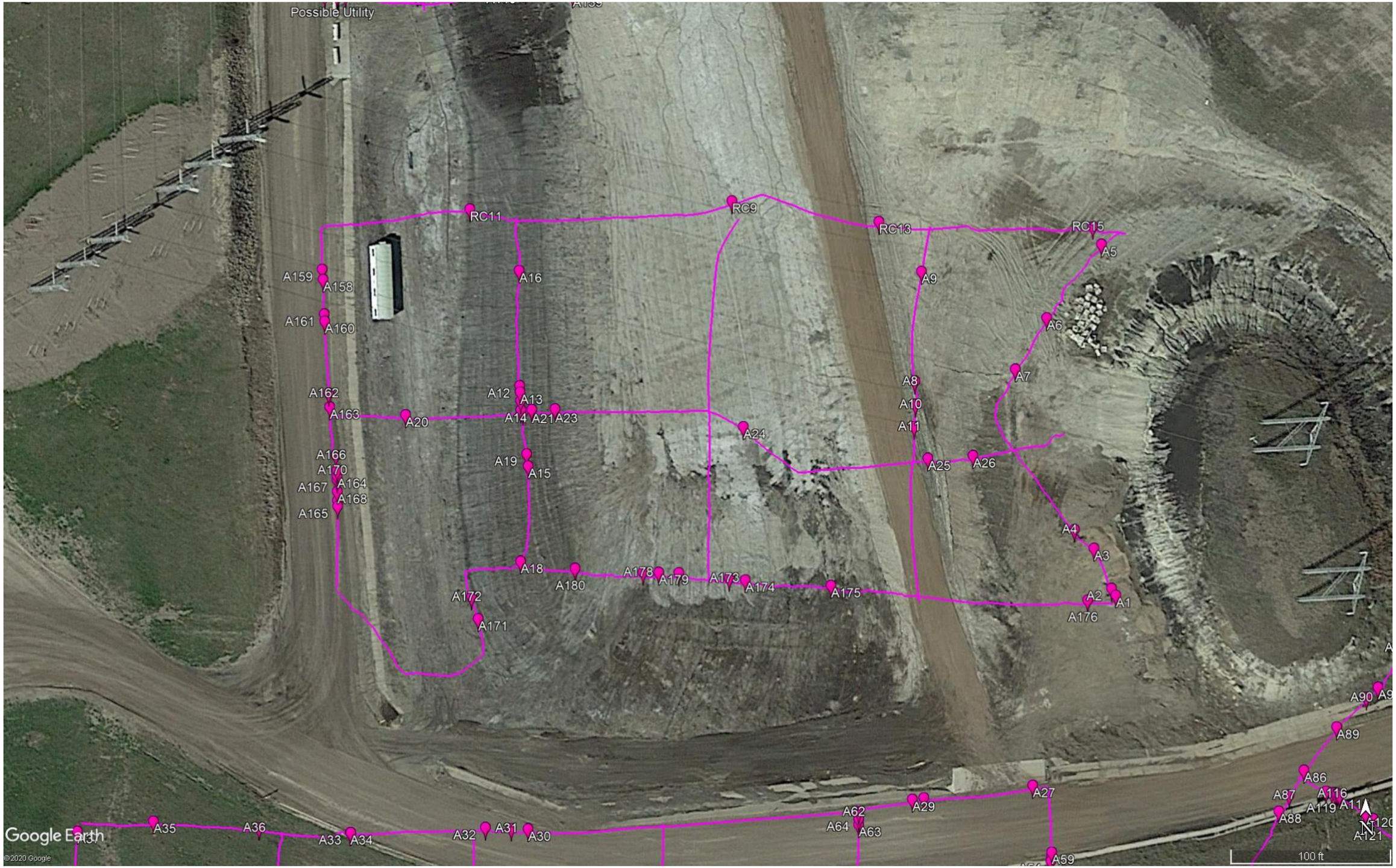
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GROUND PENETRATING RADAR

Project Tundra
Center, North Dakota

Exhibit

A3



Legend

- GPR Anomaly
- GPR Traverse

Project Manager:	CAC
Drawn by:	RMK
Checked by:	RAK
Approved by:	SRG

Project No.	M2205062
Scale:	N.T.S.
File Name:	
Date:	OCT 2020

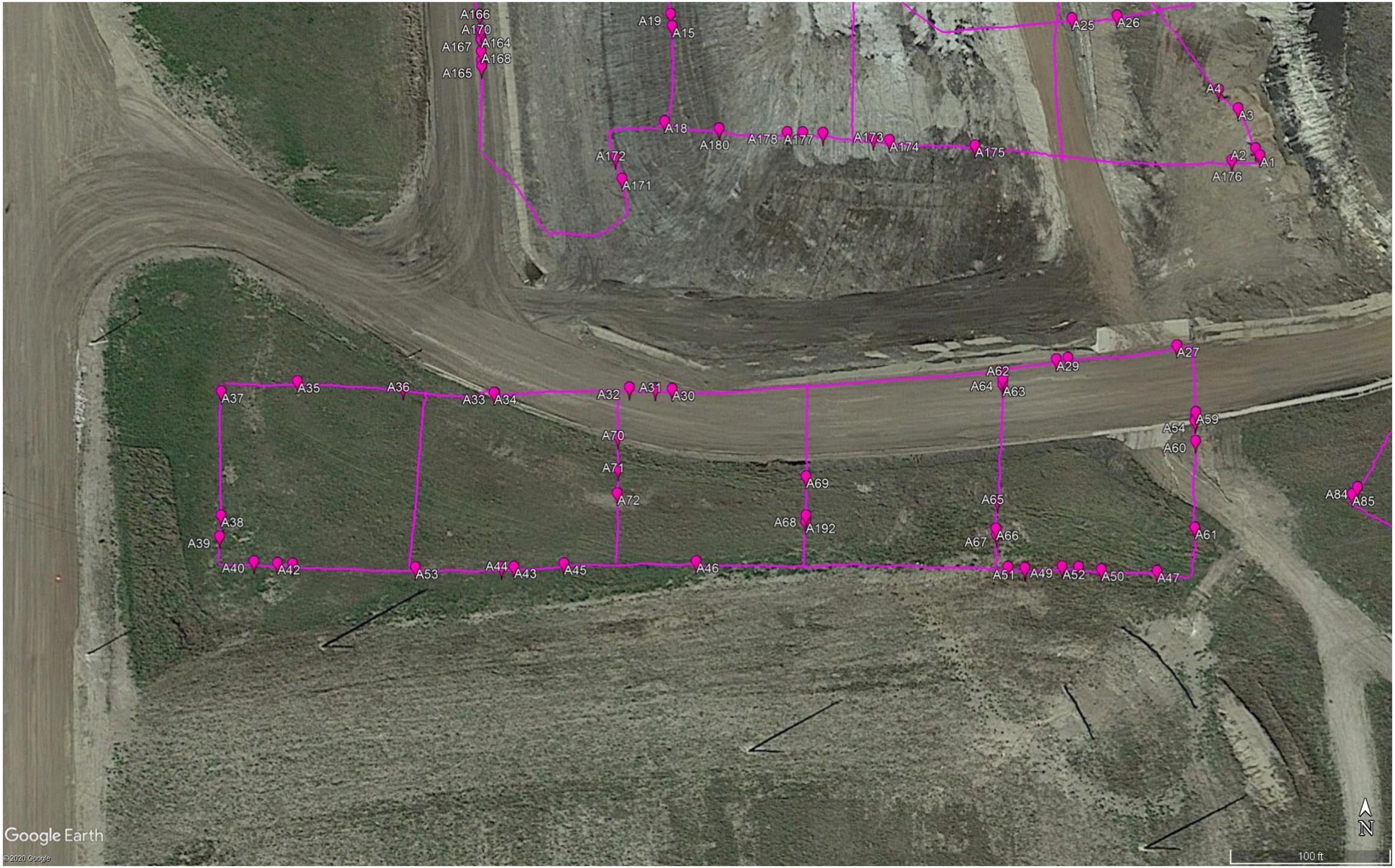
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GROUND PENETRATING RADAR

Project Tundra
Center, North Dakota

Exhibit

A4



Legend

- GPR Anomaly
- GPR Traverse

Project Manager:	CAC
Drawn by:	RMK
Checked by:	RAK
Approved by:	SRG

Project No.	M2205062
Scale:	N.T.S.
File Name:	
Date:	OCT 2020

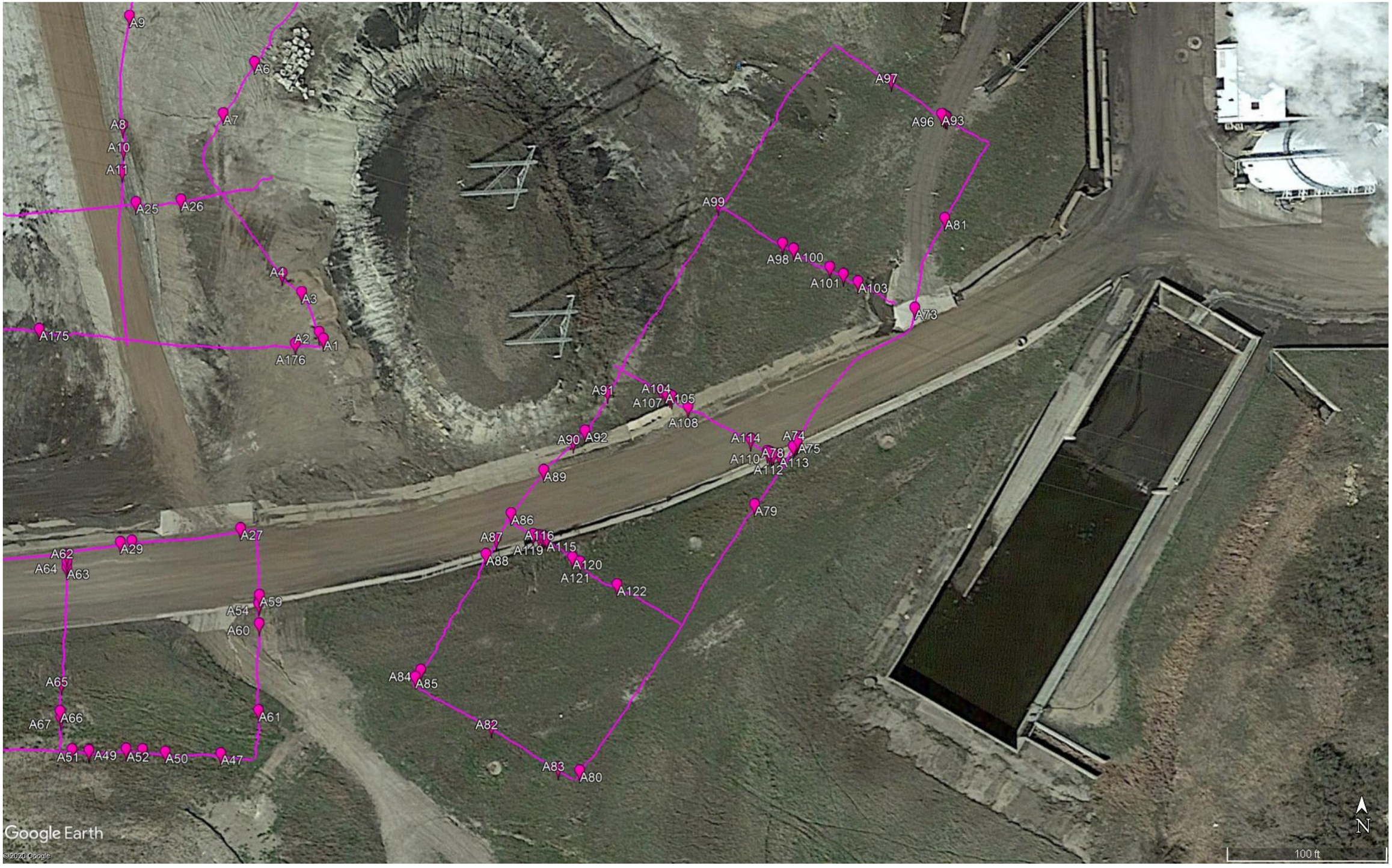
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GROUND PENETRATING RADAR

Project Tundra
Center, North Dakota

Exhibit

A5



Legend

- GPR Anomaly
- GPR Traverse

Project Manager:	CAC
Drawn by:	RMK
Checked by:	RAK
Approved by:	SRG
Project No.	M2205062
Scale:	N.T.S.
File Name:	
Date:	OCT 2020

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GROUND PENETRATING RADAR

Project Tundra
Center, North Dakota

Exhibit

A6

Latitude	Longitude	Approximate Depth (ft)	Name
47.0643272	-101.2171995	1.4	A1
47.0643389	-101.2172104	1.3	A2
47.0644074	-101.2172544	1.0	A3
47.0644397	-101.2173035	1.3	A4
47.0649268	-101.2172356	0.9	A5
47.0648013	-101.2173729	1.3	A6
47.0647136	-101.2174517	1.1	A7
47.064693	-101.2177039	1.1	A8
47.0648806	-101.2176871	2.5	A9
47.0646536	-101.2177024	2.0	A10
47.0646156	-101.2177056	4.1	A11
47.0646853	-101.2186952	1.4	A12
47.0646746	-101.2186941	1.5	A13
47.0646594	-101.2186927	1.8	A14
47.0645481	-101.2186738	2.0	A15
47.0648821	-101.2186965	1.4	A16
47.0646401	-101.218687	1.7	A17
47.0643853	-101.2186928	2.6	A18
47.0645688	-101.2186776	1.5	A19
47.0646356	-101.2189814	1.6	A20
47.0646447	-101.2186649	1.6	A21
47.0646441	-101.2186921	1.3	A22
47.0646456	-101.2186065	1.7	A23
47.0646153	-101.2181341	2.6	A24
47.0645613	-101.217671	4.4	A25
47.0645658	-101.2175579	2.7	A26
47.0640025	-101.2174081	1.3	A27
47.0639813	-101.2176813	1.5	A28
47.0639788	-101.2177102	1.7	A29
47.0639281	-101.218674	1.3	A30
47.0639291	-101.2187163	1.5	A31
47.0639305	-101.2187811	1.5	A32
47.0639217	-101.2191189	0.9	A33
47.0639216	-101.2191205	5.3	A34
47.0639414	-101.219614	4.3	A35
47.0639301	-101.2193489	4.7	A36
47.0639239	-101.2198049	1.8	A37
47.0637119	-101.2198057	1.9	A38
47.063676	-101.219809	2.3	A39
47.0636336	-101.2197227	6.6	A40

47.0636296	-101.2196262	6.2	A41
47.0636307	-101.219664	6.8	A42
47.0636243	-101.2190707	6.2	A43
47.0636237	-101.2191019	6.2	A44
47.0636302	-101.2189454	6.2	A45
47.0636337	-101.2186136	7.4	A46
47.0636171	-101.2174577	5.4	A47
47.0636239	-101.2178317	6.8	A48
47.063625	-101.2176957	7.3	A49
47.0636197	-101.2175971	6.2	A50
47.0636223	-101.2177892	2.3	A51
47.0636241	-101.2176544	2.3	A52
47.0636234	-101.2193178	6.2	A53
47.0638732	-101.2173622	0.4	A54
47.0638752	-101.2173617	0.5	A55
47.063877	-101.2173612	0.5	A56
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47.0638814	-101.2173604	0.5	A58
47.0638883	-101.2173605	0.4	A59
47.0638392	-101.2173611	0.9	A60
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47.0639573	-101.2178449	2.0	A62
47.0639355	-101.2178449	0.8	A63
47.063945	-101.2178447	2.2	A64
47.0637378	-101.2178582	2.5	A65
47.0636894	-101.2178616	2.2	A66
47.0636785	-101.2178599	2.1	A67
47.0637121	-101.2183382	0.6	A68
47.0637786	-101.2183381	2.3	A69
47.0638471	-101.2188102	1.2	A70
47.0637918	-101.2188096	6.8	A71
47.0637498	-101.2188115	2.3	A72
47.0643804	-101.2157124	0.9	A73
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47.0641537	-101.2160067	0.5	A75
47.0641494	-101.216009	0.6	A76
47.0641459	-101.2160141	0.7	A77
47.0641433	-101.2160179	0.6	A78
47.0640436	-101.2161152	1.9	A79
47.0635877	-101.2165551	2.4	A80
47.064534	-101.215637	2.7	A81

47.0636648	-101.2167771	2.3	A82
47.0635931	-101.2166093	2.6	A83
47.0637601	-101.2169548	2.3	A84
47.0637481	-101.2169686	2.4	A85
47.0640284	-101.2167277	1.1	A86
47.0639859	-101.2167647	1.1	A87
47.0639584	-101.2167907	7.3	A88
47.0641023	-101.2166456	2.4	A89
47.0641529	-101.2165711	2.7	A90
47.0642378	-101.2164847	1.7	A91
47.0641701	-101.2165418	0.3	A92
47.0647126	-101.2156449	0.3	A93
47.064709	-101.2156355	0.4	A94
47.0647074	-101.2156316	0.4	A95
47.0647106	-101.2156398	0.3	A96
47.0647717	-101.2157715	3.6	A97
47.0644913	-101.2160449	2.6	A98
47.0645603	-101.2162069	2.9	A99
47.0644815	-101.2160172	6.1	A100
47.0644504	-101.2159261	6.6	A101
47.0644383	-101.2158919	6.5	A102
47.0644257	-101.2158552	6.7	A103
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47.0642364	-101.2163397	1.4	A105
47.0642305	-101.216328	1.0	A106
47.064229	-101.2163234	0.5	A107
47.0642112	-101.2162826	5.6	A108
47.064135	-101.2160832	0.4	A109
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47.0641318	-101.2160735	0.6	A111
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47.0639066	-101.2164611	6.0	A122

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47.0661862	-101.2158925	8.7	A125
47.0661101	-101.2158642	4.7	A126
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47.0660546	-101.2156115	3.2	A128
47.0659698	-101.2185168	3.8	A129
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47.0657207	-101.2195131	5.4	A131
47.0657501	-101.2193796	3.9	A132
47.0655984	-101.220207	5.9	A133
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47.0653755	-101.2194416	4.3	A135
47.0653527	-101.219184	0.5	A136
47.0653524	-101.2191317	0.6	A137
47.0653607	-101.2187344	3.4	A138
47.0653529	-101.2185622	3.4	A139
47.065359	-101.2186803	4.4	A140
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47.0653793	-101.2193891	4.4	A142
47.0654424	-101.2183031	2.8	A143
47.0658077	-101.2182701	5.5	A144
47.0658606	-101.2182737	4.1	A145
47.0658351	-101.2182744	3.4	A146
47.0657315	-101.2187926	6.8	A147
47.0657798	-101.2193063	2.9	A148
47.0656757	-101.2197491	5.2	A149
47.0654614	-101.2197324	1.0	A150
47.0655437	-101.2201437	1.0	A151
47.0655938	-101.2191028	1.6	A152
47.0655921	-101.2191211	1.2	A153
47.0656202	-101.2189115	0.9	A154
47.0656171	-101.2189334	2.7	A155
47.0656553	-101.2186276	2.7	A156
47.0656595	-101.2186118	7.1	A157
47.0648668	-101.2191883	5.3	A158
47.0648841	-101.2191908	7.3	A159
47.0647955	-101.2191843	5.8	A160
47.0648077	-101.2191854	5.9	A161
47.0646725	-101.2191742	5.4	A162
47.064649	-101.2191717	4.9	A163

47.064531	-101.2191531	7.0	A164
47.0644794	-101.2191518	6.4	A165
47.0645668	-101.2191563	4.3	A166
47.0645243	-101.2191531	0.7	A167
47.0645044	-101.2191528	1.2	A168
47.0644888	-101.2191524	0.9	A169
47.0645408	-101.2191533	0.7	A170
47.0642873	-101.2187994	0.6	A171
47.0643247	-101.218816	0.4	A172
47.0643566	-101.2181696	1.4	A173
47.0643533	-101.2181292	1.9	A174
47.064344	-101.2179142	2.4	A175
47.0643191	-101.2172702	2.5	A176
47.0643656	-101.2182957	1.6	A177
47.0643666	-101.2183856	1.2	A178
47.0643663	-101.2183463	4.0	A179
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47.06598	-101.2184884	5.0	A181
47.0656866	-101.2197872	1.1	A182
47.0655861	-101.2202021	5.0	A183
47.0656193	-101.2201387	0.7	A184
47.0655679	-101.2201985	6.0	A185
47.0657075	-101.21964	3.9	A186
47.0655334	-101.2201805	6.8	A187
47.0656609	-101.2199968	3.7	A188
47.0655519	-101.220187	5.5	A189
47.06548	-101.2201649	6.2	A190
47.0655421	-101.2201832	5.3	A191
47.0637016	-101.218339	2.5	A192
47.066159	-101.2154813	1.4	Debris1
47.0661519	-101.2154816	1.3	Debris2
47.066145	-101.2154818	1.5	Debris3
47.0661338	-101.2154803	1.3	Debris4
47.0659964	-101.2163033	3.1	Debris5
47.0660331	-101.216317	4.4	Debris6
47.0653523	-101.2191537	0.8	Possible Utility
47.065586	-101.2191879	0.6	RC1
47.065587	-101.2191807	0.7	RC2
47.065588	-101.2191724	1.1	RC3
47.0655895	-101.2191622	1.1	RC4
47.0655909	-101.2191556	0.9	RC5

47.0655922	-101.2191489	0.7	RC6
47.065592	-101.2191345	0.5	RC7
47.0655053	-101.2189791	2.0	RC8
47.0650011	-101.2181628	3.6	RC9
47.0654628	-101.218977	1.2	RC10
47.0649873	-101.2188201	4.1	RC11
47.0654252	-101.2189707	1.5	RC12
47.0649657	-101.2177939	6.5	RC13
47.0655794	-101.2189932	2.0	RC14
47.0649571	-101.2172574	0.5	RC15
47.0655505	-101.2189843	1.3	RC16
47.0656213	-101.2190047	2.1	RC17
47.0657248	-101.2190351	1.8	RC18
47.0657734	-101.2190527	1.7	RC19
47.0657568	-101.2190468	0.6	RC20
47.0656543	-101.2190126	0.6	RC21
47.0656948	-101.2190261	0.6	RC22
47.065682	-101.2190214	0.6	RC23

1. A# - Refers to Anomaly
2. RC# - Refers to Reinforced Concrete

Appendix B
Downhole Seismic Results

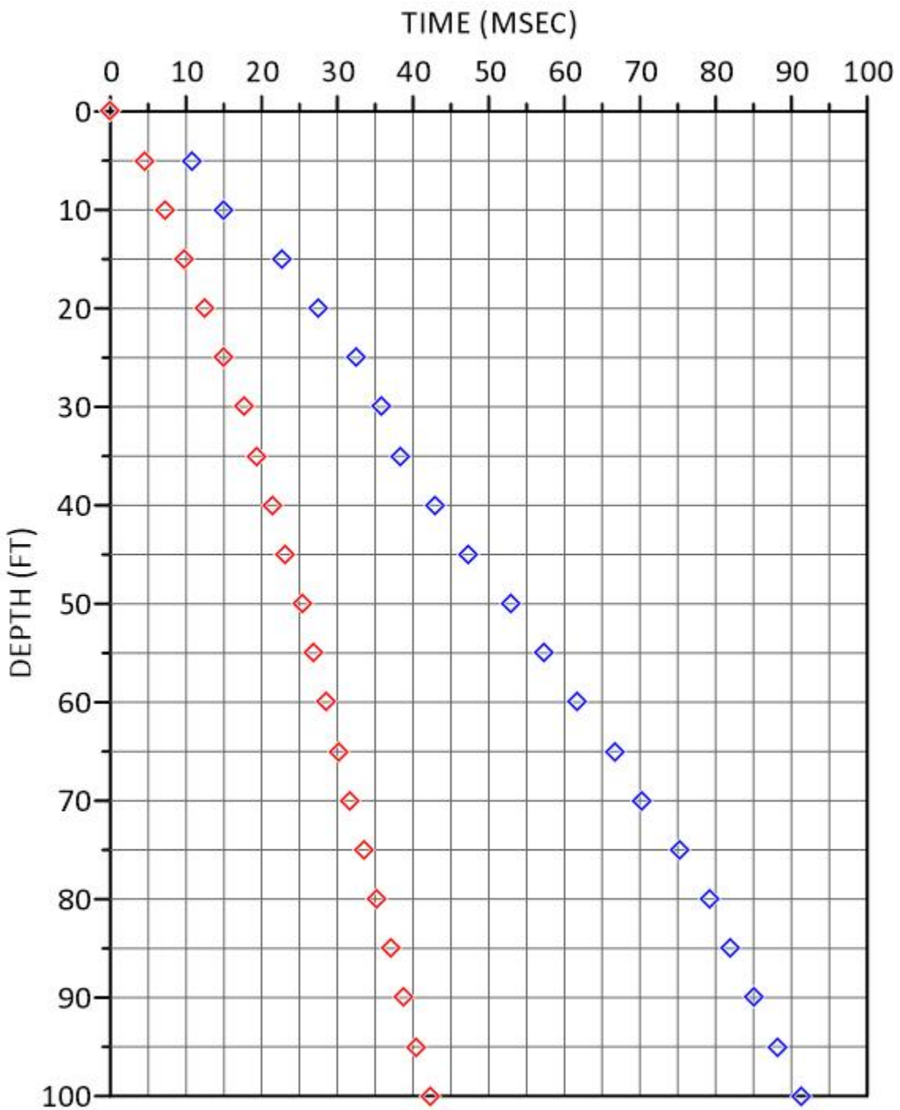


Figure 1: Downhole P-wave travel times (red diamonds) and S-wave travel times (blue diamonds).

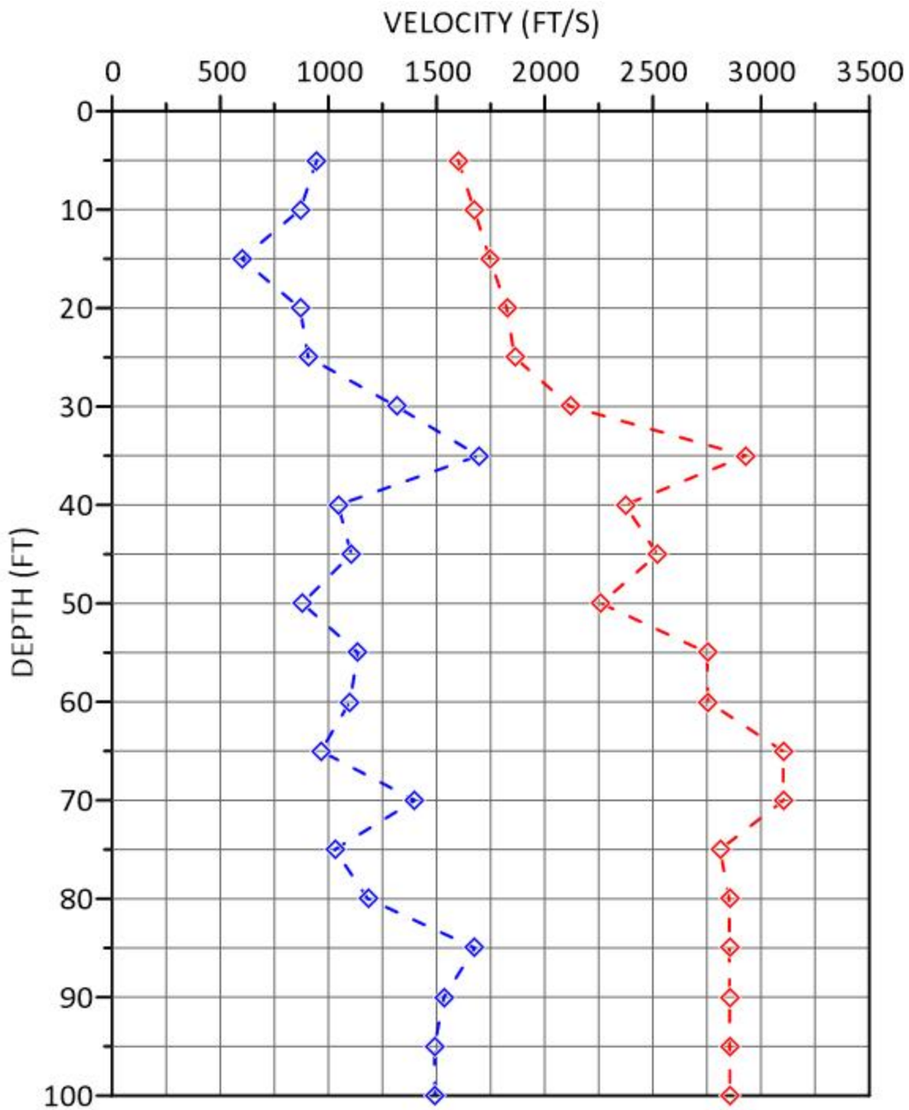


Figure 2: Downhole P-wave velocities (red diamonds) and S-wave velocities (blue diamonds). Dashed Lines represent interval velocities.

DEPTH (FT)	Interval Velocities		Poisson's Ratio
	Vp (ft/sec)	Vs (ft/sec)	
0	0	0	0
5	1600	947	0.230
10	1674	870	0.315
15	1746	600	0.433
20	1825	869	0.353
25	1861	907	0.344
30	2119	1316	0.186
35	2929	1694	0.249
40	2371	1045	0.379
45	2521	1106	0.381
50	2261	879	0.411
55	2751	1136	0.397
60	2755	1100	0.405
65	3101	966	0.446
70	3104	1400	0.372
75	2810	1029	0.423
80	2853	1183	0.396
85	2854	1677	0.236
90	2855	1534	0.297
95	2856	1491	0.313
100	2856	1492	0.312

Weighted Average Shear Wave Velocity Over Profile	**1064 ft/sec**

Project Manager: CAC Drawn by: RMK Checked by: RAK Approved by: SRG	Project No. M2205062 Scale: N.T.S. File Name: Date: OCT 2020	Terracon Consulting Engineers & Scientists 15080 A Circle Omaha, NE 68144 PH. (402) 330-2202 terracon.com	DOWNHOLE SEISMIC Project Tundra Center, North Dakota	Exhibit B1

APPENDIX C
THERMAL & FIELD RESISTIVITY RESULTS

21239 FM529 Rd., Bldg. F
Cypress, TX 77433
Tel: 281-985-9344
Fax: 832-427-1752
info@geothermusa.com
http://www.geothermusa.com

October 8, 2020

Terracon Consultants, Inc.
1805 Hancock Drive
Bismarck, ND 58502-2084
Attn: Chad Cowley, P.E.

Re: Thermal Analysis of Native Soil Sample
Project Tundra – Center, ND (Project No. M2205062)

The following is the report of thermal dryout characterization tests conducted on the bulk sample of native soil from the referenced project sent to our laboratory.

Thermal Resistivity Tests: The sample was tested at the 'optimum' moisture content and at 90% of the density **provided by Terracon.** The tests were conducted in accordance with the IEEE standard 442-2017. The results are tabulated below, and the thermal dryout curves are presented in **Figure 1.**

Sample ID, Description, Thermal Resistivity, Moisture Content and Density

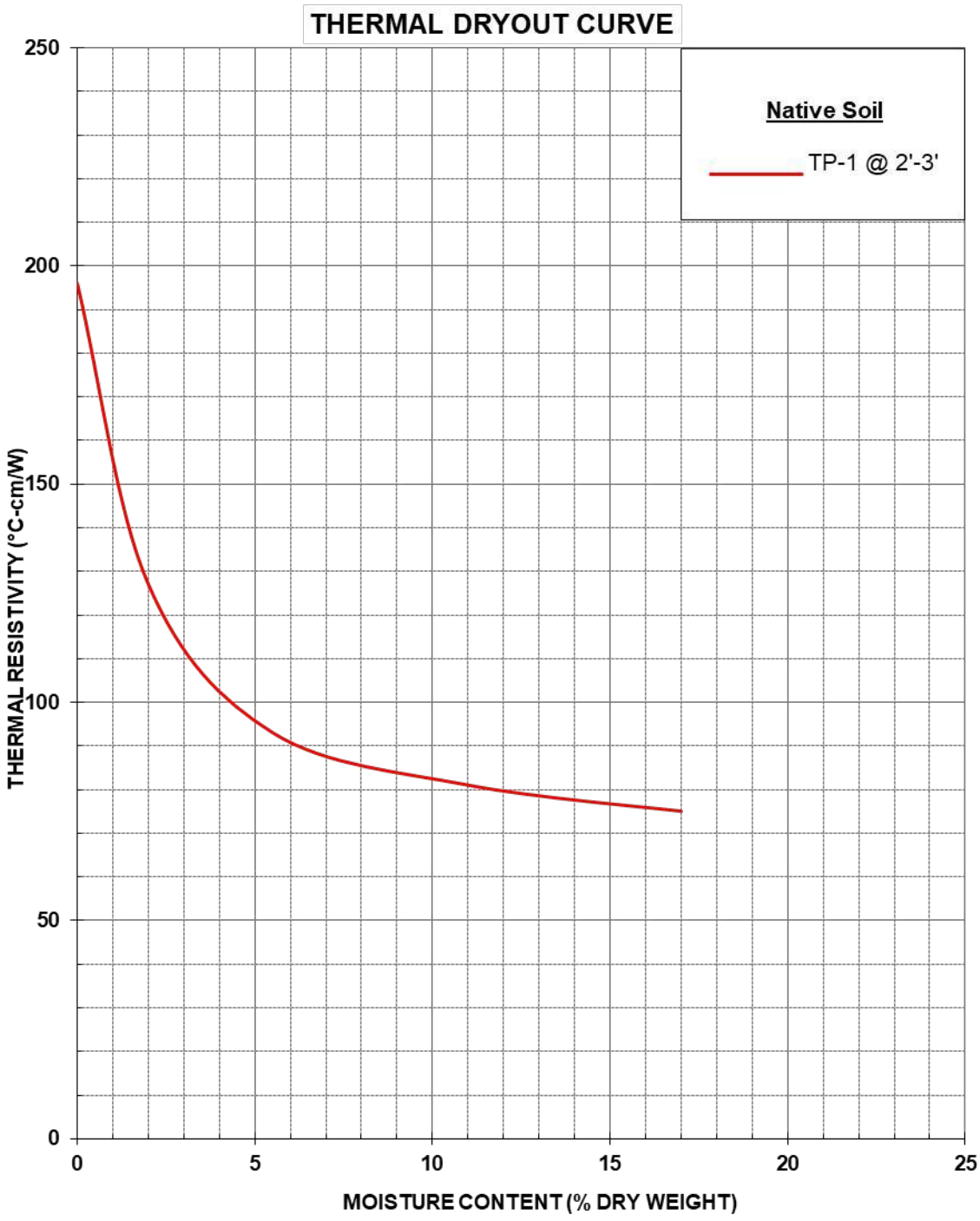
Sample ID	Description (Terracon)	Thermal Resistivity (°C-cm/W)		Moisture Content (%)	Dry Density (lb/ft^3)
		Wet	Dry		
TP-1 @ 2'-3'	Sandy lean clay	75	196	17	96

Comments: The thermal characteristic depicted in the dryout curve applies for the sample at the test dry density.

Please contact us if you have any questions or if we can be of further assistance.

Geotherm USA

Nimesh Patel



Terracon Consultants (Project No. M2205062)

Thermal Analysis of Native Soil Sample

Tundra – Center, ND

October 2020

Figure 1

APPENDIX C

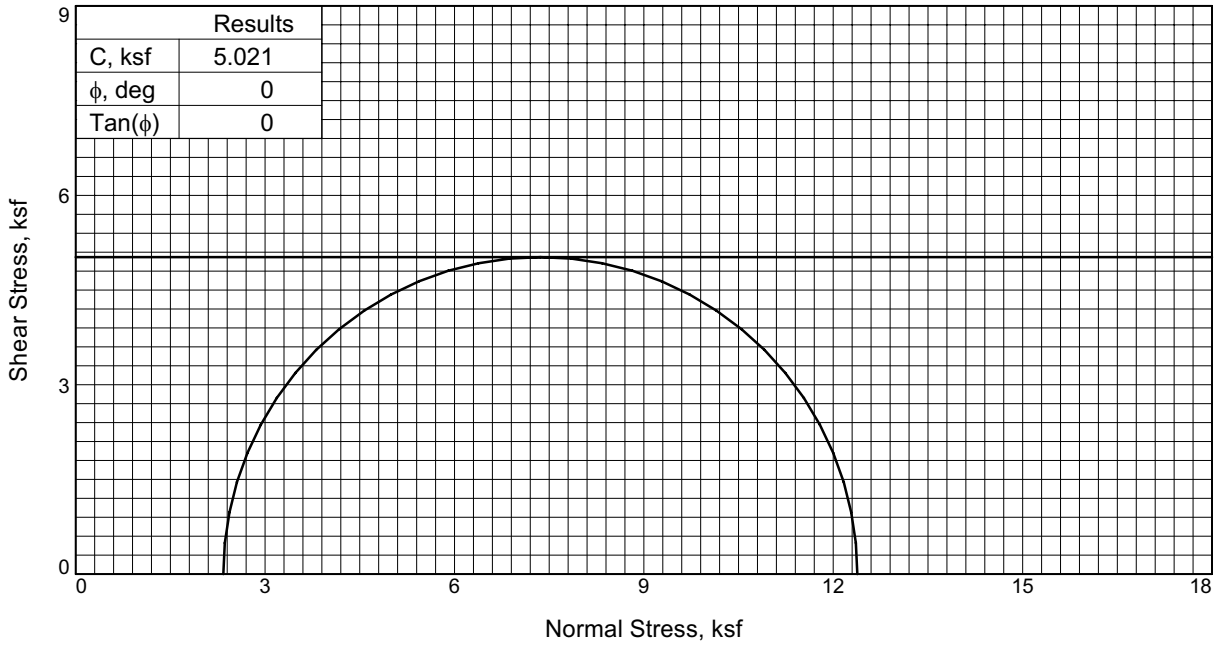
Terracon GeoReport

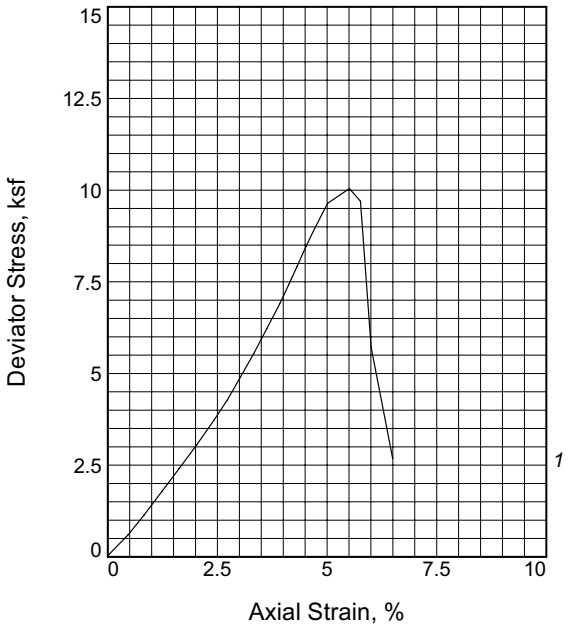
Soil Resistivity - Field Report

Conditions: 66˚, Partly Cloudy, Wind 15-20 mph SE	**Date: 9-18-2020**
Test Completed by: Mike Roberts, Eric Mayer	**Test Method:** Wenner 4-Pin
Test Instrument: Nilsson, Model 400	**Serial Number:** 4-9588
Calculation: Soil resistivity (Ω-m) = 1.915 x Probe Spacing (ft) x R(Ω)	
Notes:	

Testing Results

Test Location	Probe Spacing (ft)	Resistance (Ω)		Calculated Soil Resistivity (Ω-m)	
B-4	5	11.0	Ω	105.3	Ω–m
47.0645º N, 101.2198º W	10	3.1	Ω	59.4	Ω–m
North to South	20	0.53	Ω	20.3	Ω–m
	30	0.50	Ω	28.7	Ω–m
	40	0.49	Ω	37.5	Ω–m
	50	0.47	Ω	45.0	Ω–m
B-4	5	0.29	Ω	124.5	Ω–m
47.0645º N, 101.2198º W	10	0.27	Ω	53.6	Ω–m
East to West	20	0.25	Ω	21.8	Ω–m
	30	0.23	Ω	28.7	Ω–m
	40	0.22	Ω	36.8	Ω–m
	50	0.21	Ω	44.0	Ω–m





Sample No.		1
Initial	Water Content, %	24.4
	Dry Density, pcf	103.8
	Saturation, %	99.6
	Void Ratio	0.6845
	Diameter, in.	2.830
	Height, in.	5.690
At Test	Water Content, %	24.4
	Dry Density, pcf	103.8
	Saturation, %	99.6
	Void Ratio	0.6845
	Diameter, in.	2.830
	Height, in.	5.690
Strain rate, in./min.		0.000
Back Pressure, psi		0.000
Cell Pressure, psi		16.240
Fail. Stress, ksf		10.04
Ult. Stress, ksf		
σ_1 Failure, ksf		12.38
σ_3 Failure, ksf		2.34

Type of Test:
Unconsolidated Undrained

Sample Type: Undisturbed

Description: Dark gray Fat Clay

Assumed Specific Gravity= 2.80

Remarks: ASTM D2850

Client: Fluor Enterprises Inc Greenville, SC

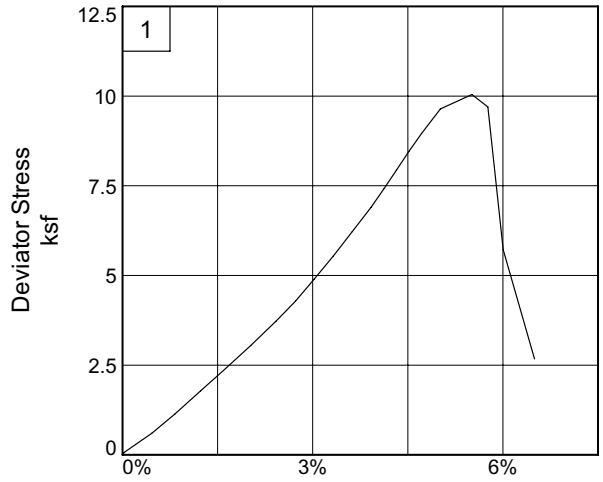
Project: Project Tundra

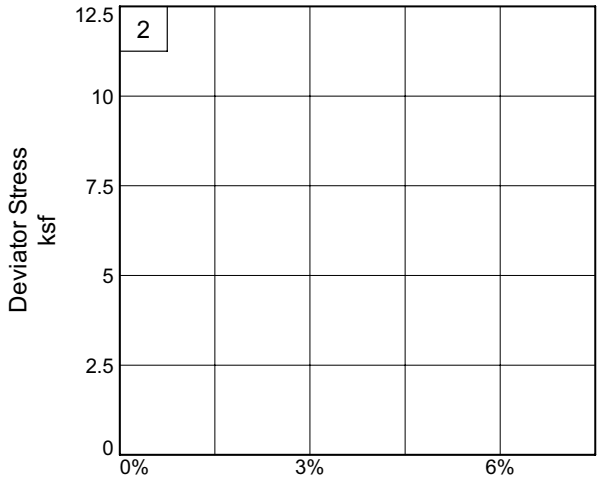
Location: B-1

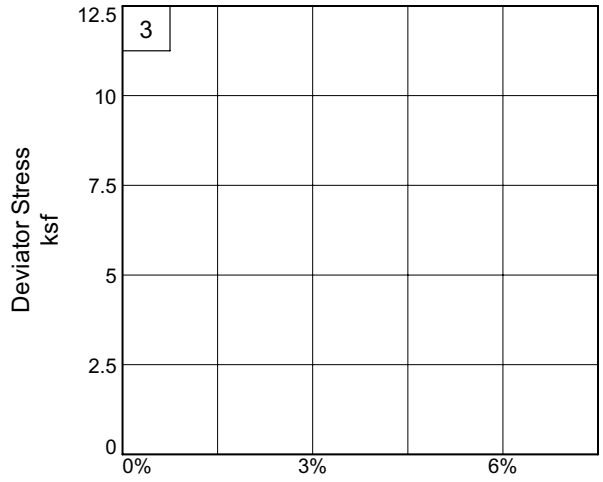
Depth: 24.5-26 ft.

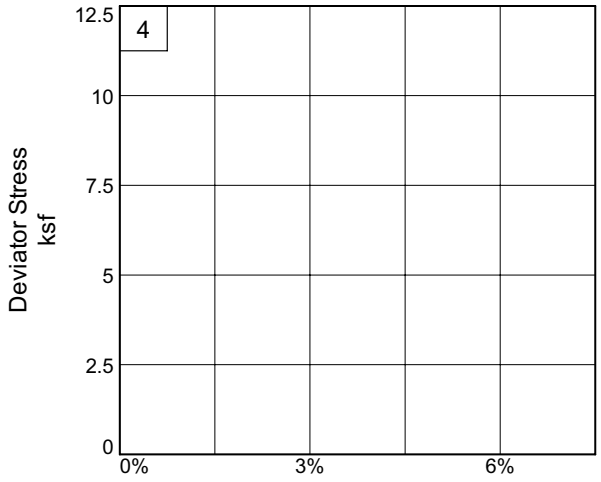
Proj. No.: M2205062 **Date Sampled:**

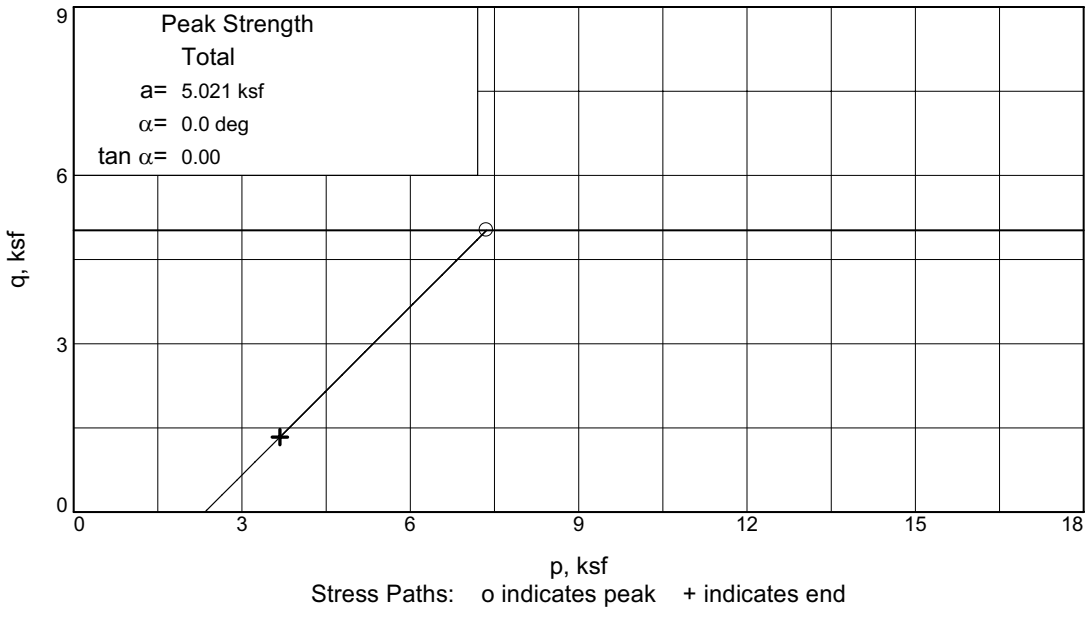
TRIAXIAL SHEAR TEST REPORT
Terracon Consultants, Inc.
Houston, TX





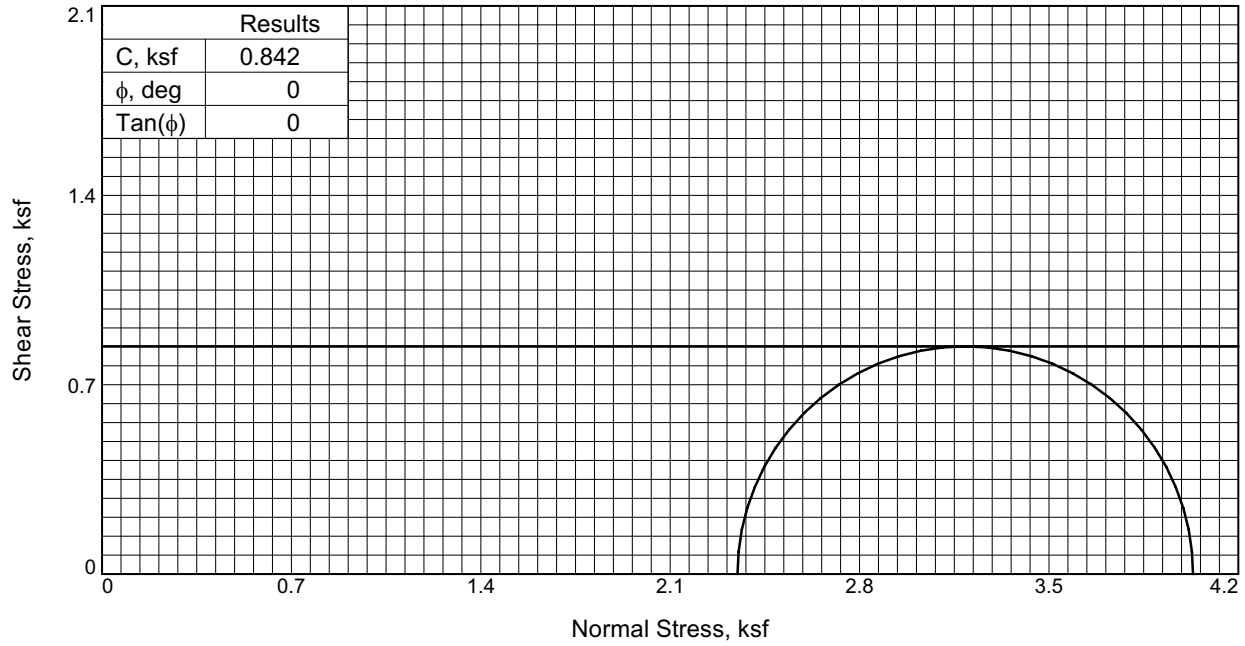


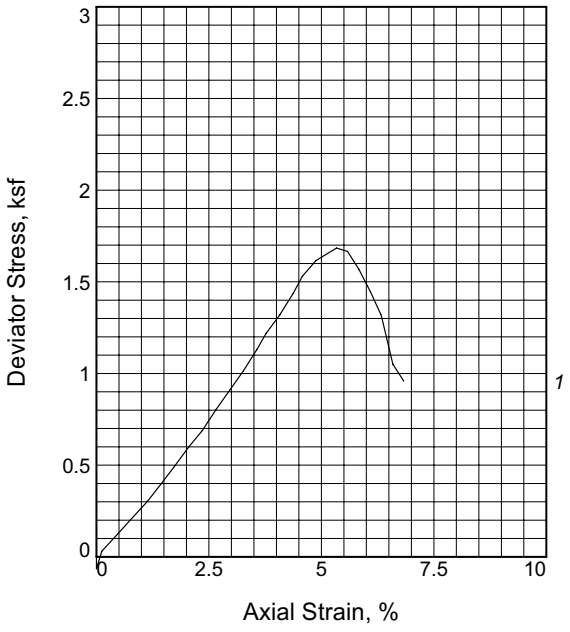




Client: Fluor Enterprises Inc Greenville, SC
Project: Project Tundra
Location: B-1 **Depth:** 24.5-26 ft.
Project No.: M2205062

Terracon Consultants, Inc.





Sample No.		1
Initial	Water Content, %	21.8
	Dry Density, pcf	101.2
	Saturation, %	86.9
	Void Ratio	0.6846
	Diameter, in.	2.820
	Height, in.	5.280
At Test	Water Content, %	21.8
	Dry Density, pcf	101.2
	Saturation, %	86.9
	Void Ratio	0.6846
	Diameter, in.	2.820
	Height, in.	5.280
Strain rate, in./min.		0.055
Back Pressure, psi		0.000
Cell Pressure, psi		16.310
Fail. Stress, ksf		1.684
Ult. Stress, ksf		
σ_1 Failure, ksf		4.033
σ_3 Failure, ksf		2.349

Type of Test:
Unconsolidated Undrained

Sample Type: Undisturbed

Description: Gray Lean Clay w/sand and silt pockets

Assumed Specific Gravity= 2.73

Remarks:

Client: Fluor Enterprises Inc Greenville, SC

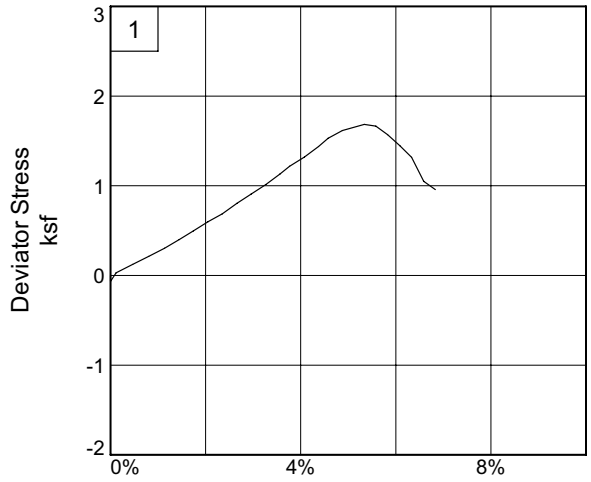
Project: Project Tundra

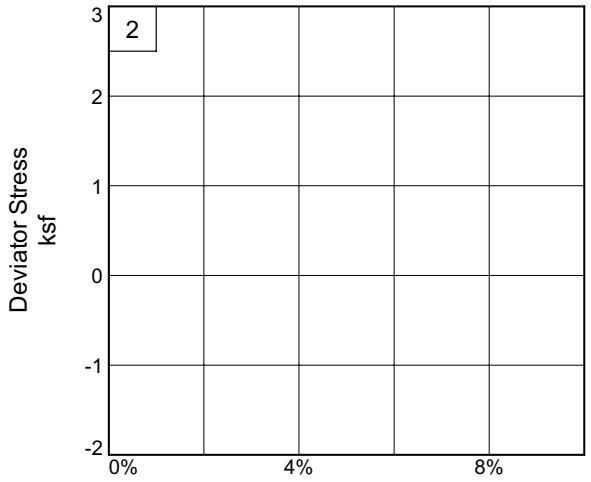
Location: B-2

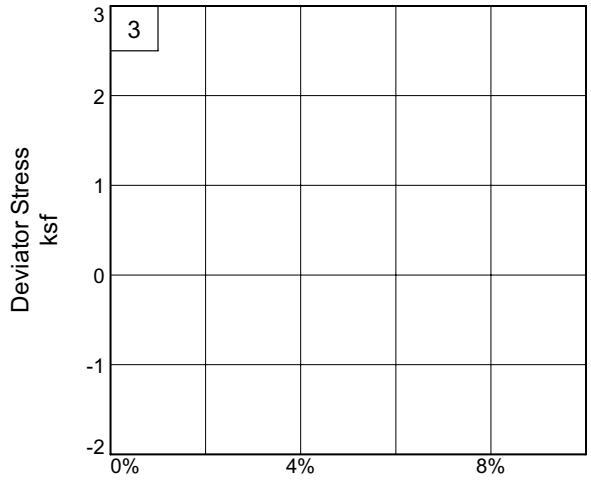
Depth: 19.5-21 ft.

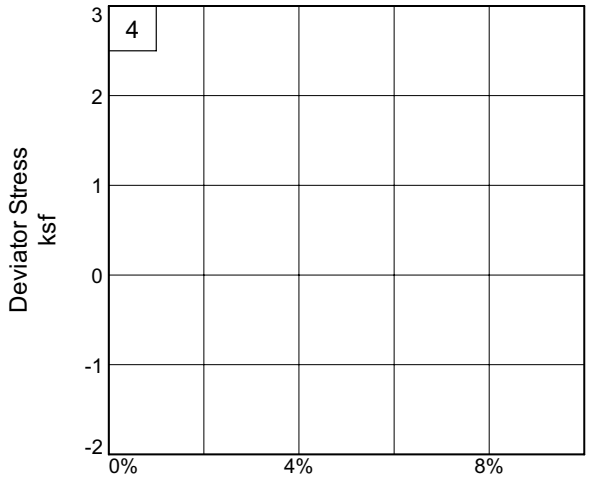
Proj. No.: M2205062 **Date Sampled:**

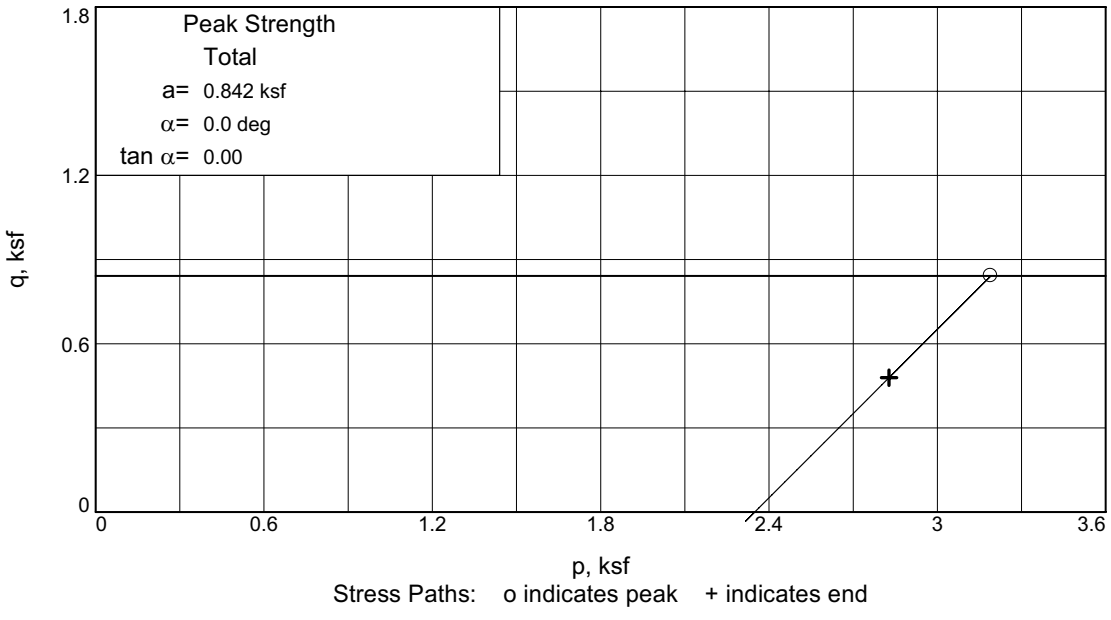
TRIAXIAL SHEAR TEST REPORT
Terracon Consultants, Inc.
Houston, TX





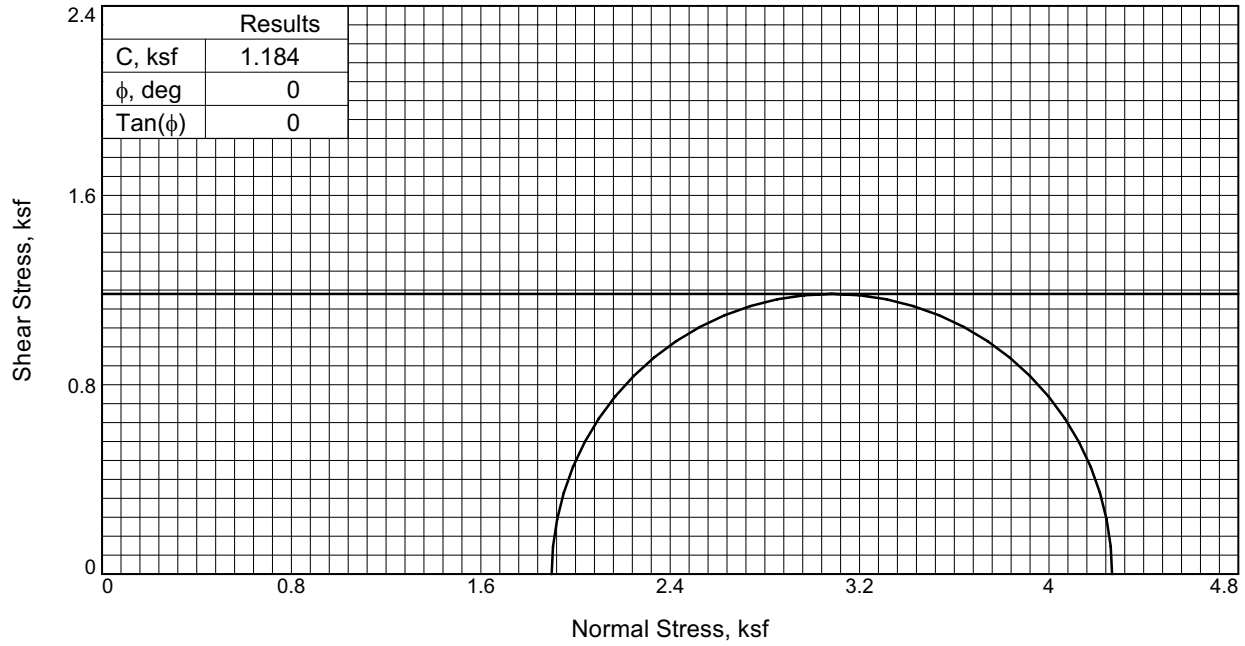


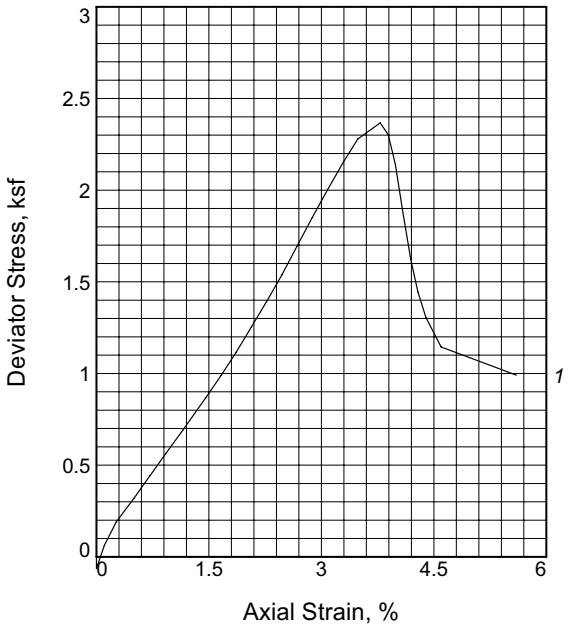




Client: Fluor Enterprises Inc Greenville, SC
Project: Project Tundra
Location: B-2 **Depth:** 19.5-21 ft.
Project No.: M2205062

Terracon Consultants, Inc.





Sample No.		1
Initial	Water Content, %	21.0
	Dry Density, pcf	99.3
	Saturation, %	80.2
	Void Ratio	0.7160
	Diameter, in.	2.850
	Height, in.	5.580
At Test	Water Content, %	21.0
	Dry Density, pcf	99.3
	Saturation, %	80.2
	Void Ratio	0.7160
	Diameter, in.	2.850
	Height, in.	5.580
Strain rate, in./min.		0.055
Back Pressure, psi		0.000
Cell Pressure, psi		13.190
Fail. Stress, ksf		2.367
Ult. Stress, ksf		
σ_1 Failure, ksf		4.266
σ_3 Failure, ksf		1.899

Type of Test:
Unconsolidated Undrained

Sample Type: Undisturbed

Description: Dark gray Fat Clay w/silt pockets

Assumed Specific Gravity= 2.73

Remarks:

Client: Fluor Enterprises Inc Greenville, SC

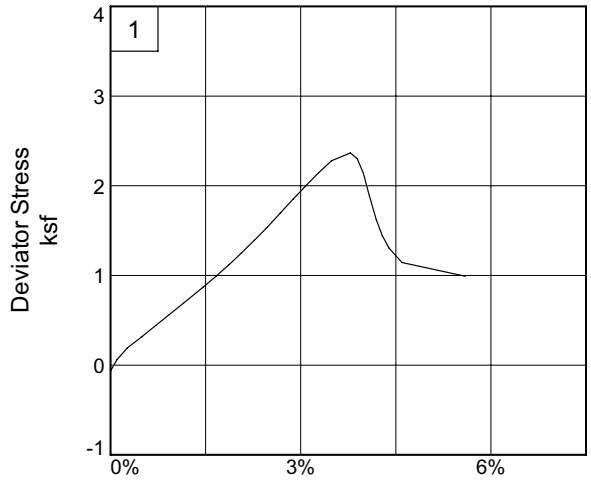
Project: Project Tundra

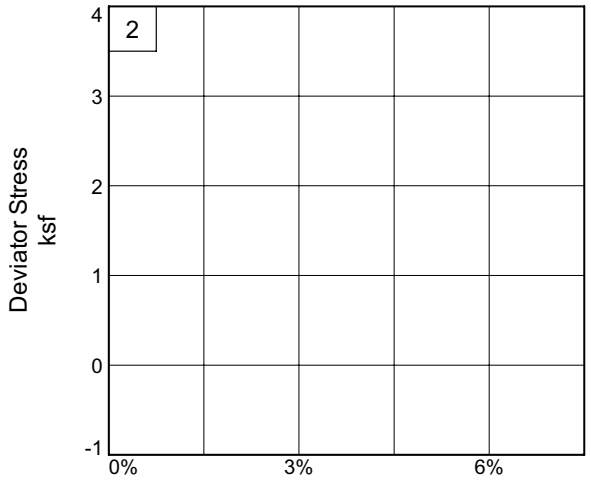
Location: B-3

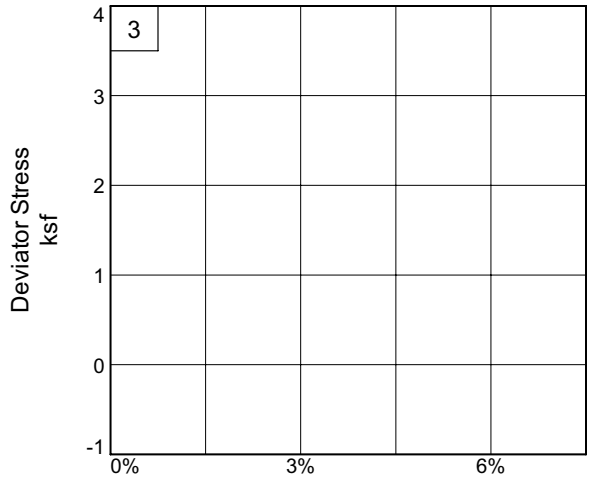
Depth: 14.5-16 ft.

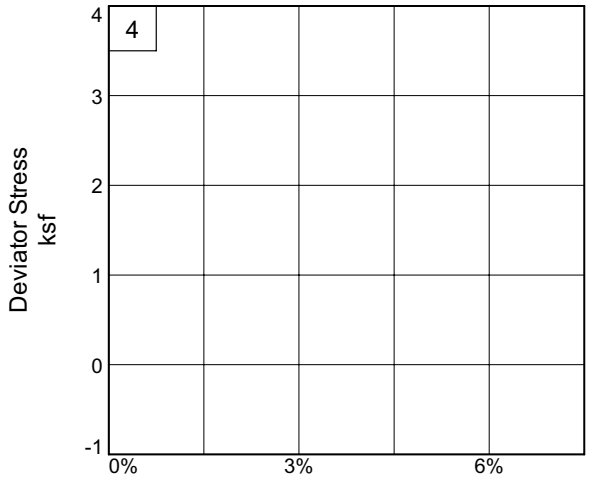
Proj. No.: M2205062 **Date Sampled:**

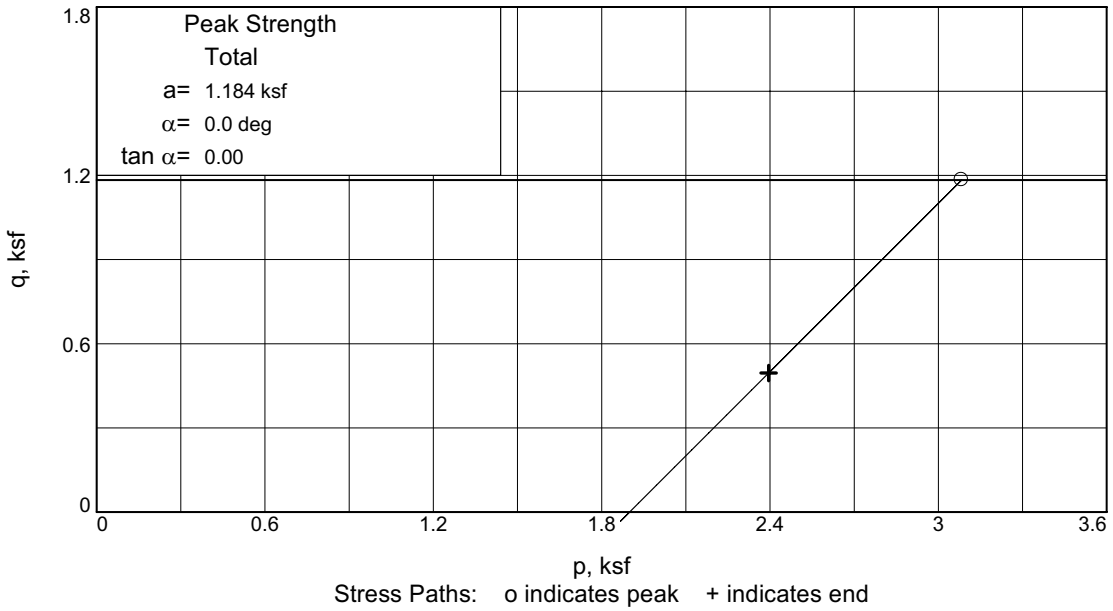
TRIAXIAL SHEAR TEST REPORT
Terracon Consultants, Inc.
Houston, TX











Client: Fluor Enterprises Inc Greenville, SC
Project: Project Tundra
Location: B-3 **Depth:** 14.5-16 ft.
Project No.: M2205062

Terracon Consultants, Inc.

MVTL

MINNESOTA VALLEY TESTING LABORATORIES, INC.

1126 N. Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
2616 E. Broadway Ave. ~ Bismarck, ND 58501 ~ 800-279-6885 ~ Fax 701-258-9724
51 W. Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885

MEMBER ACIL

MVTL guarantees the accuracy of the analysis done on the sample submitted for testing. It is not possible for MVTL to guarantee that a test result obtained on a particular sample will be the same on any other sample unless all conditions affecting the sample are the same, including sampling by MVTL. As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of clients, and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval.

AN EQUAL OPPORTUNITY EMPLOYER

Report Date: 7 Oct 20
Lab Number: 20-M1949
Work Order #:81-0804
Account #: 002148
Date Sampled: 22 Sep 20
Date Received: 2 Oct 20 12:23
Sampled By: Client

Chad Cowley
Terracon
PO Box 2084
Bismarck ND 58502

Project Name: M2205062
Sample Description: DH-1 9 1/2-11

Temp at Receipt: Ambient

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH-Environmental	8.7	units	N/A	SW 846 9045D	2 Oct 20 16:24	HT
Sulfate	227	ug/g	12.3	ASTM D516-11	7 Oct 20 9:20	EV
Chloride	22.6	ug/g	2.49	SM4500-Cl-E	5 Oct 20 8:21	EV

Approved by: Claudette K. Carroll

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix # = Due to concentration of other analytes
! = Due to sample quantity + = Due to internal standard response

CERTIFICATION: ND # ND-00016

APPENDIX E

MVTL

MINNESOTA VALLEY TESTING LABORATORIES, INC.

1126 N. Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
2616 E. Broadway Ave. ~ Bismarck, ND 58501 ~ 800-279-6885 ~ Fax 701-258-9724
51 W. Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885

MEMBER ACIL

MVTL guarantees the accuracy of the analysis done on the sample submitted for testing. It is not possible for MVTL to guarantee that a test result obtained on a particular sample will be the same on any other sample unless all conditions affecting the sample are the same, including sampling by MVTL. As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of clients, and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval.

AN EQUAL OPPORTUNITY EMPLOYER

Report Date: 7 Oct 20
Lab Number: 20-M1950
Work Order #:81-0804
Account #: 002148
Date Sampled: 22 Sep 20
Date Received: 2 Oct 20 12:23
Sampled By: Client

Chad Cowley
Terracon
PO Box 2084
Bismarck ND 58502

Project Name: M2205062
Sample Description: B-2 4 1/2-6

Temp at Receipt: Ambient

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH-Environmental	8.0	units	N/A	SW 846 9045D	2 Oct 20 16:24	HT
Sulfate	357	ug/g	12.0	ASTM D516-11	7 Oct 20 9:20	EV
Chloride	92.7	ug/g	2.40	SM4500-Cl-E	5 Oct 20 8:21	EV

Approved by: Claudette K. Carroll

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix # = Due to concentration of other analytes
! = Due to sample quantity + = Due to internal standard response

CERTIFICATION: ND # ND-00016

Terracon
1805 Hancock Dr / PO Box 2084 / Bismarck, North Dakota 58502
Telephone (701) 258-2833 / Fax (701) 258-2857

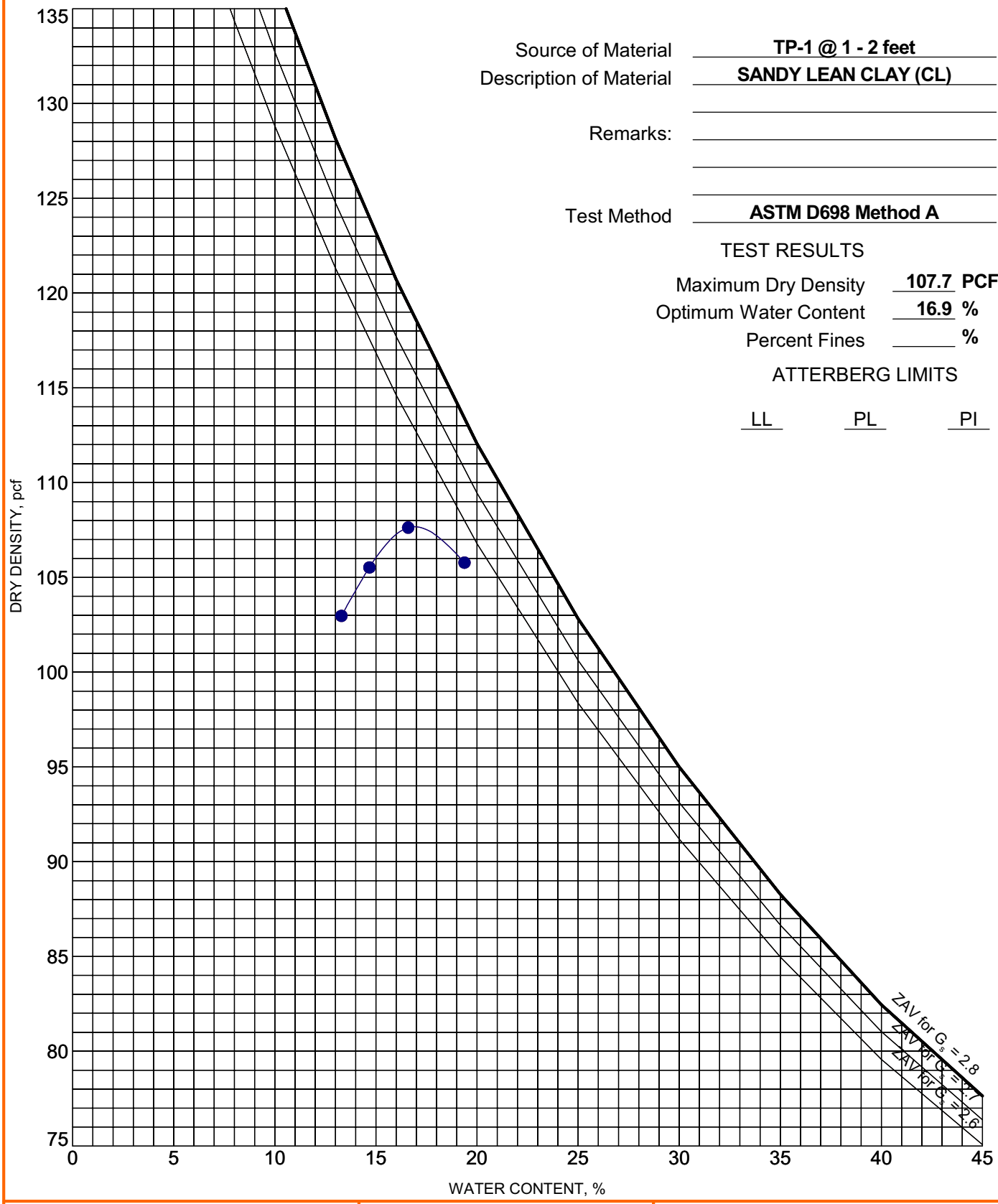
REPORT OF: TESTS OF SOILS - PERMEABILITY

PROJECT:	Project Tundra 3401 24th St SW Center, North Dakota	DATE:	October 12, 2020
REPORTED TO:	Fluor Corporation Attn: David Alewine 100 Fluor Daniel Dr Mail Code C104B Greenville, SC 29607-2761	COPIES:	
PROJECT NO:	M2205052		

SAMPLE NUMBER:	TOS #1	TOS #2
LOCATION:	Borehole #1, depth 14½-16’	Borehole #4, depth 4-6’
CLASSIFICATION:	SILTY SAND (SM)	SILTY CLAYEY SAND (SC-SM)
COLOR:	Brown	Light brown
PARTICLE DISTRIBUTION:		
Gravel (%)	0	0
Sand (%)	60	66
Fines (%)	40	34
LABORATORY PERMEABILITY:		
Method	ASTM:D5856, Falling head Method	US Army Corps of Engineers, EM1110-2-1906 Appendix VII – Permeability Tests (modified)
Specimen Density (pcf)	105.4	98.2
Specimen Moisture Content (%)	19.2	17.8
Final Moisture Content (%)	23.0	20.1
Coefficient of Permeability (cm/sec)	8.7×10^{-5}	3.0×10^{-7}

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material	**TP-1 @ 1 - 2 feet**
Description of Material	**SANDY LEAN CLAY (CL)**
Remarks:	
Test Method	**ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density	**107.7**	**PCF**
Optimum Water Content	**16.9**	**%**
Percent Fines		**%**

ATTERBERG LIMITS

LL	PL	PI

PROJECT: Project Tundra

SITE: 3401 24th Street SW
Center, ND

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

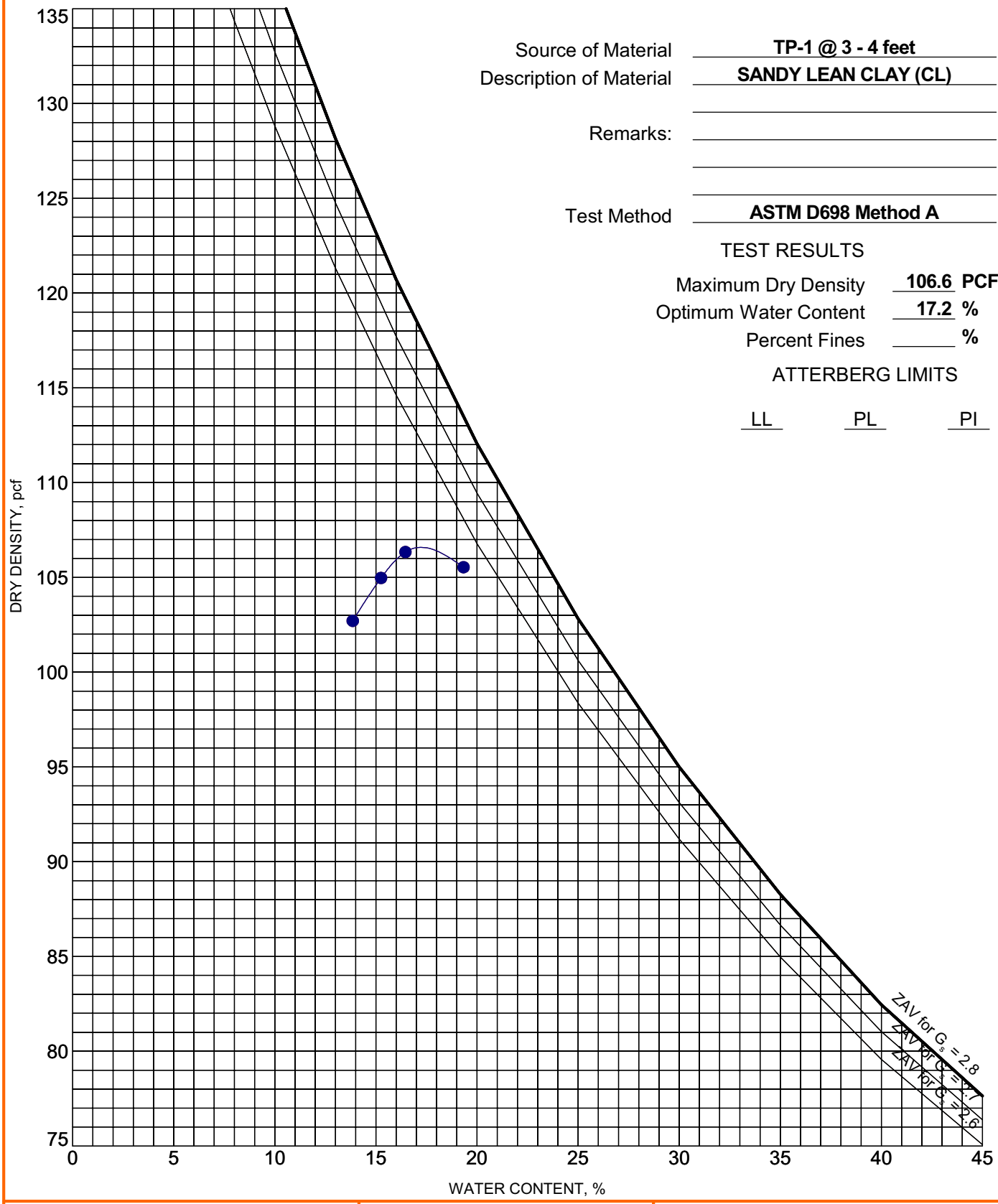
PROJECT NUMBER: M2205062
CLIENT: Fluor Enterprises Inc
Greenville, SC

APPENDIX G

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. COMPACTION - V2 M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/7/20

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material: **TP-1 @ 3 - 4 feet**

Description of Material: **SANDY LEAN CLAY (CL)**

Remarks:

Test Method: **ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density	**106.6**	**PCF**
Optimum Water Content	**17.2**	**%**
Percent Fines		**%**

ATTERBERG LIMITS

LL	PL	PI

PROJECT: Project Tundra

SITE: 3401 24th Street SW
Center, ND

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

PROJECT NUMBER: M2205062
CLIENT: Fluor Enterprises Inc
Greenville, SC

APPENDIX G

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. COMPACTION - V2 M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/7/20

California Bearing Ratio of Laboratory-Compacted Soils

Client

Fluor Enterprises Inc
Greenville, SC

Project

Geotechnical Engineering Report
Project Tundra
Center, North Dakota

Project No. M2205062

SAMPLE INFORMATION

Sample Type:	Bulk Sample	Proctor Method:	ASTM D698-Method A
Boring Number:	TP-1	Maximum Dry Density (pcf):	107.7
Sample Location:	See Exploration Plan	Optimum Moisture (%):	16.9
Depth (ft.):	1-2	Liquid Limit:	NT
Material Description:	Sandy Lean Clay	Plasticity Index:	NT
		Percent Passing No. 200 Sieve:	NT

CBR TEST DATA

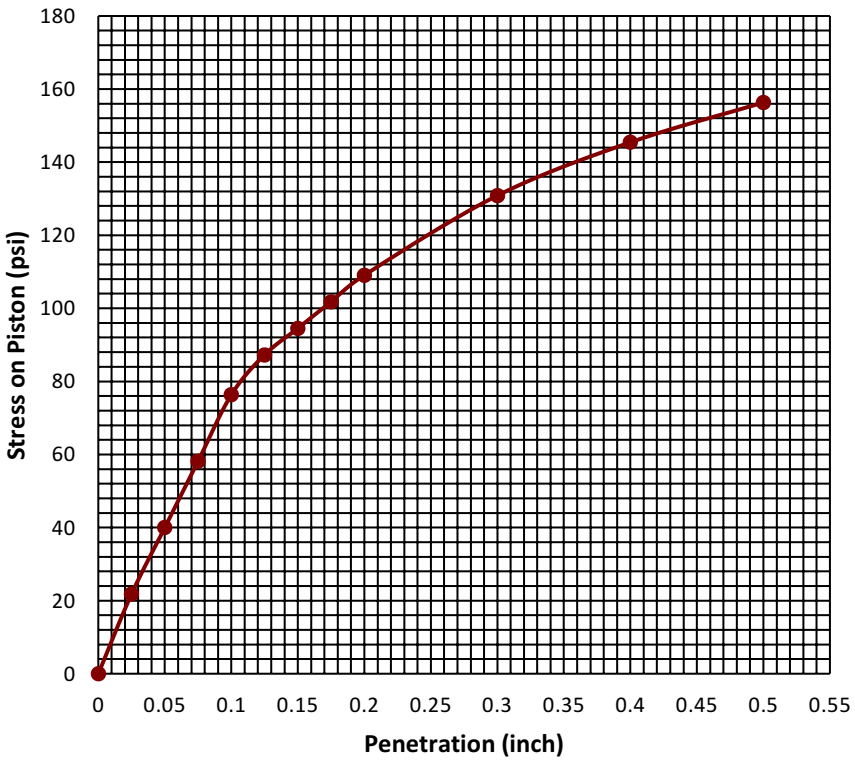
CBR Value at 0.100 inch:	**7.6**
CBR Value at 0.200 inch:	**7.3**
Surcharge Weight (lbs):	10
Soaking Condition:	Soaked
Length of Soaking (hours):	96
Swell (%):	3.4

DENSITY DATA

Dry Density Before Soaking (pcf):	102.6
Compaction of Proctor (%):	95.3

MOISTURE DATA

Before Compaction (%):	16.9
After Compaction (%):	16.9
Top 1" After Soaking (%):	25.9
Average After Soaking (%):	21.6



Comments:

Test Methods: ASTM D1883

California Bearing Ratio of Laboratory-Compacted Soils

Client

Fluor Enterprises Inc
Greenville, SC

Project

Geotechnical Engineering Report
Project Tundra
Center, North Dakota

Project No. M2205062

SAMPLE INFORMATION

Sample Type:	Bulk Sample	Proctor Method:	ASTM D698-Method A
Boring Number:	TP-1	Maximum Dry Density (pcf):	106.6
Sample Location:	See Exploration Plan	Optimum Moisture (%):	17.2
Depth (ft.):	3-4	Liquid Limit:	NT
Material Description:	Sandy Lean Clay	Plasticity Index:	NT
		Percent Passing No. 200 Sieve:	NT

CBR TEST DATA

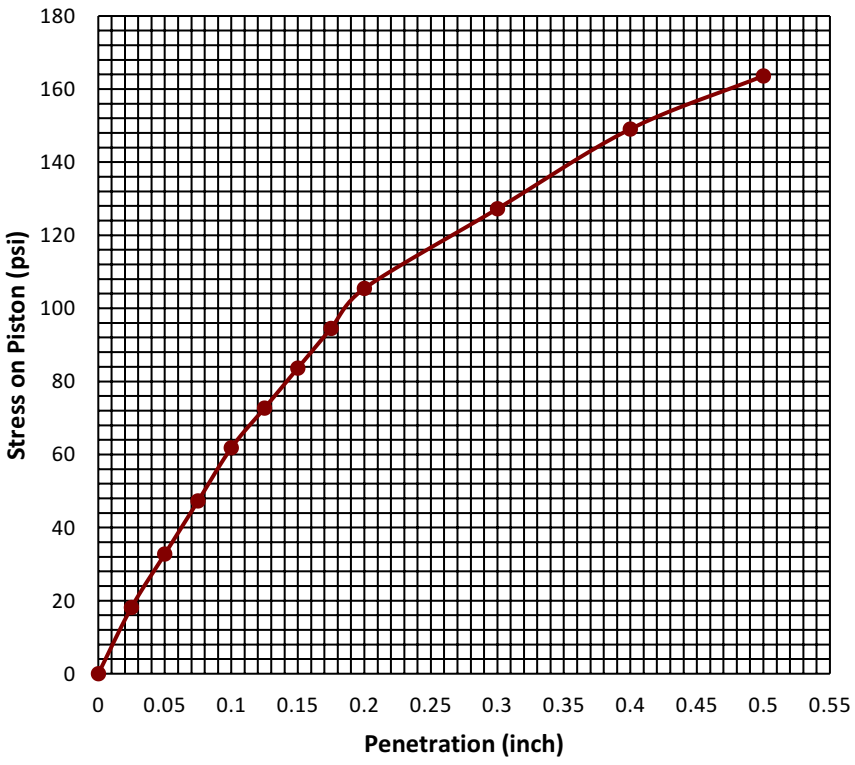
CBR Value at 0.100 inch:	**6.2**
CBR Value at 0.200 inch:	**7.0**
Surcharge Weight (lbs):	10
Soaking Condition:	Soaked
Length of Soaking (hours):	96
Swell (%):	3.6

DENSITY DATA

Dry Density Before Soaking (pcf):	102.0
Compaction of Proctor (%):	95.7

MOISTURE DATA

Before Compaction (%):	16.9
After Compaction (%):	16.9
Top 1" After Soaking (%):	23.9
Average After Soaking (%):	21.6



Comments:

Test Methods: ASTM D1883

16 October 2020

Project No. 2020-0008

PROJECT MEMORANDUM

To: **Rao Gudavalli, Terracon Consultants**

CC.:

From: **Spyros Giannakos and Jacob Chacko, GR8 GEO**

Subject: **Liquefaction Triggering Hazard Assessment for the Tundra Project, North Dakota, USA**

1 INTRODUCTION

The Tundra project is located near the south shoreline of Nelson Lake near Center, North Dakota (Figure 1). Terracon Consultants is conducting geotechnical assessment for the proposed carbon capture facility at the site. As part of the geotechnical program, Terracon Consultants has performed 5 borings and 9 Cone Penetration Tests (CPTs). GR8 GEO is supporting Terracon by performing liquefaction triggering hazard assessment for the project site in accordance with the requirements of the International Building code (IBC, 2018)

This memo presents the results of the liquefaction triggering assessment.



Figure 1. Project Location

2 DEVELOPMENT OF DESIGN SPECTRA

2.1 Site Class Assessment

Site classification of the project site per International Building Code (IBC, 2018) which is based on the provisions of ASCE 7-16 was performed for existing site grades using the subsurface information collected from the site investigation. Geotechnical boreholes (5 in total) with Standard Penetration

Tests (SPT) and nine (9) Cone Penetration Tests (CPT) were performed by Terracon Consultants. Borings were drilled to depths ranging from 61 to 121 ft while the Cone Penetration Tests (CPT) were conducted to depths ranging from 16 to 55 ft. The top layer consists of fill material of mainly silty sand of varying thickness with a maximum thickness of 12ft. This layer is underlain by a sand layer with varying fines content which overlies a very stiff to very hard clay layer. The surface elevation of the performed explorations ranges from approximately 1983 to 2039 ft while we understand the final site grade will be 1988 ft.

Table 1. Empirical Shear Wave Velocity Correlations from SPT Data

Reference	Soil Type	Correlated Parameters	Correlations
Ohta and Goto (1978)	All	SPT blow count (N_{60}) Depth, D	$66.9*N_{60}^{0.21}*D^{0.19}$
Wair et al. (2012)	All	SPT blow count (N_{60}) Effective vertical stress, σ'_v	$Vs = a*N_{60}^{b}*\sigma'^{c}_{v}*d$ where V_s – Shear wave velocity in m/s a, b, and c – Regression parameters depend on soil type d – Age Scaling Factor

Table 2. Empirical Shear Wave Velocity Correlations from CPT Data

Reference	Soil Type	Correlated Parameters	Correlations
Mayne (2006)	All	• Sleeve friction, fs	$V_s = 118.8 * \log(f_s)+18.5$ where V_s in m/s, and f_s in kilopascals (kPa).
Andrus et al. (2007)	All	• Total cone tip resistance, q_t • Soil behavior type index, I_c • Depth, D • Age scaling factor, SF	$Vs = 2.62\ (q_t)^{0.395} * I_c^{0.912} * D^{0.124} * SF$ where; V_s in m/s depth D in m q_t in kilopascals (kPa) SF = 0.92 for Holocene soil and 1.12 for Pleistocene soil.
Robertson (2009)	All	• Total cone tip resistance, q_t • Soil behavior type index, I_c • Effective vertical stress, σ'_v	$Vs = [(10^{(0.55Ic+1.68)})\ (q_t - \sigma_v) / pa]^{0.5}$ where; V_s in m/s σ_v and q_t in kilopascals (kPa) pa = 100 kPa SF = 0.92 for Holocene soil and 1.12 for Pleistocene soil.

The time-weighted average shear wave velocity in the top 30 meters (V_{s30}) is an important input parameter for the purpose of assigning a Site Class. V_{s30} is calculated using the shear wave velocity (V_s) data to a depth of 30 meters (100 ft). Dynamic subsurface conditions were characterized by means of: a) empirical correlations between SPT data from 5 borings extending to a maximum depth of 121 ft depth and shear wave velocity V_s from Ohta and Goto (1978) and Wair et al (2012), and b) empirical correlations between CPT data extending to approximately 61 ft depth and shear wave velocity V_s from Mayne (2006), Andrus et al (2007) and Robertson (2009). Table 1 and Table 2 present the empirical correlations between SPT and CPT tip resistance to shear wave velocity, respectively.

Figure 2-1 presents the development of the shear wave velocity profile based on the available geotechnical data. Shown on this figure are: (a) V_s estimates from the CPT data using empirical correlations, (b) V_s estimates from the SPT data using empirical correlations, and (c) the idealized shear wave velocity profile for the existing site conditions. The estimated V_{s30} value for the existing grades is approximately 820 ft/s while the estimated V_{s30} value for the final grade is approximately 987 ft/s. Thus, for both as-is and final grades, the project site is categorized as Site Class D per ASCE 7-16.

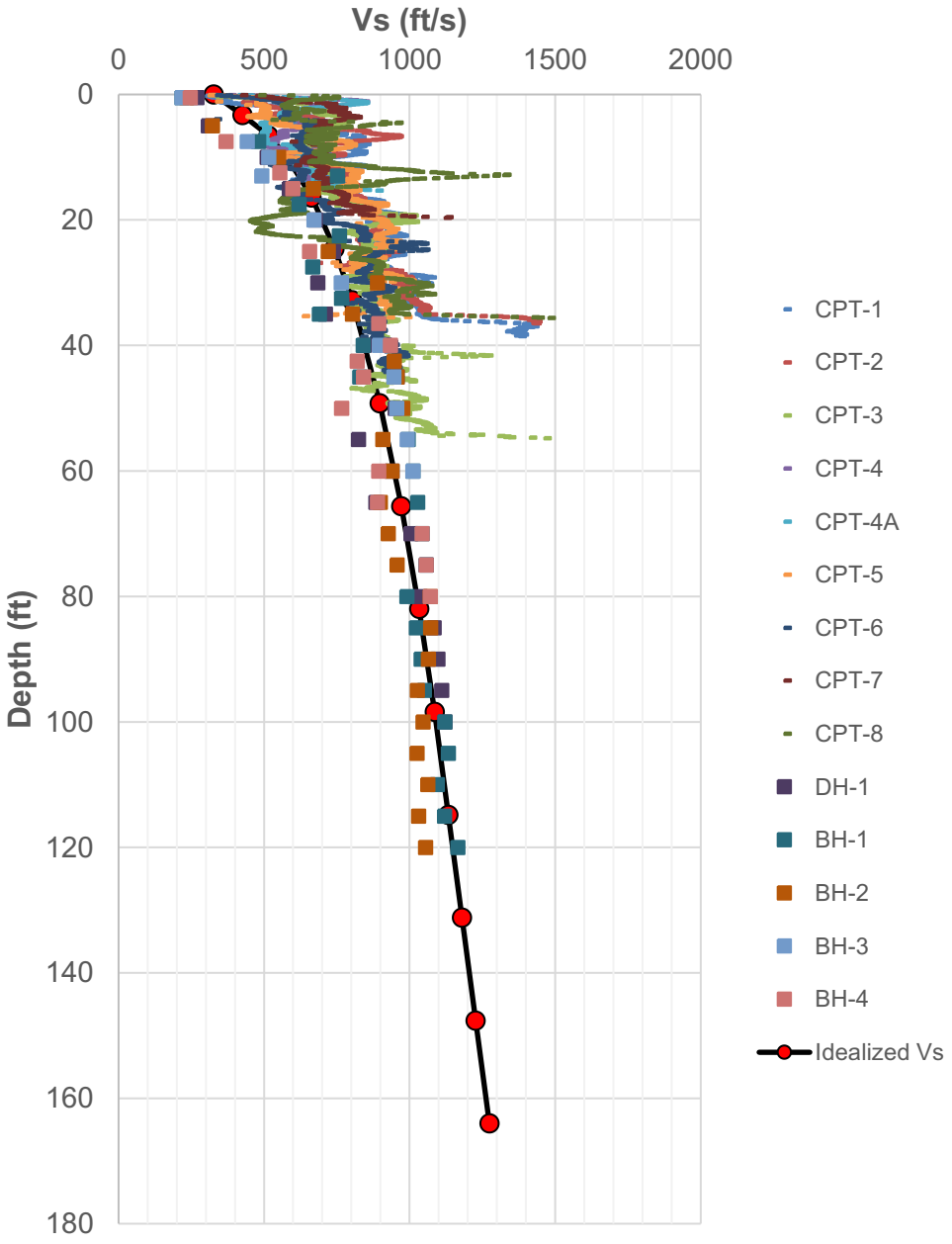


Figure 2. Development of Idealized Shear Wave Velocity Profile

2.2 Code-based Spectra

Design acceleration parameters and spectra were developed per the requirements of the International Building Code (IBC, 2018) which is based on the provisions of ASCE 7-16. For this study, code-based ground motion criteria were developed per the provisions of Chapter 11 of ASCE 7-16.

Design ground motion criteria were developed for Site Class D based on the site classification described above.

ASCE 7-16 defines a Risk-adjusted Maximum Considered Earthquake (MCE_R) spectrum and a Design Spectrum. The MCE_R corresponds to the lesser of: (a) the risk-adjusted UHS corresponding to a return period of 2,475-years (i.e., 2 percent probability of exceedance in 50 years); and (b) the median + 1 standard deviation deterministic spectrum calculated for characteristic earthquakes on all known active faults within the region (Section 21.2.2 of ASCE 7-16). The spectra are computed for the direction of the maximum component of ground motion. The design earthquake (DE) response spectrum is calculated as 2/3 of MCE_R, along with some other checks pertaining to spectral shape.

For this study, code-based ground motion design parameters and spectra were developed using the online U.S. ASCE 7 Hazard Tool web application (ASCE) (https://asce7hazardtool.online) recommended by USGS. The geographical coordinates of the project location used for the development of the code-based design parameters are tabulated in Table 3.

Table 3. Project Location Coordinates

Longitude	Latitude
47.065000	-101.216667

The resulting seismic design criteria are presented in Table 4 for Site Class D (Stiff Soil).

Table 4. Summary of IBC (2018)/ASCE 7-16 Seismic Design Parameters

Parameter	Value
Site Class	D
Mapped MCE_R, 5% Damped, Spectral Response Acceleration Parameter at Short Period (0.2 Second), S_S (g)	0.052
Mapped MCE_R, 5% Damped, Spectral Response Acceleration Parameter at 1.0 Second, S_1 (g)	0.022
MCE_R, 5% Damped, Spectral Response Acceleration at Short Period (0.2 Second) Adjusted for Site Class Effects, S_{MS} (g)	0.083
MCE_R, 5% Damped, Spectral Response Acceleration at a Period of 1.0 Second Adjusted for Site Class Effects, S_{M1} (g)	0.054
Design, 5% Damped, Spectral Response Acceleration at Short Period (0.2 Second), S_{DS} (g)	0.055
Design, 5% Damped, Spectral Response Acceleration at a Period of 1.0 Second, S_{D1} (g)	0.036
Long-period Transition Period, T_L (sec)	4
Short Period Site Coefficient (0.2 Second), F_a	1.6
Long Period Site Coefficient at 1.0 Second, F_v	2.4
Mapped MCE_G Peak Ground Acceleration, PGA	0.023
MCE_G Peak Ground Acceleration Adjusted for Site Class Effects, PGA_M	0.037
Site Coefficient for Peak Ground Acceleration, F_{PGA}	1.6
Vertical Coefficient, C_v	0.7

3 LIQUEFACTION TRIGGERING HAZARD ASSESSMENT

3.1 Introduction

As very loose to medium dense saturated granular soils are shaken, their tendency to contract and compress may lead to the development of positive pore pressures. If the seismic shaking is strong

and long enough, the build-up in pore pressure can produce a significant loss of shear strength. Liquefaction occurs when the excess pore pressure equals the initial effective stress in the soil. If the shaking continues after the onset of liquefaction, ground distress may occur (e.g., sand boils, settlement, lurching, and lateral deformation). Liquefaction may also cause a loss of axial capacity of shallow or deep foundations, loss of lateral pile capacity or stiffness, and lateral ground spreading.

The susceptibility of a granular soil to liquefaction is a function of the gradation, density, aging/cementation, and fines content of the soil. The resistance to liquefaction increases with respective increases in: a) distribution of grain size, b) soil density, c) aging/cementation, d) fines content, and e) plasticity characteristics of the fines.

This section presents a summary of the procedures adopted and the results from the liquefaction potential evaluations at the site.

3.2 Basis of Evaluation

The liquefaction analyses presented herein are based on:

- Cyclic stress ratio (CSR) evaluated from the earthquake parameters based on ground motion evaluations presented in Section 2.
- Cyclic resistance of the deposit evaluated from cone penetration test (CPT) tip resistance data and from standard penetration test (SPT) data.

The Peak Ground Acceleration (PGA) and earthquake magnitude are used to estimate the seismically induced demand or cyclic stress ratio (CSR). The CPT data and SPT data were used to evaluate the liquefaction resistance or cyclic resistance ratio (CRR) in the liquefiable layers. The factor of safety (FOS) against liquefaction was then calculated as the ratio of the CRR to the CSR (FOS = CRR/CSR). Liquefaction evaluation was conducted based on Boulanger and Idriss (2014) method. This method is largely based on databases of liquefaction/non-liquefaction of Holocene-age siliceous sands.

Accurate depths to the ground water table were not available from the site geotechnical data as ground water was not observed in the boreholes. This may in part be due to the primarily fine-grained nature of the site for which long term measurements (perhaps with piezometers) would be required to assess the water level. We note, however, that in a few CPTs pore pressure responses were observed at shallow depth. For these evaluations, existing site grades were considered and the water table was conservatively assumed to be at the ground surface.

The liquefaction triggering hazard evaluation was performed for the MCE_G level (Maximum Considered Earthquake Geometric Mean Peak Ground Acceleration) per ASCE 7-16. Based on the deaggregation from the online Unified Hazard USGS web application (USGS) (https://earthquake.usgs.gov/hazards/interactive) the majority of the hazard for the project site derives from M_w 6.5 magnitude earthquakes. The Peak Ground Acceleration (PGA) for MCE_G level as presented in Section 2 is 0.037 g. This PGA value was used for the liquefaction evaluations (Table 5).

Table 5. Earthquake Scenarios for Liquefaction Evaluation Analyses

EQ Event	PGA (g)	Magnitude
MCE_G	0.037	6.5

3.3 Evaluation of Seismically Induced Cyclic Demand

In liquefaction triggering evaluations, the seismic demand is expressed by means of the earthquake induced cyclic stress ratio (CSR)

$$CSR = 0.65 \cdot \frac{\sigma_{vo}}{\sigma'_{vo}} \cdot \frac{a_{\max}}{g} \cdot r_d \quad (3\text{-}1)$$

where: σ_{vo} and σ'_{vo} are the vertical total and effective stress, respectively; a_{max} is the peak ground acceleration; and r_d is a depth varying acceleration reduction factor.

The magnitude of the seismically induced shear stresses was estimated according to the Boulanger and Idriss (2014) procedures through the estimation of the Cyclic Stress Ratio (CSR). The estimated earthquake and depth-specific CSR is converted to a reference magnitude of 7.5 and effective vertical effective stress of 1 atm by means of the magnitude scaling factor (MSF) and overburden correction factor (K_σ) as shown in the following equation.

$$CSR_{M=7.5,\sigma'=1atm} = CSR \cdot \frac{1}{MSF} \cdot \frac{1}{K_\sigma} \quad (3\text{-}2)$$

For example, if the controlling magnitude event is greater than the reference magnitude of 7.5, a MSF less than 1 is applied to increase the equivalent cyclic stress ratio due to the higher number of cycles imparted by the larger magnitude event. As tabulated in Table 5, a controlling magnitude of 6.5 was used in the liquefaction potential evaluation.

Magnitude scaling factors (MSF) were estimated using the Boulanger and Idriss (2014) procedure. The calculated CSR values were multiplied by the appropriate magnitude weighting factor to obtain equivalent CSR for a reference magnitude 7.5 earthquake (CSR7.5). Magnitude 7.5 earthquakes are estimated to produce about 15 equivalent cycles of uniform loading.

3.4 Cyclic Resistance to Liquefaction From CPT Data

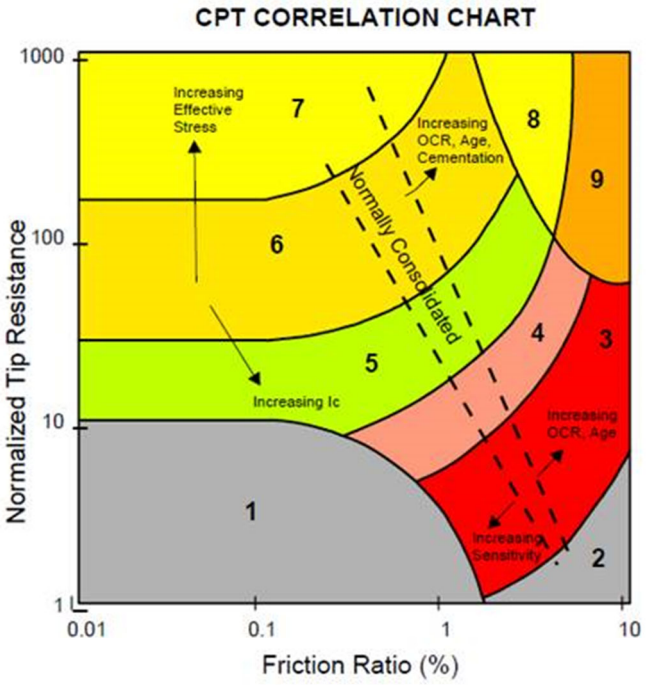
The evaluation of the liquefaction resistance of cohesionless layers from cone penetration test (CPT) data was based on the empirical procedures recommended by Boulanger and Idriss (2014). For these analyses, the measured tip resistances were corrected for fines content and normalized to an overburden pressure of 1 atmosphere (~0.1 MPa).

The site conditions indicate the presence of lignite and coal layers within the strata indicating that the native soils are most likely older than Holocene age. For this study the additional cyclic resistance due to ageing has conservatively been ignored.

The fines content was estimated from the CPT measured tip resistance and sleeve friction ratio using the procedure suggested in Boulanger and Idriss (2014). Based on this procedure the CPT friction ratio (sleeve resistance f_s divided by cone tip resistance q_c) generally increases with increasing fines content and soil plasticity, allowing rough estimates of soil type and fines content to be estimated from CPT data. Figure 3 presents the key to CPT characterization per Robertson (1990).

The available cyclic shear resistance of the potentially liquefiable strata encountered was compared to the estimated cyclic shear stress that would be induced for a given design level. The estimated factor of safety against liquefaction is the ratio of the available cyclic shear resistance to the induced cyclic shear stress.

In some cases, a thin layer correction factor is applied to the raw cone tip resistance using methods described in Youd et al. (2001). This correction was applied if a thin (i.e., less than 1 meter thick) sand layer existed immediately above a softer clay or silt layer.



Zone	Soil Behavior Type
1	Sensitive Fine-grained
2	Peats
3	Silty Clay to Clay
4	Clayey Silt to Silty Clay
5	Silty Sand to Sandy Silt
6	Clean Sand to Silty Sand
7	Gravelly Sand to Dense Sand
8	Very Stiff Sand to Clayey Sand*
9	Very Stiff Fine-Grained*

*heavily overconsolidated or cemented

Figure 3. Key to CPT Characterization

3.5 Cyclic Resistance to Liquefaction from SPT Data

The evaluation of the liquefaction resistance of cohesionless layers from SPT data from the borings was based on the empirical procedures recommended by Boulanger and Idriss (2014). Correction factors proposed by this method were applied on the SPT N values measured in the field to derive the N_{60} values. The N_{60} values were corrected for overburden ($N_{1,60}$) and for fines content. The fine content values used for each layer was based on the characterization of each layer from the boring logs.

3.6 Results

3.6.1 Results from CPT Data

CPT-based simplified liquefaction triggering evaluations were performed using Boulanger and Idriss (2014) empirical correlation for MCE_G shaking level. CSR was estimated based on a PGA value of 0.037g. Results of the liquefaction triggering analyses of 9 CPTs from the site (i.e. CPT-1, CPT-2, CPT-3, CPT-4, CPT-4A, CPT-5, CPT-6, CPT-7 and CPT-8) for the existing conditions are included in Appendix A for the MCE_G shaking level.

Example results are shown for CPT-1 on Figure 4. Shown for the CPT data on this figure and in Appendix A are:

- Panel 1 - the measured CPT tip resistance together with the tip resistance required to produce a factor of safety against liquefaction of 1. When the latter is lower than the measured tip resistance, the area between the two lines is shaded blue (denoting liquefiable soils).
- Panel 2 - The measured friction ratio;
- Panel 3 - The estimated soil behaviour index (I_c);
- Panel 4 - The estimated CSR from Boulanger and Idriss (2014) (blue line) and the estimated CRR (red line) using Boulanger and Idriss (2014) correlation with Youd et al (2001) thin layer correction; and
- Panel 5 - The estimated factor of safety against liquefaction

The colour coding used on Panels 1 to 3 for the CPT data are the soil behaviour types per the classification chart of Robertson (1990) as shown on Figure 3. A review of the CPT liquefaction triggering evaluation results for MCE_G shaking level indicates liquefaction is not expected to occur.

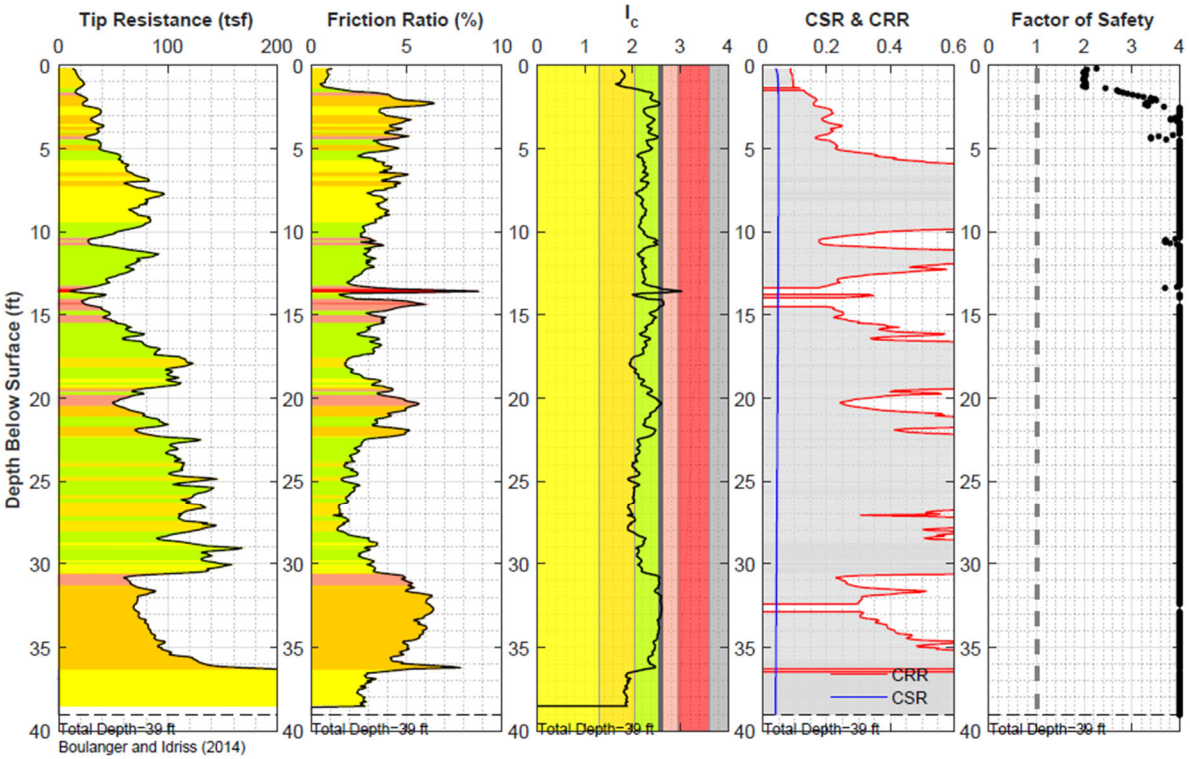


Figure 4. Liquefaction Triggering Assessment CPT Log, CPT-1, Boulanger and Idriss (2014)

3.6.2 Results from SPT Data

SPT-based simplified liquefaction triggering evaluations were performed using Boulanger and Idriss (2014) empirical correlation for MCE_G shaking level. CSR was estimated based on a PGA value of 0.037g. Results of the liquefaction triggering analyses of 5 boreholes with SPT data from the site (i.e. BH-1, BH-2, BH-3, BH-4 and DH-1) for the existing conditions are included in Appendix B for the MCE_G shaking level. The safety factor is provided for the cases where it is less than two.

Example results are shown for DH-1 on Figure 5. Shown for the SPT data on this figure and in Appendix B are:

- Panel 1 – Measured N_{60} values.
- Panel 2 - The estimated CSR from Boulanger and Idriss (2014) (blue line) and the estimated CRR (red points) using Boulanger and Idriss (2014); and
- Panel 3 - The estimated factor of safety against liquefaction

A review of the SPT liquefaction triggering evaluation results for MCE_G shaking level indicates liquefaction is not expected to occur.

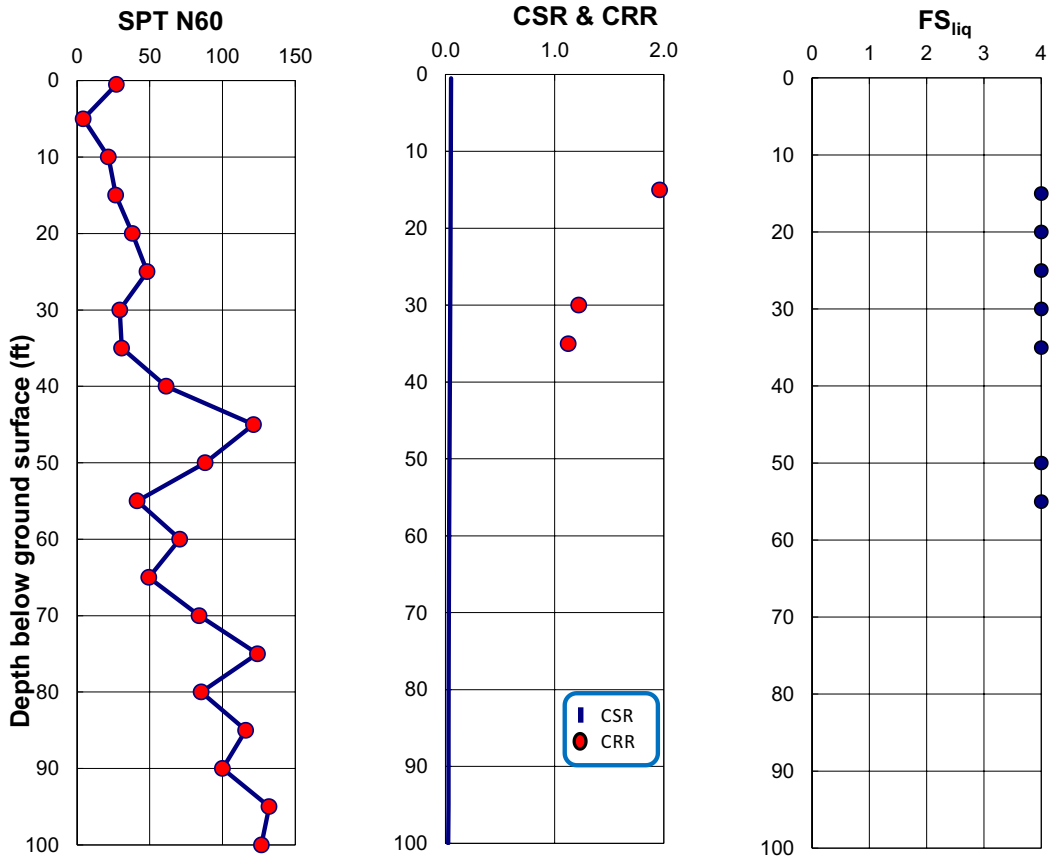


Figure 5. Liquefaction Triggering Assessment SPT Log, DH-1, Boulanger and Idriss (2014)

3.6.3 Consideration of Changes in Site Grades

The above evaluations were conducted using existing site grades. We note that in areas where the site grades will be lowered, somewhat higher cyclic stresses could be computed as the depth to a given soil layer reduces, however the overburden and fines corrected cyclic resistance will largely be

unchanged or slightly increased. Figure 6 shows a comparison of the CSR for existing grades compared with the CSR for final grades for the exploration with the highest existing site grades. As shown on this figure the ratio of the CSR for the final site grades versus existing site grades is typically less than 1.5. Given that the factors of safety are high typically > 3, even increasing the cyclic stress ratio by a factor of 1.5 will not alter the conclusions derived from the analyses for existing site grades.

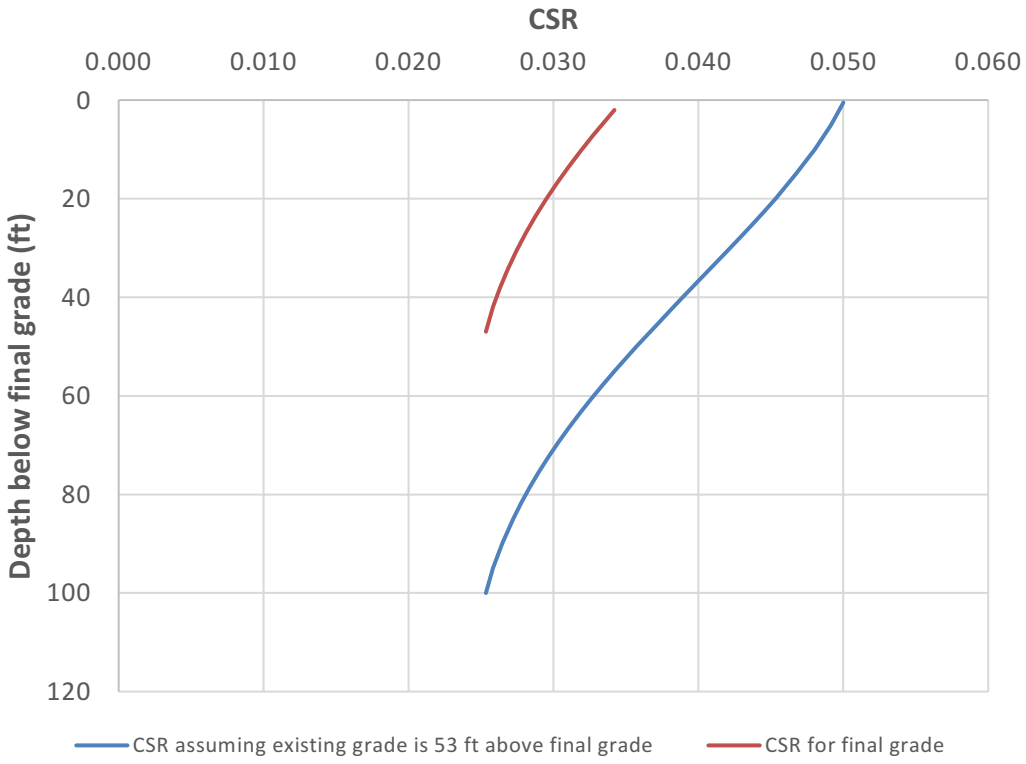


Figure 6. Comparison of CSR at the existing and final grade from DH-1

3.6.4 Summary

As shown on the figures of Appendix A and B, liquefaction is not expected to occur at the coarse-grained layers encountered at the project site as the estimated factors of safety against liquefaction is larger than 2.0 throughout the site. These results suggest that liquefaction is unlikely under both MCE_G and Design Earthquake levels. The analyses conservatively assume that the soil layers below surface are submerged. We note that in cut areas, a higher cyclic stress level maybe considered for layers that are now closer to the ground surface. However, even considering a worst case scenario, this increase in demand does not impact the main conclusions related to liquefaction.

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APPENDIX A
CPT-BASED LIQUEFACTION TRIGGERING HAZARD ASSESSMENT RESULTS

Soil Liquefaction Report
Tundra Carbon Capture & Sequestration (CSS) Project
Center, North Dakota
Terracon Report No. M2205062

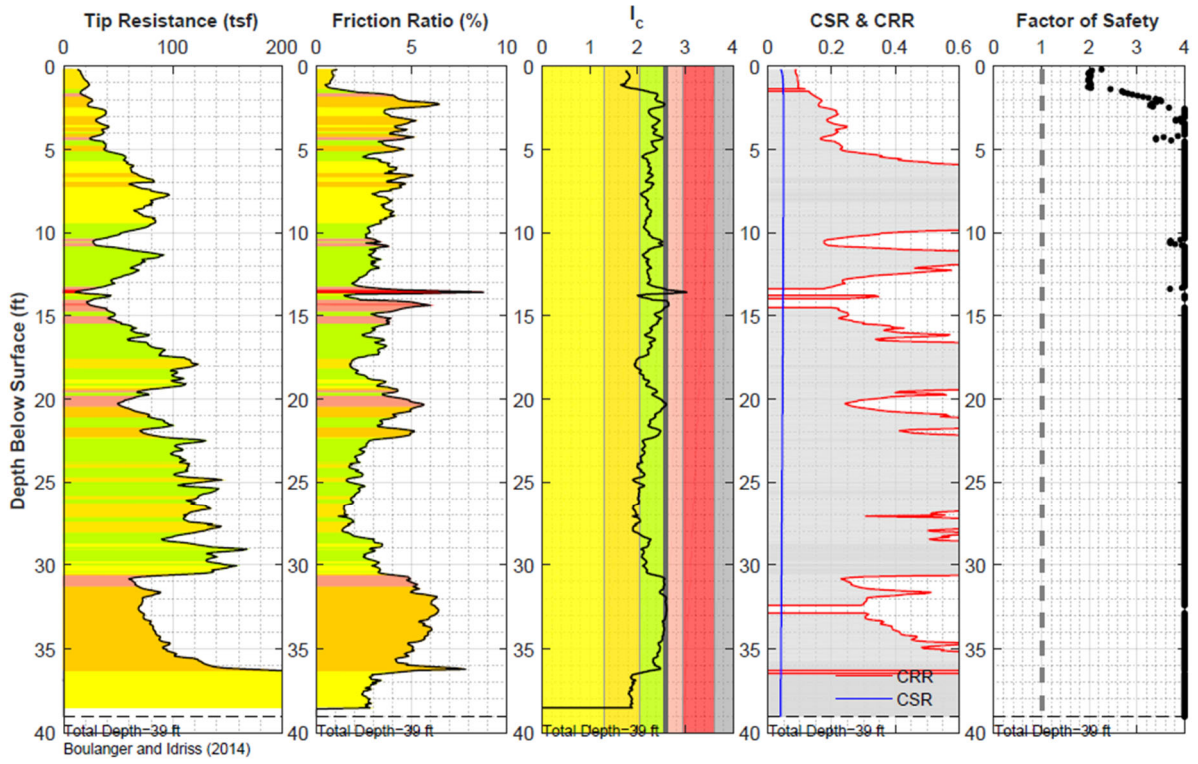


Figure A-1. CPT-Based Liquefaction Triggering Assessment of Boring CPT-1 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

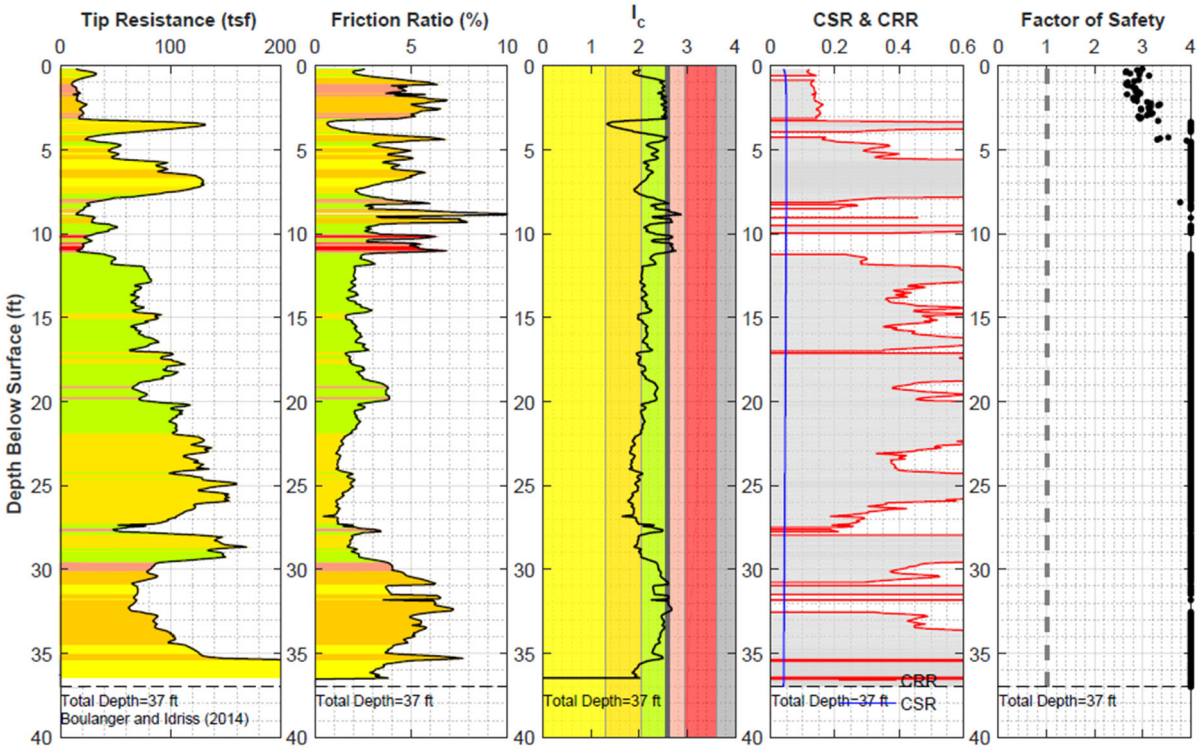


Figure A-2. CPT-Based Liquefaction Triggering Assessment of Boring CPT-2 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

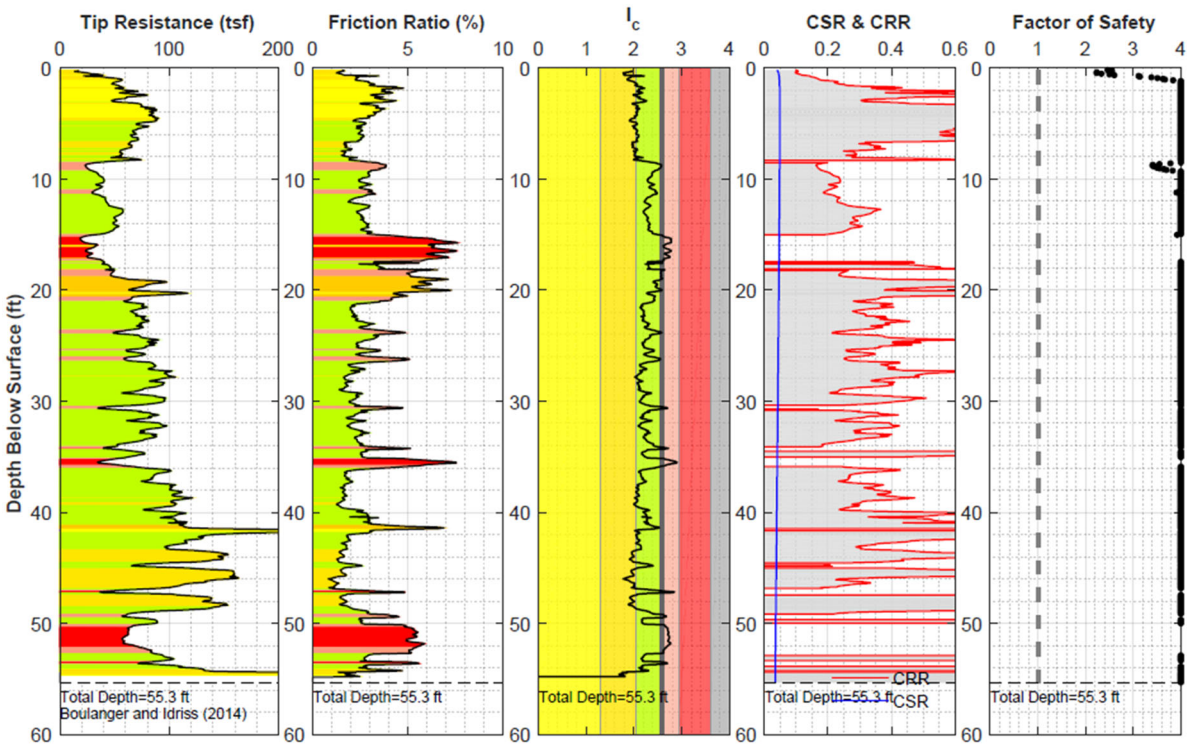


Figure A-3. CPT-Based Liquefaction Triggering Assessment of Boring CPT-3 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

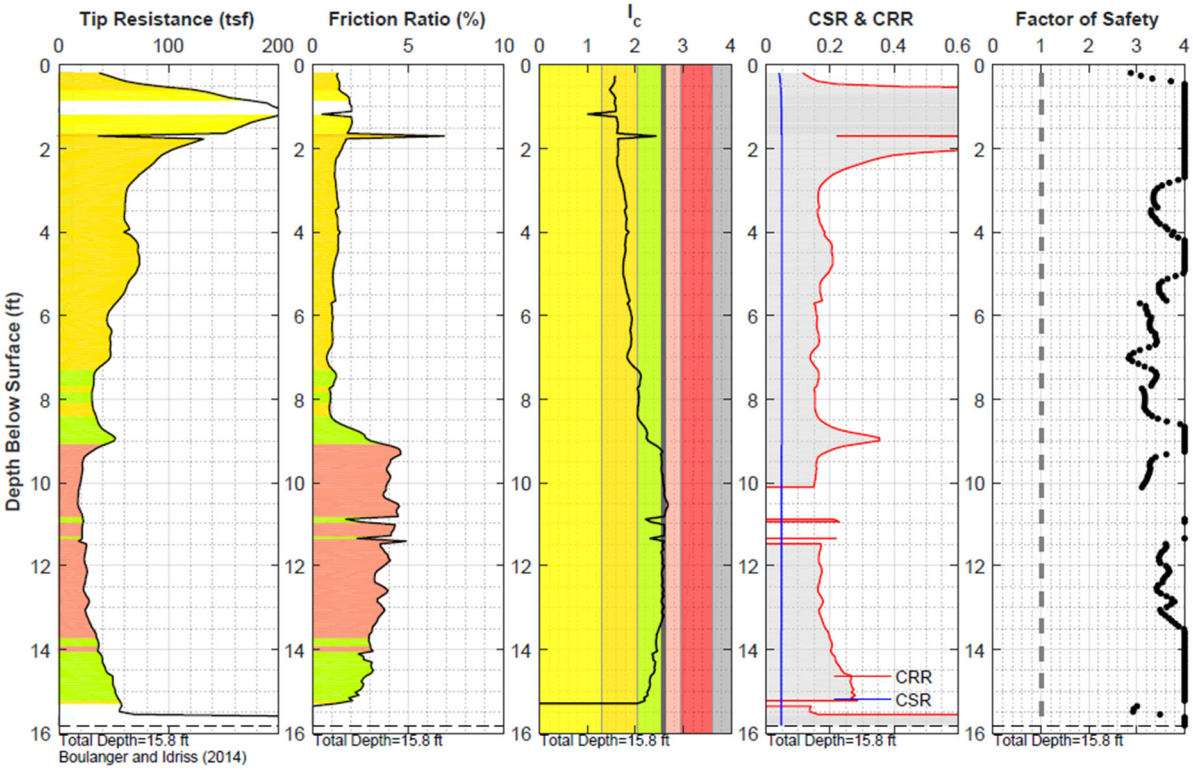


Figure A-4. CPT-Based Liquefaction Triggering Assessment of Boring CPT-4 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

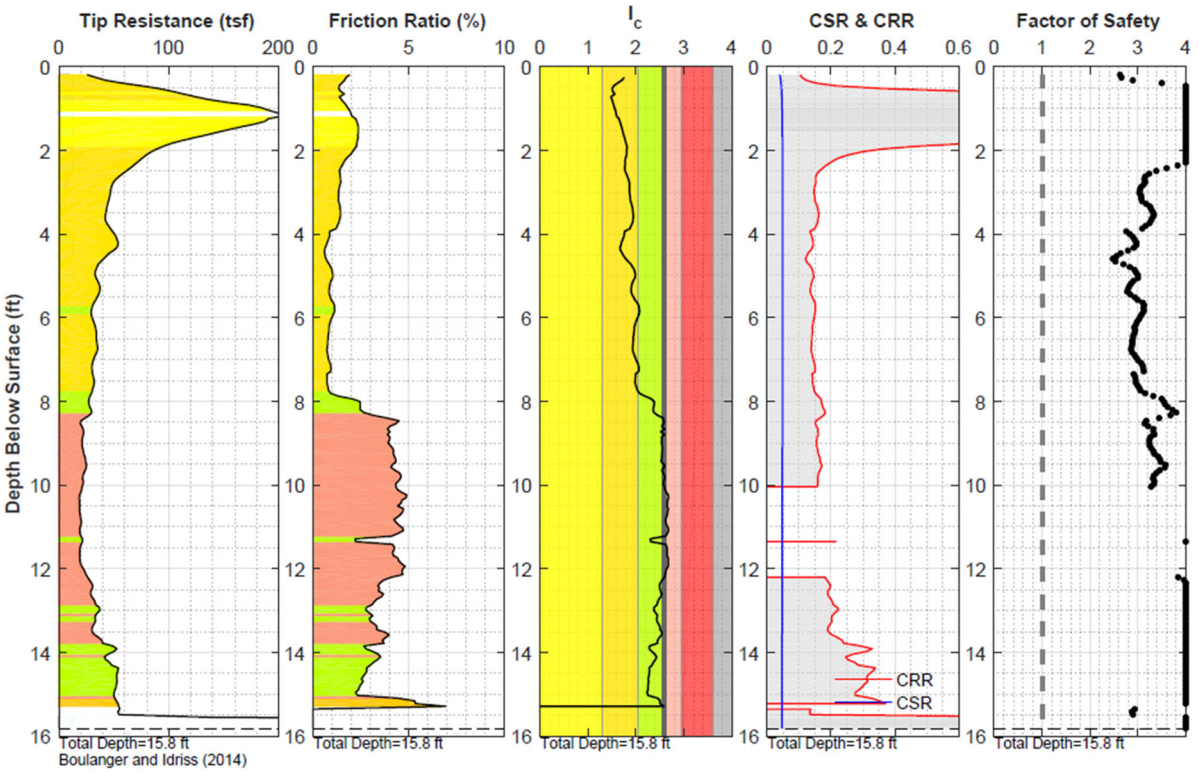


Figure A-5. CPT-Based Liquefaction Triggering Assessment of Boring CPT-4A for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

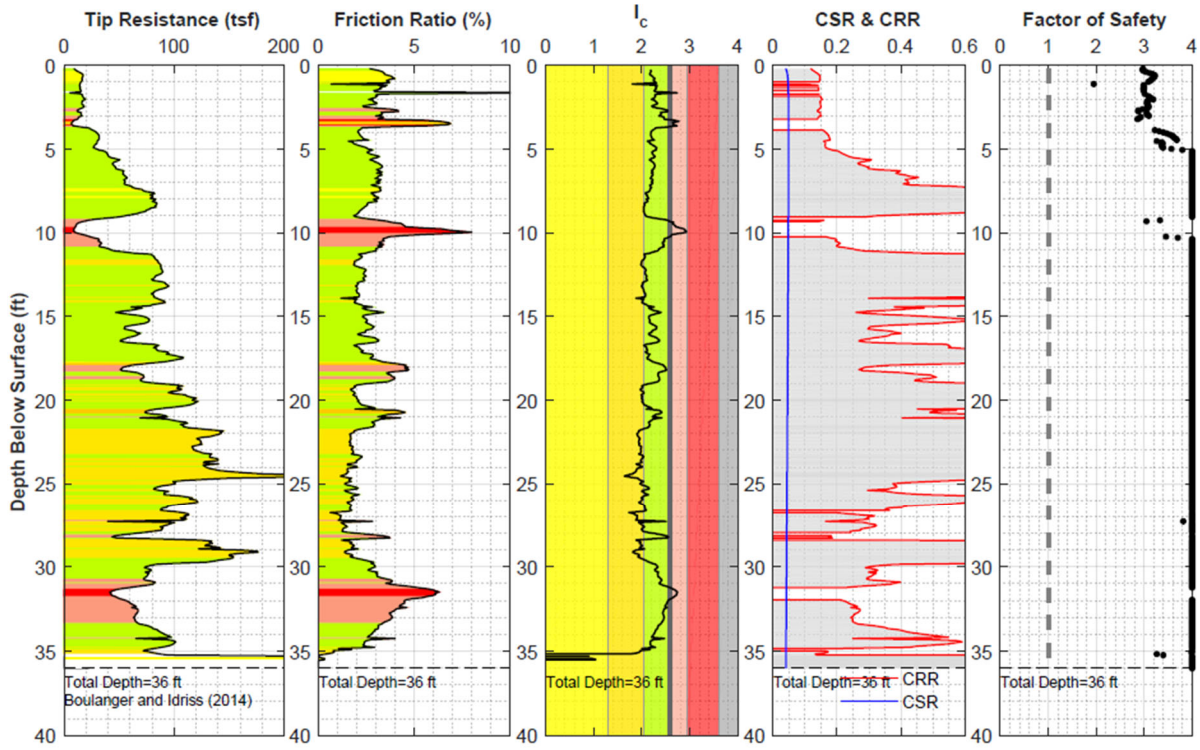


Figure A-6. CPT-Based Liquefaction Triggering Assessment of Boring CPT-5 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

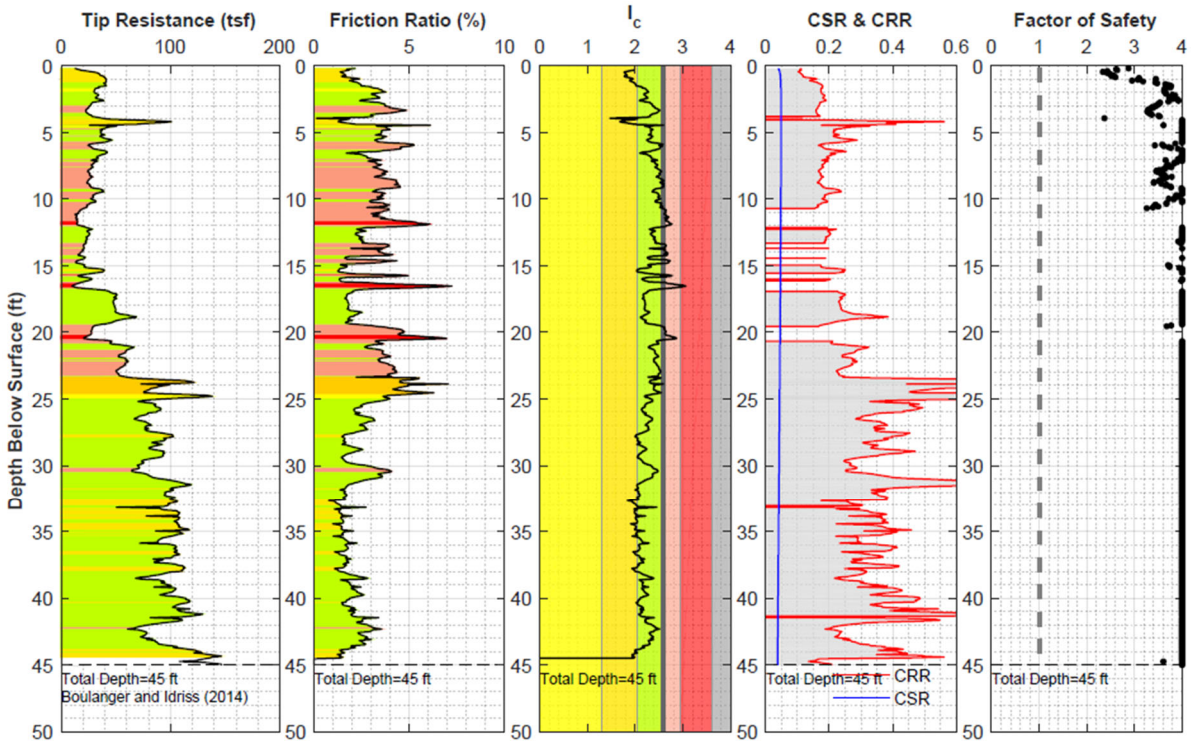


Figure A-7. CPT-Based Liquefaction Triggering Assessment of Boring CPT-6 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

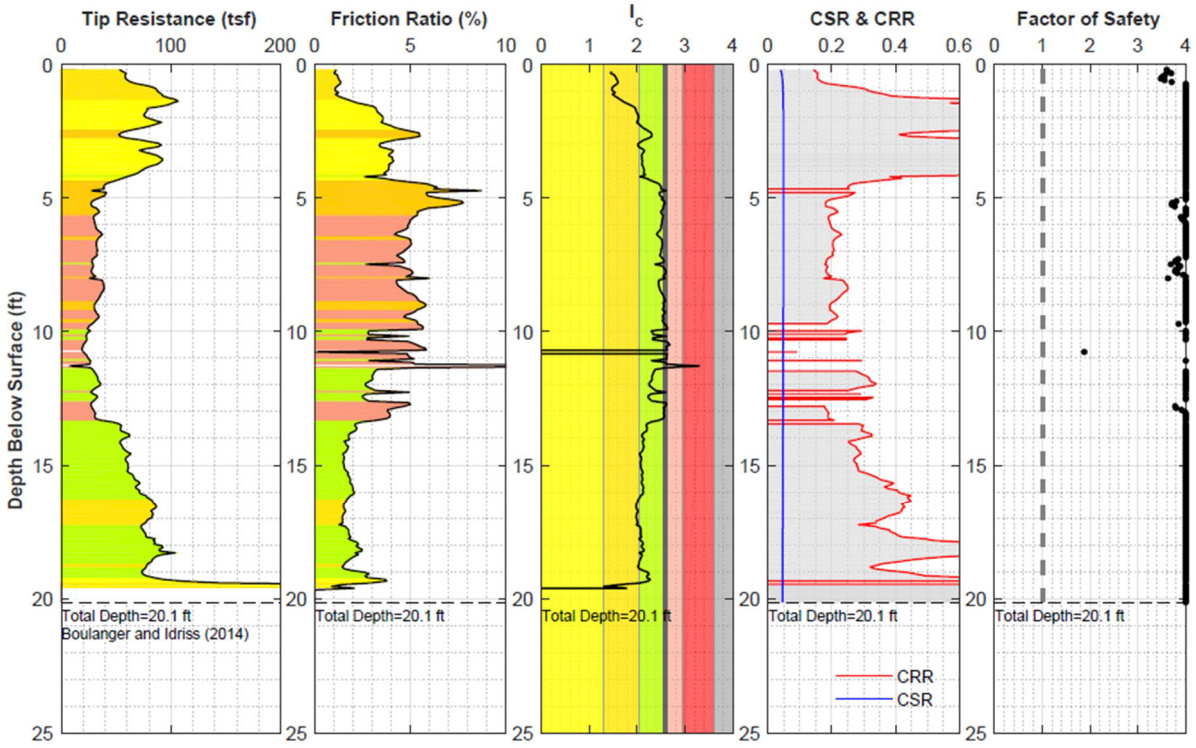


Figure A-8. CPT-Based Liquefaction Triggering Assessment of Boring CPT-7 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

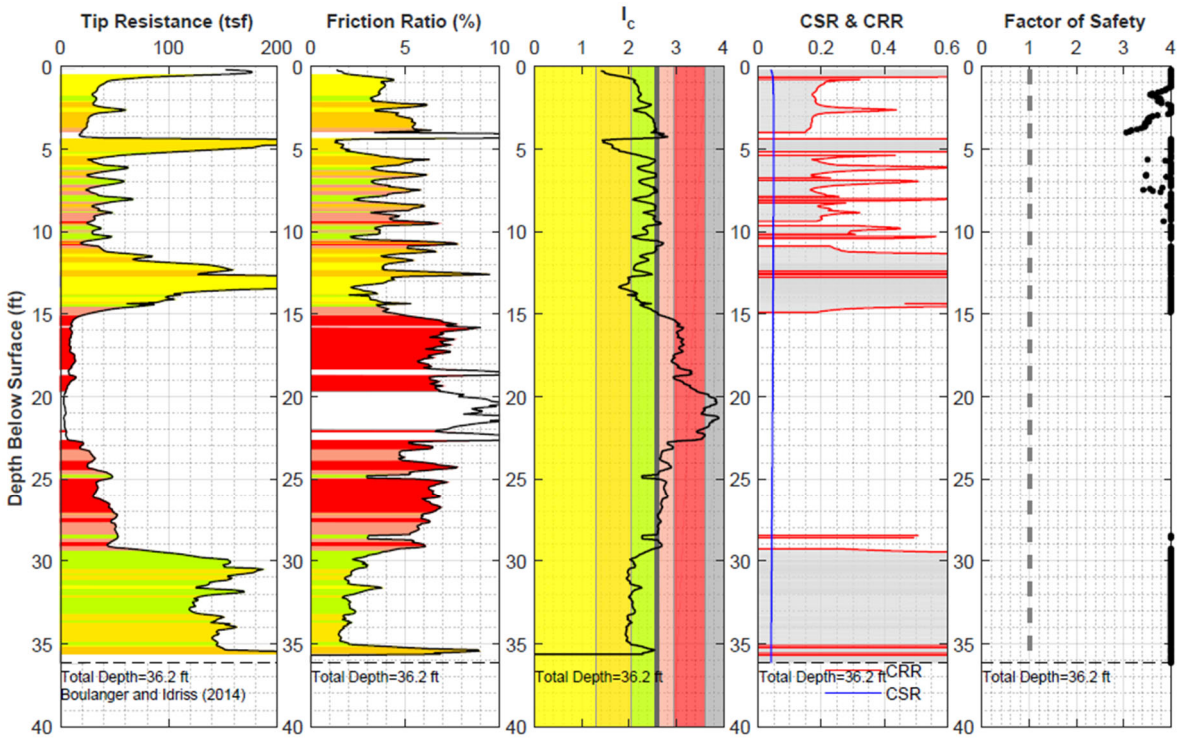


Figure A-9. CPT-Based Liquefaction Triggering Assessment of Boring CPT-8 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

APPENDIX B
SPT-BASED LIQUEFACTION TRIGGERING HAZARD ASSESSMENT RESULTS

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Tundra Carbon Capture & Sequestration (CSS) Project
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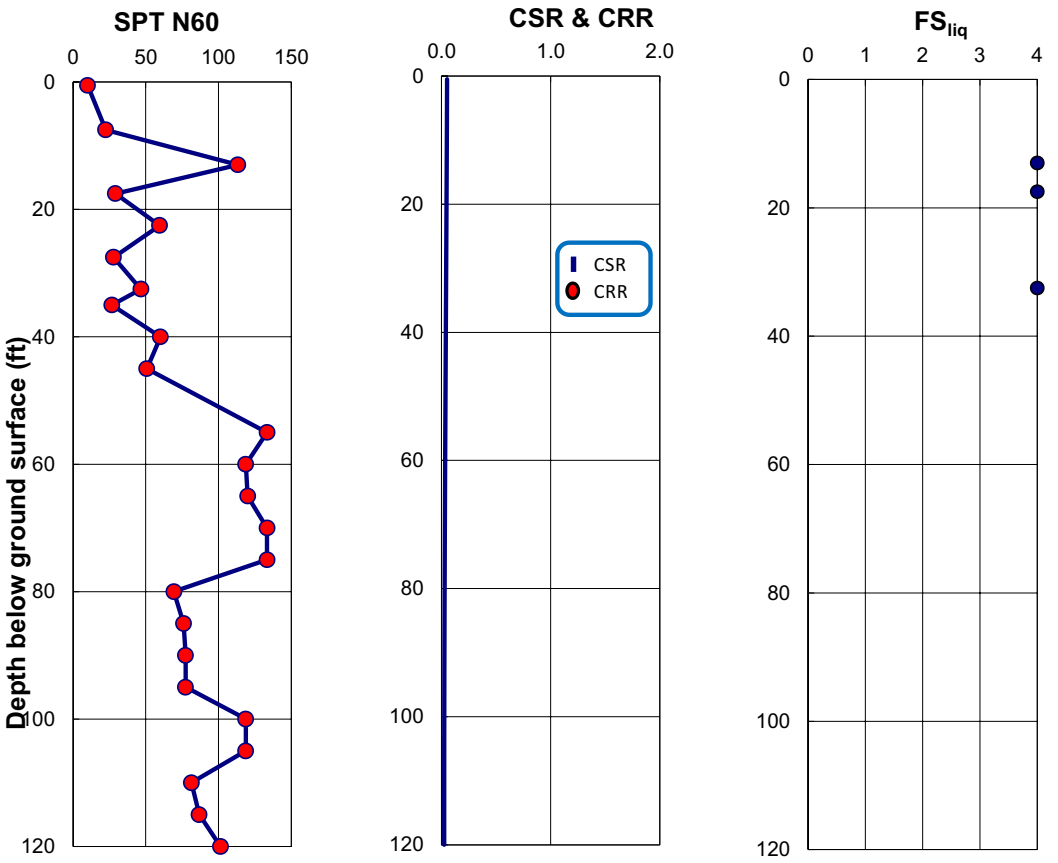


Figure B-1. SPT-Based Liquefaction Triggering Assessment of Boring BH-1 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

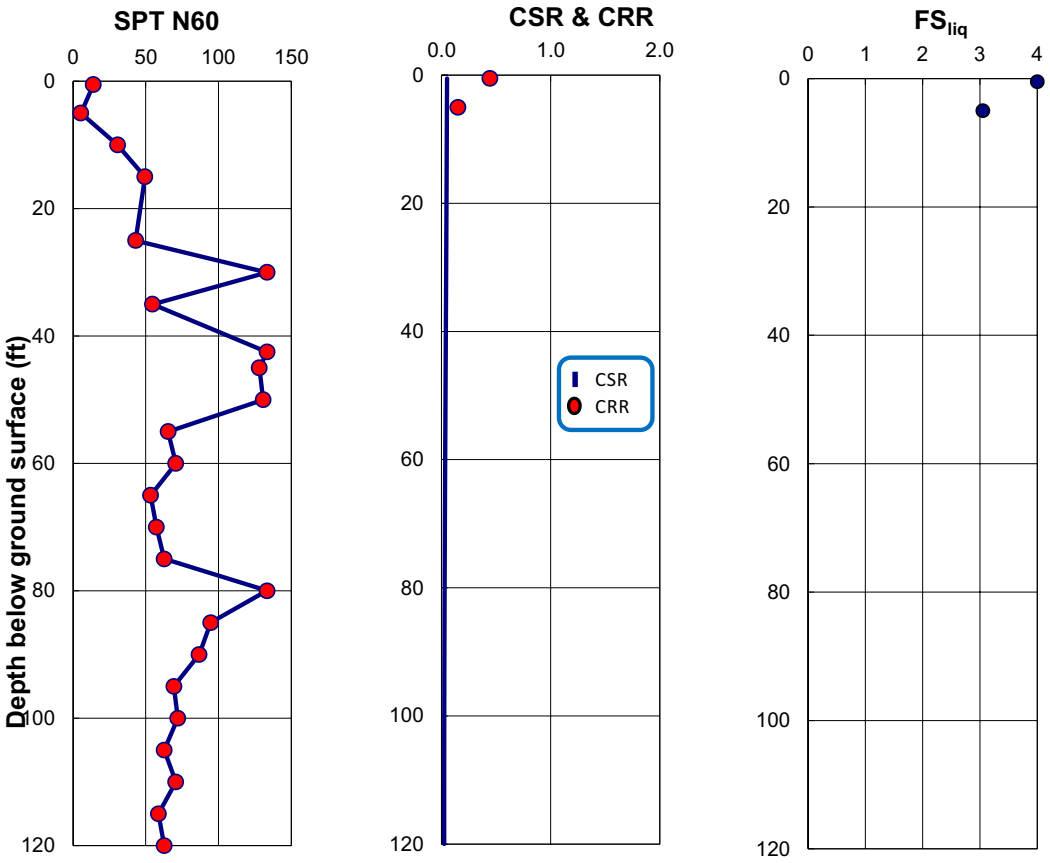


Figure B-2. SPT-Based Liquefaction Triggering Assessment of Boring BH-2 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

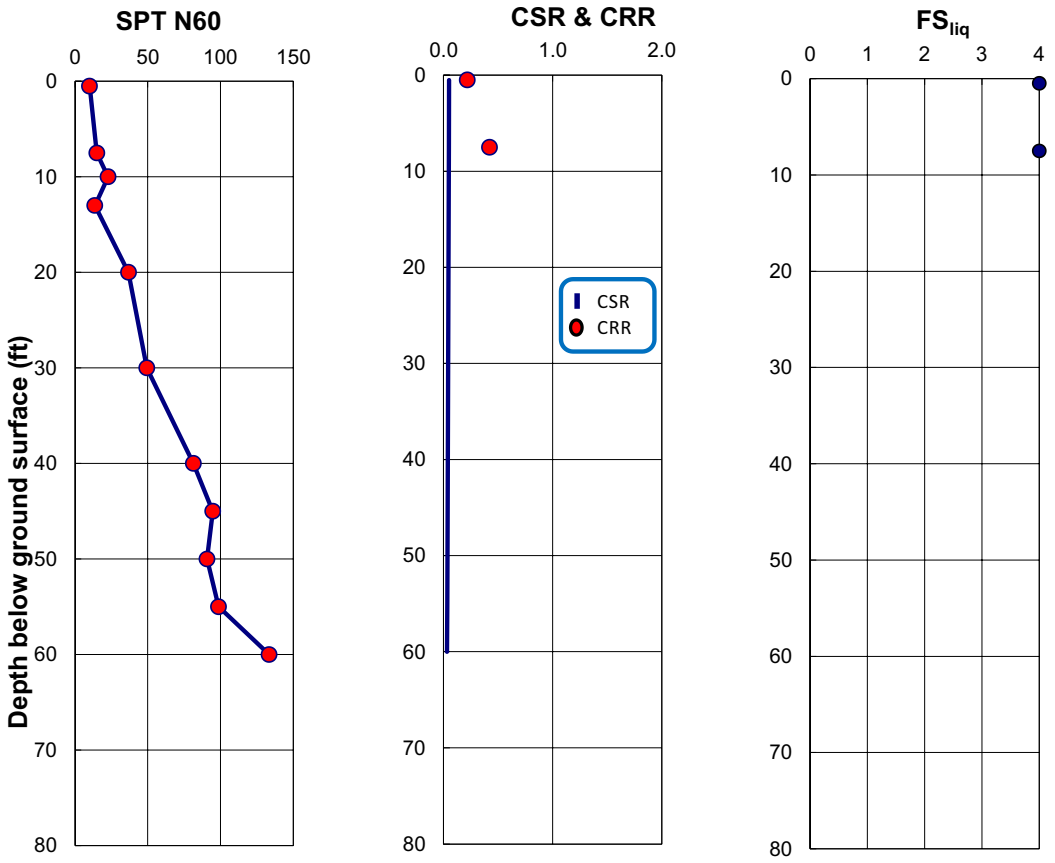


Figure B-3. SPT-Based Liquefaction Triggering Assessment of Boring BH-3 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

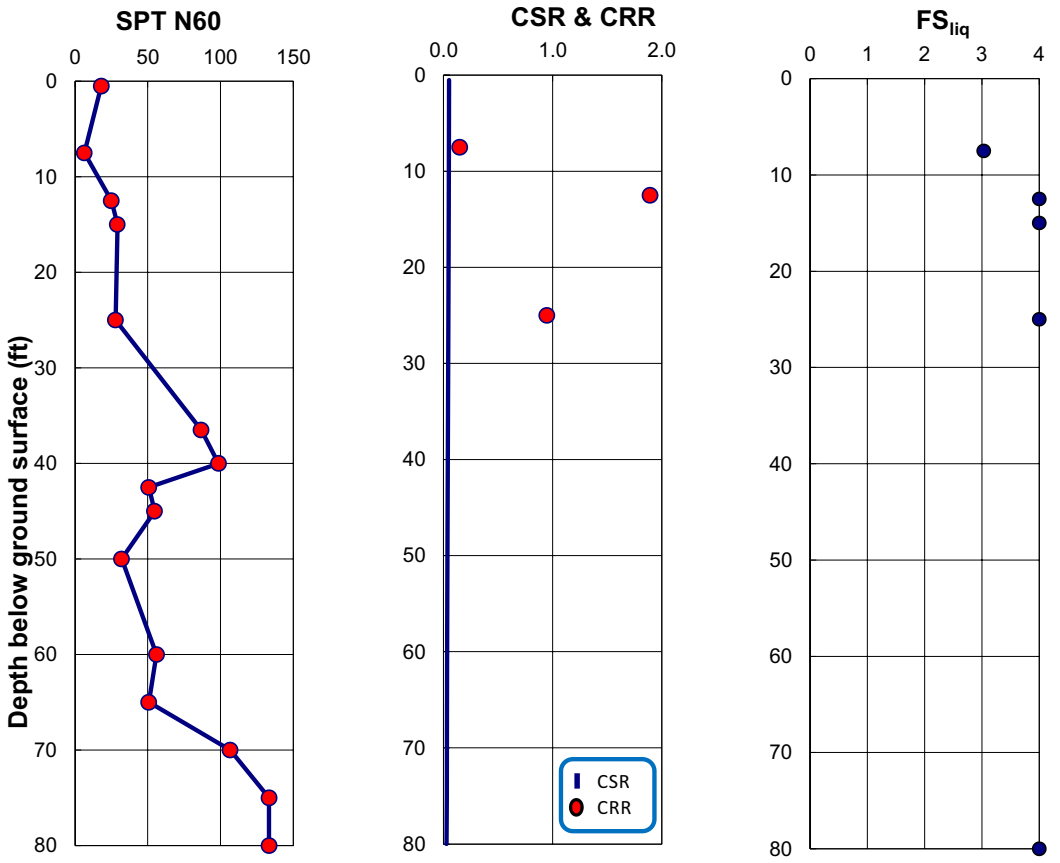


Figure B-4. SPT-Based Liquefaction Triggering Assessment of Boring BH-4 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

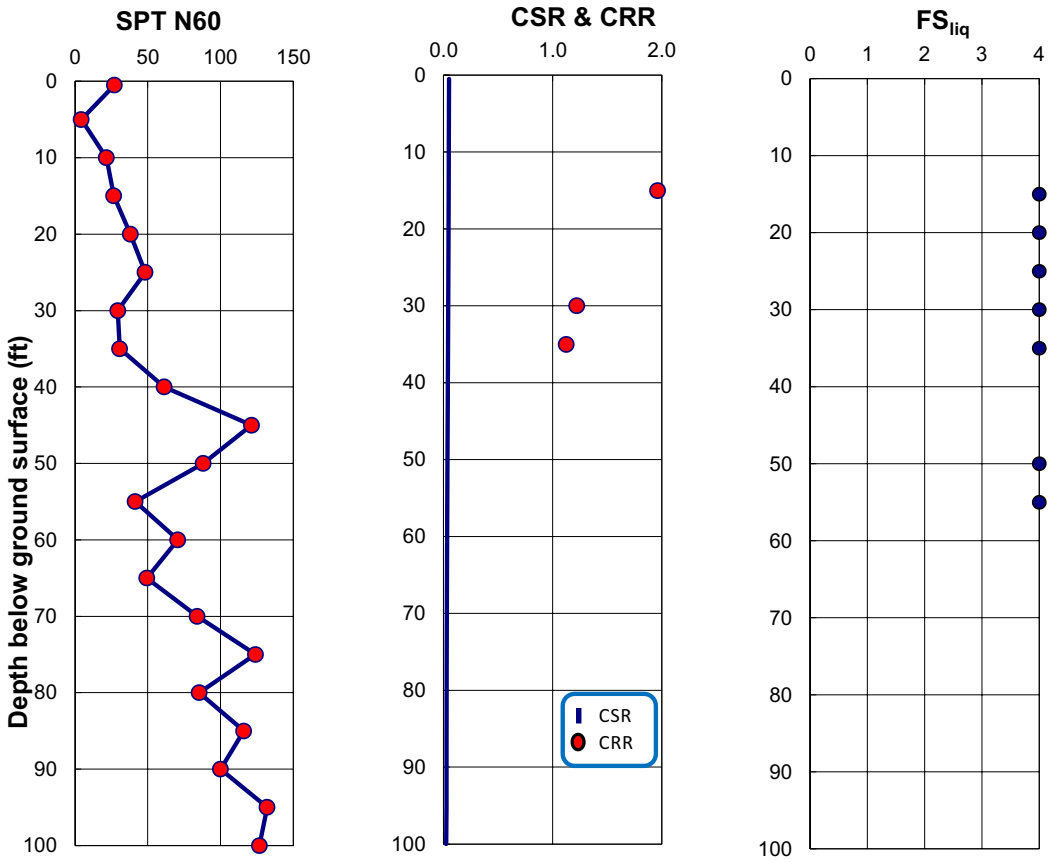
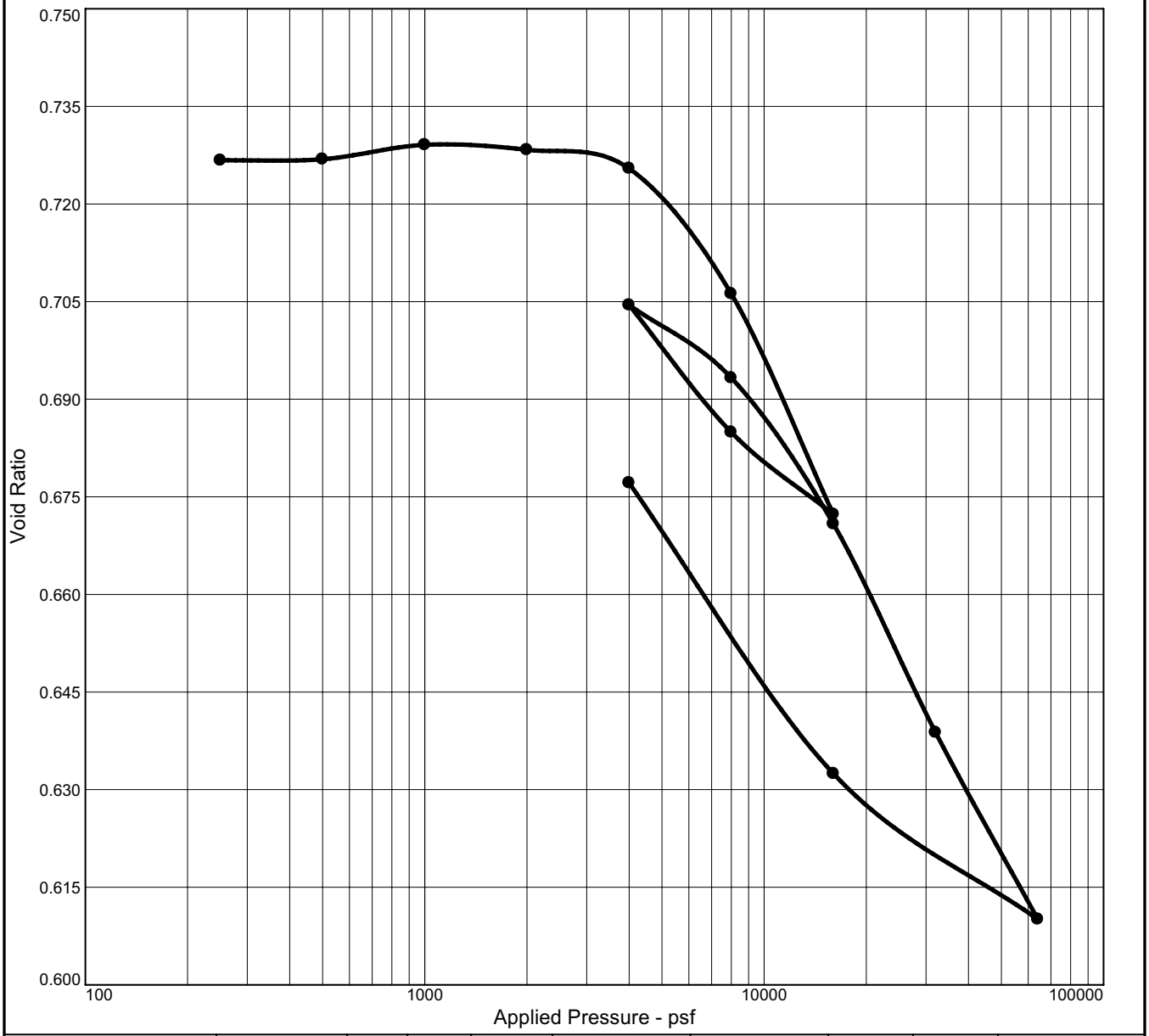


Figure B-5. SPT-Based Liquefaction Triggering Assessment of Boring DH-1 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_r	Initial Void Ratio
Saturation	Moisture									
98.5 %	26.2 %	98.7			2.73		5374	0.11	0.06	0.726

MATERIAL DESCRIPTION	USCS	AASHTO
Dark gray Fat Clay		

Project No. M2205062 **Client:** Fluor Enterprises Inc Greenville, SC

Project: Project Tundra

Location: B-1 **Depth:** 19-21 ft.

Terracon Consultants, Inc.

Houston, TX

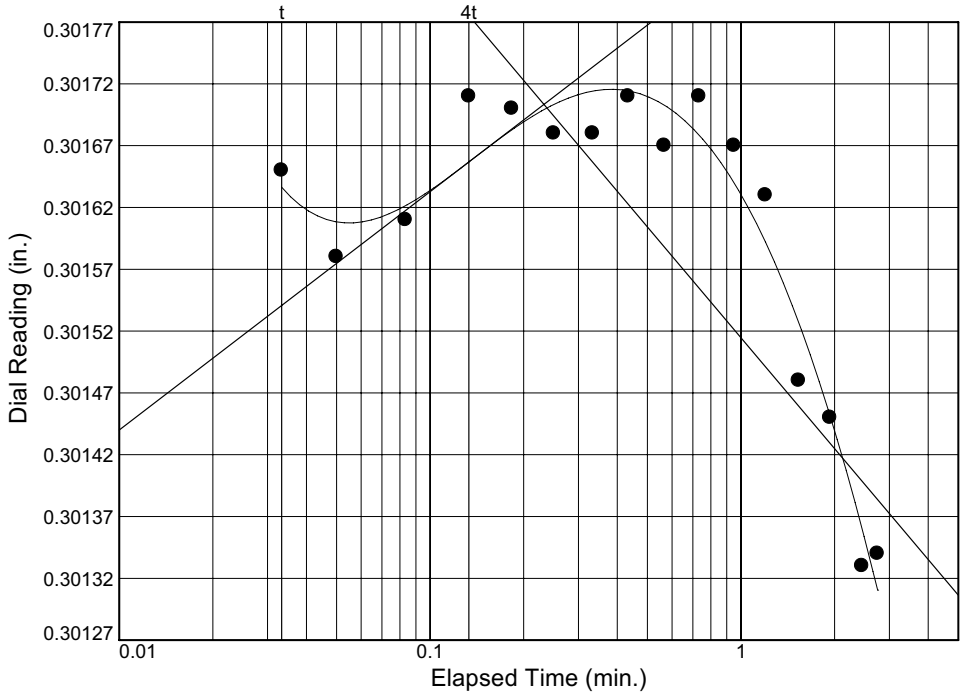
Remarks:

ASTM D2435
Specific gravity assumed

Dial Reading vs. Time

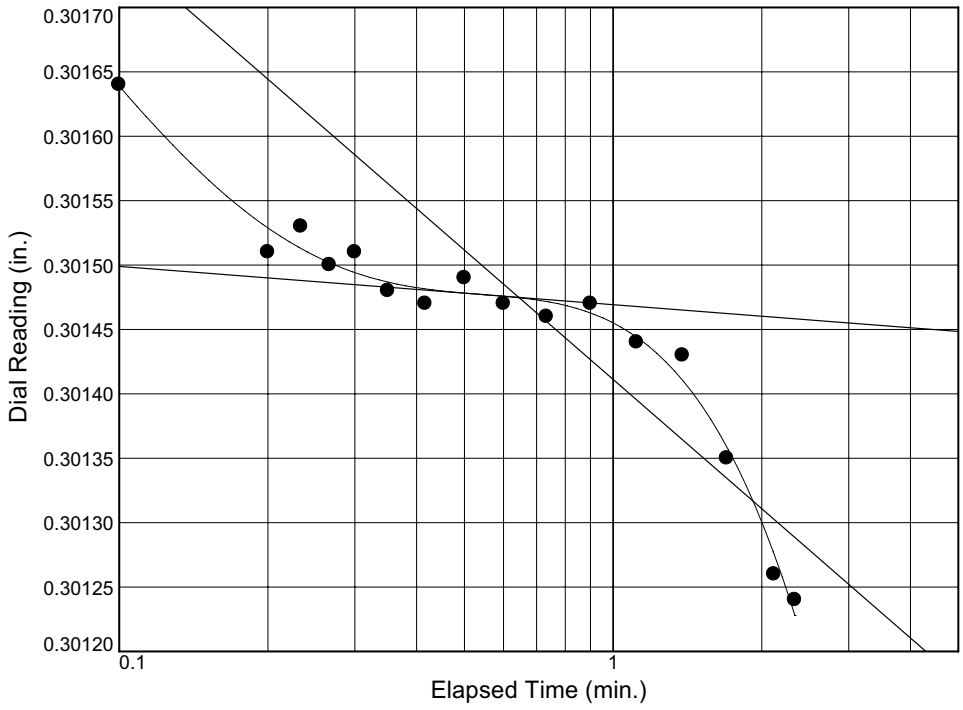
Project No.: M2205062
Project: Project Tundra

Location: B-1 Depth: 19-21 ft.



Load No.= 1
Load= 250 psf
D_0 = 0.3016
D_{50} = 0.3017
D_{100} = 0.3017
T_{50} = 0.14 min.

C_v @ T_{50}
3.573 ft.^{2}/day



Load No.= 2
Load= 500 psf
D_0 = 0.3010
D_{50} = 0.3013
D_{100} = 0.3015
T_{50} = 2.20 min.

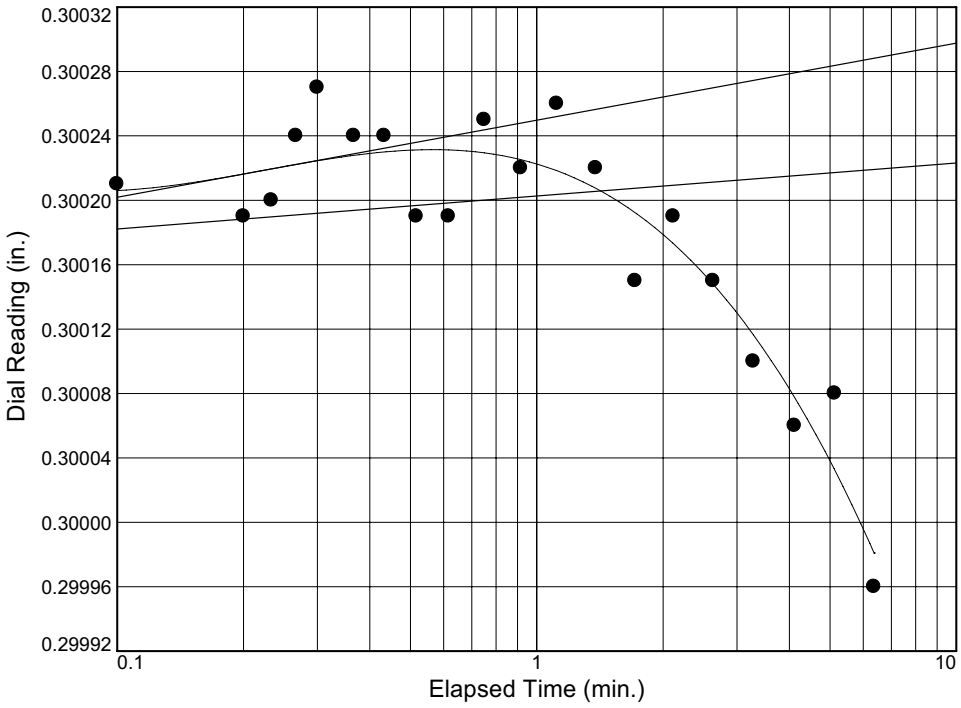
C_v @ T_{50}
0.224 ft.^{2}/day

Terracon Consultants, Inc.

Dial Reading vs. Time

Project No.: M2205062
Project: Project Tundra

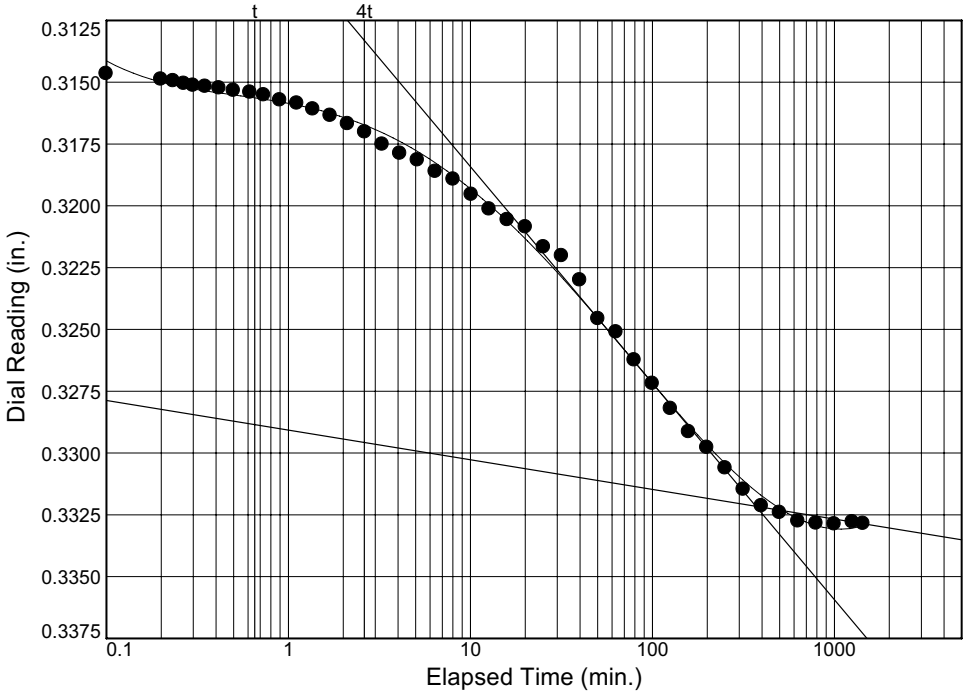
Location: B-1 Depth: 19-21 ft.



Load No.= 3
Load= 1000 psf
D_0 = 0.2999
D_{50} = 0.3001
D_{100} = 0.3002
T_{50} = 4.65 min.

C_v @ T_{50}
0.106 ft.^{2}/day

C_α = 0.000



Load No.= 7
Load= 16000 psf
D_0 = 0.3145
D_{50} = 0.3233
D_{100} = 0.3322
T_{50} = 36.04 min.

C_v @ T_{50}
0.013 ft.^{2}/day

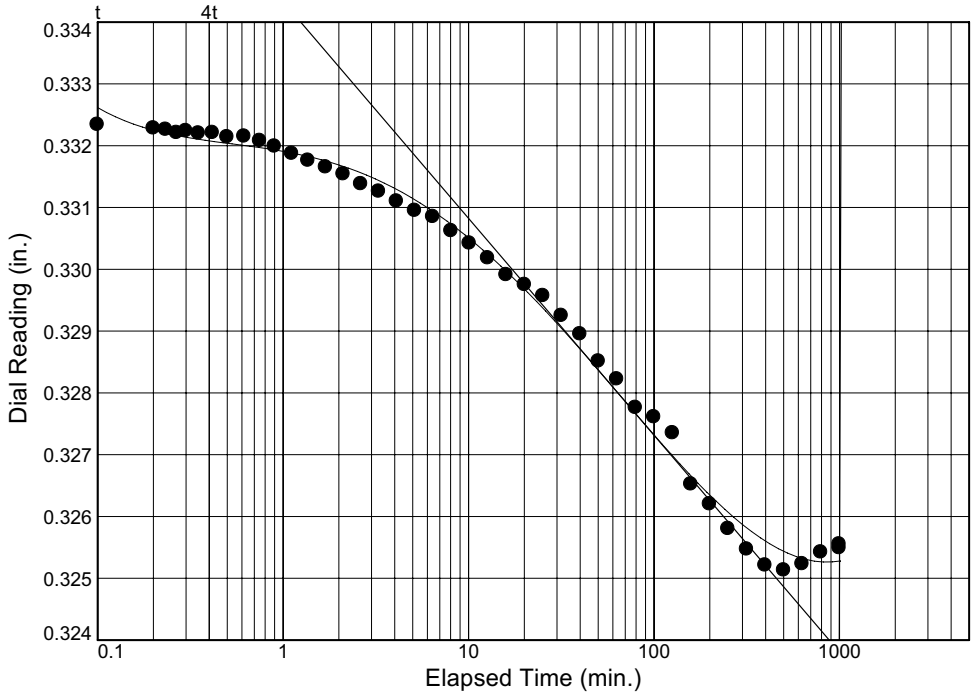
C_α = 0.001

Terracon Consultants, Inc.

Dial Reading vs. Time

Project No.: M2205062
Project: Project Tundra

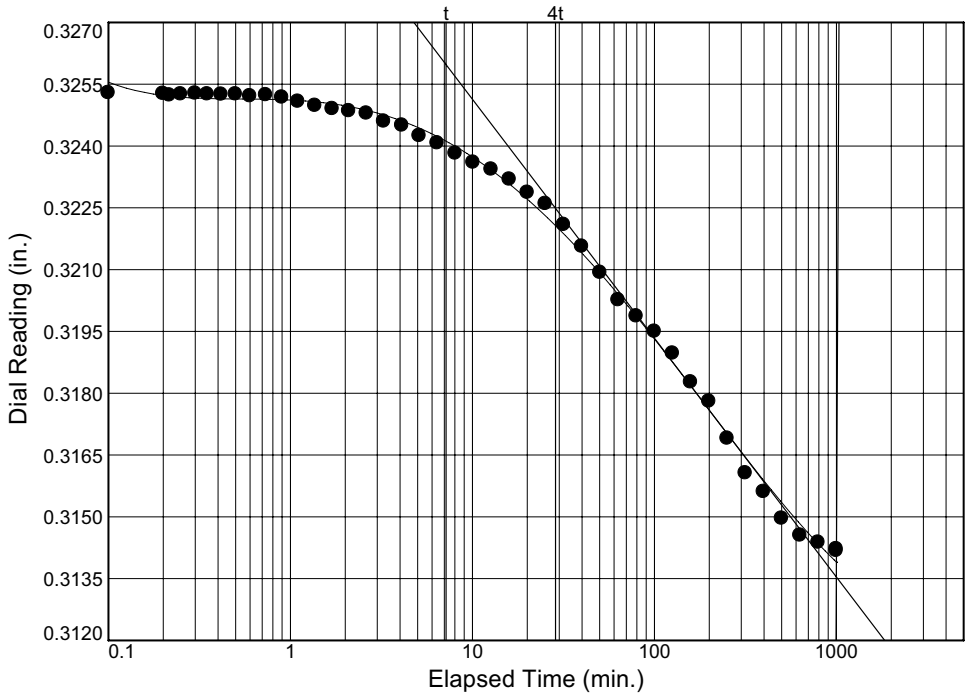
Location: B-1 Depth: 19-21 ft.



Load No.= 8
Load= 8000 psf
D_0 = 0.3332
D_{50} = 0.3285
D_{100} = 0.3238
T_{50} = 46.38 min.

C_v @ T_{50}
0.010 ft.^{2}/day

C_α = 0.921



Load No.= 9
Load= 4000 psf
D_0 = 0.3262
D_{50} = 0.3199
D_{100} = 0.3135
T_{50} = 79.86 min.

C_v @ T_{50}
0.006 ft.^{2}/day

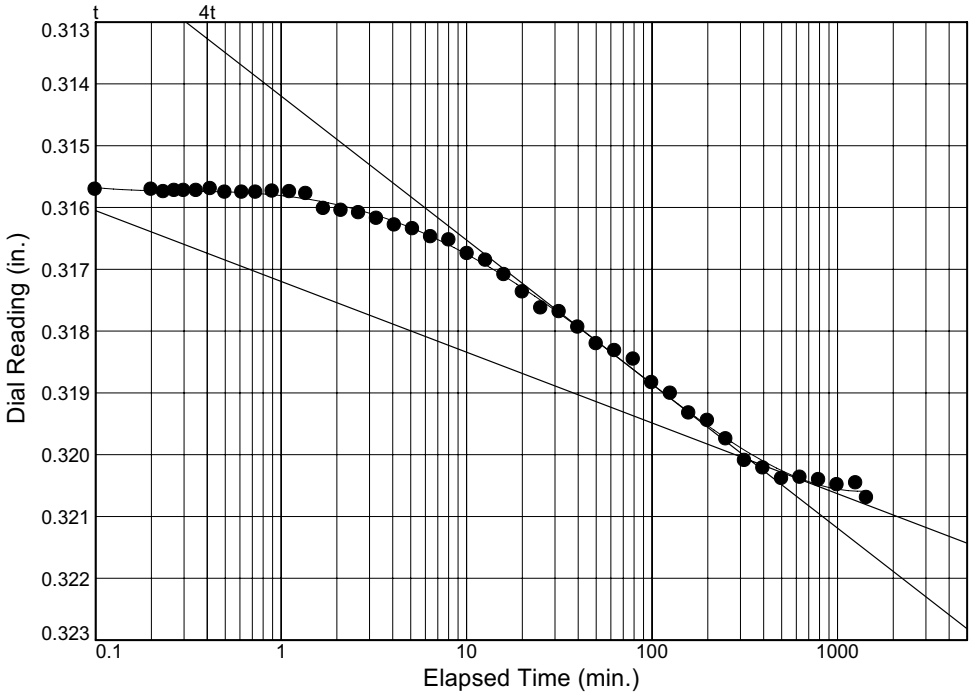
C_α = 0.921

Terracon Consultants, Inc.

Dial Reading vs. Time

Project No.: M2205062
Project: Project Tundra

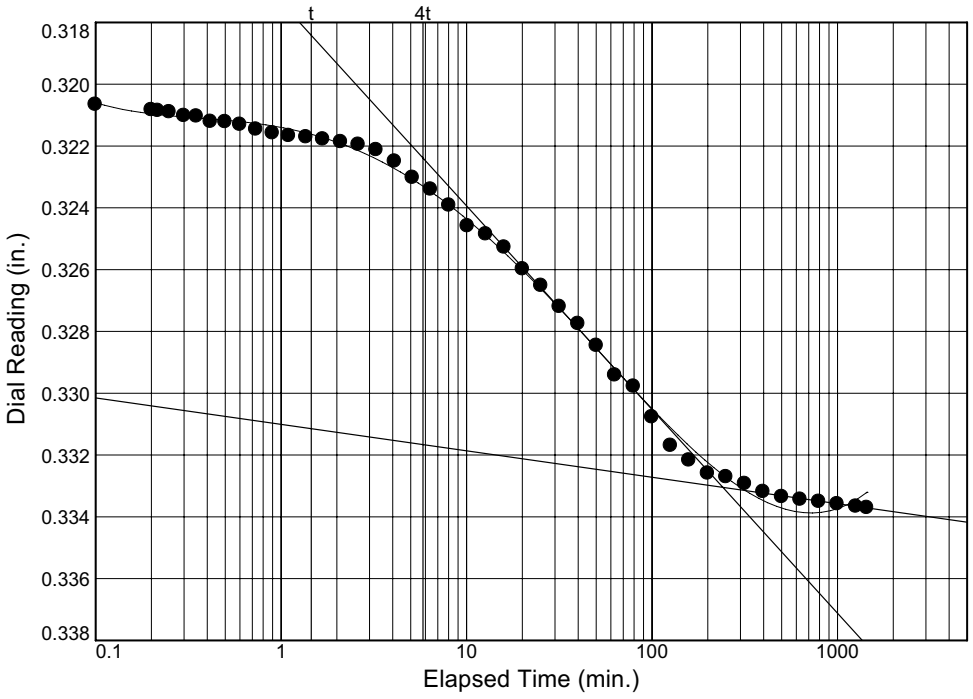
Location: B-1 Depth: 19-21 ft.



Load No.= 10
Load= 8000 psf
D_0 = 0.3156
D_{50} = 0.3179
D_{100} = 0.3201
T_{50} = 36.66 min.

C_v @ T_{50}
0.013 $ft.^2$/day

C_α = 0.001



Load No.= 11
Load= 16000 psf
D_0 = 0.3199
D_{50} = 0.3265
D_{100} = 0.3330
T_{50} = 23.98 min.

C_v @ T_{50}
0.020 $ft.^2$/day

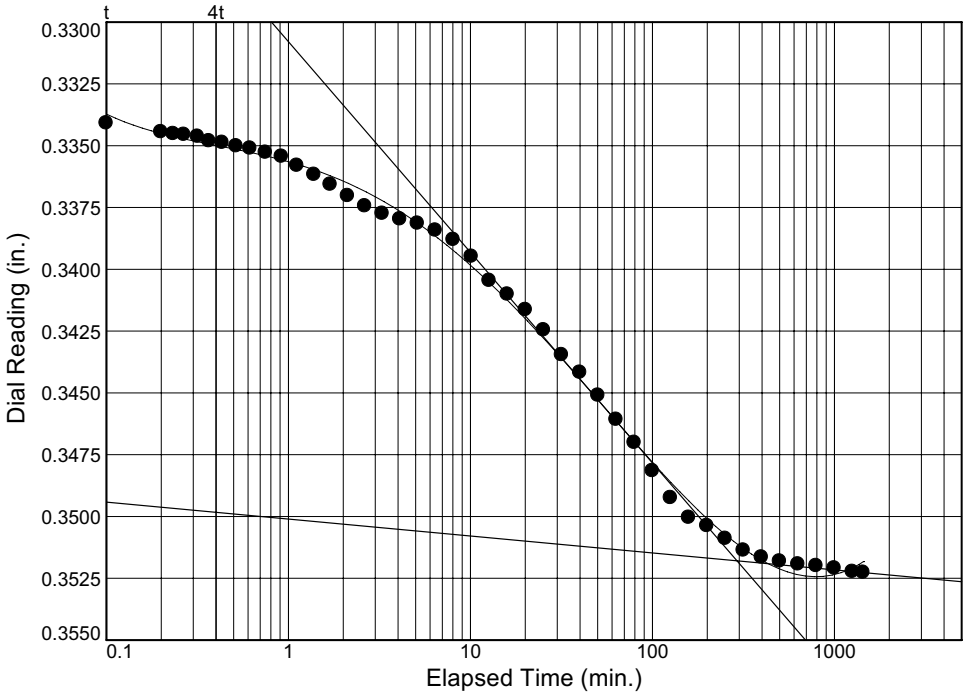
C_α = 0.001

Terracon Consultants, Inc.

Dial Reading vs. Time

Project No.: M2205062
Project: Project Tundra

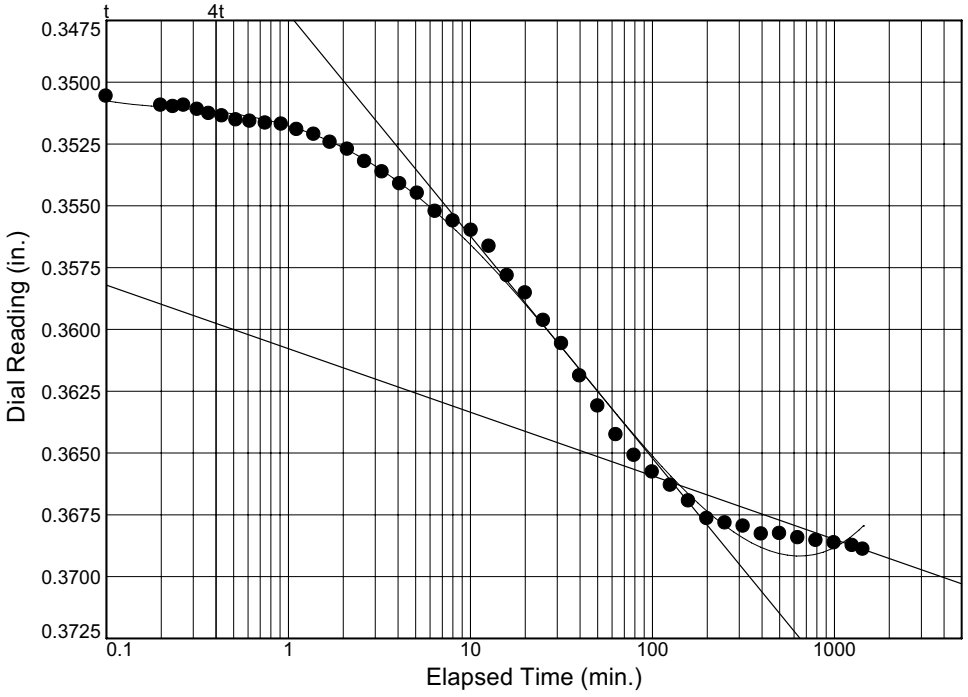
Location: B-1 Depth: 19-21 ft.



Load No.= 12
Load= 32000 psf
D_0 = 0.3325
D_{50} = 0.3421
D_{100} = 0.3518
T_{50} = 20.78 min.

C_v @ T_{50}
0.022 ft.^{2}/day

C_α = 0.001



Load No.= 13
Load= 64000 psf
D_0 = 0.3503
D_{50} = 0.3583
D_{100} = 0.3662
T_{50} = 16.43 min.

C_v @ T_{50}
0.027 ft.^{2}/day

C_α = 0.003

CONSOLIDATION TEST DATA

10/12/2020

Client: Fluor Enterprises Inc Greenville, SC
Project: Project Tundra
Project Number: M2205062
Location: B-1
Depth: 19-21 ft.
Material Description: Dark gray Fat Clay
Testing Remarks: ASTM D2435
Specific gravity assumed

Test Specimen Data

NATURAL MOISTURE		VOID RATIO		AFTER TEST	
Wet w+t =	288.70 g.	Spec. Gr. =	2.73	Wet w+t =	218.65 g.
Dry w+t =	238.88 g.	Est. Ht. Solids =	0.579 in.	Dry w+t =	185.45 g.
Tare Wt. =	48.71 g.	Init. V.R. =	0.726	Tare Wt. =	58.91 g.
Moisture =	26.2 %	Init. Sat. =	98.5 %	Moisture =	26.2 %
UNIT WEIGHT		**TEST START**		Dry Wt. =	126.54 g.
Height =	1.000 in.	Height =	1.000 in.		
Diameter =	2.500 in.	Diameter =	2.500 in.		
Weight =	160.53 g.				
Dry Dens. =	98.7 pcf				

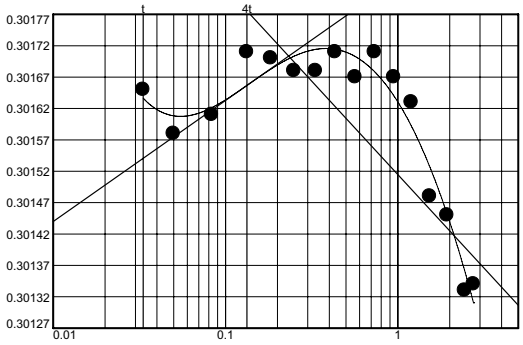
End-Of-Load Summary

Pressure (psf)	Final Dial (in.)	Deformation (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Strain
start	0.30155	0.00000			0.726	
250	0.30134	-0.00021	3.573		0.727	0.0 Swell
500	0.30124	-0.00031	0.224		0.727	0.0 Swell
1000	0.29996	-0.00159	0.106	0.000	0.729	0.2 Swell
2000	0.30040	-0.00115			0.728	0.1 Swell
4000	0.30206	0.00051		0.000	0.725	0.1 Comprs.
8000	0.31322	0.01167		0.001	0.706	1.2 Comprs.
16000	0.33286	0.03131	0.013	0.001	0.672	3.1 Comprs.
8000	0.32555	0.02400	0.010	0.921	0.685	2.4 Comprs.
4000	0.31422	0.01267	0.006	0.921	0.704	1.3 Comprs.
8000	0.32070	0.01915	0.013	0.001	0.693	1.9 Comprs.
16000	0.33371	0.03216	0.020	0.001	0.671	3.2 Comprs.
32000	0.35227	0.05072	0.022	0.001	0.639	5.1 Comprs.
64000	0.36890	0.06735	0.027	0.003	0.610	6.7 Comprs.
16000	0.35594	0.05439			0.632	5.4 Comprs.
4000	0.33006	0.02851		0.020	0.677	2.9 Comprs.

Compression index (C_c), psf = 0.11 **Preconsolidation pressure (P_p), psf =** 5374 **Void ratio at P_p (e_m) =** 0.720
Recompression index (C_r) = 0.06

Pressure: 250 psf	TEST READINGS	Load No. 1

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.30155	11	0.7333	0.30171
2	0.0333	0.30165	12	0.9500	0.30167
3	0.0500	0.30158	13	1.2000	0.30163
4	0.0833	0.30161	14	1.5333	0.30148
5	0.1333	0.30171	15	1.9333	0.30145
6	0.1833	0.30170	16	2.4500	0.30133
7	0.2500	0.30168	17	2.7500	0.30134
8	0.3333	0.30168			
9	0.4333	0.30171			
10	0.5667	0.30167			

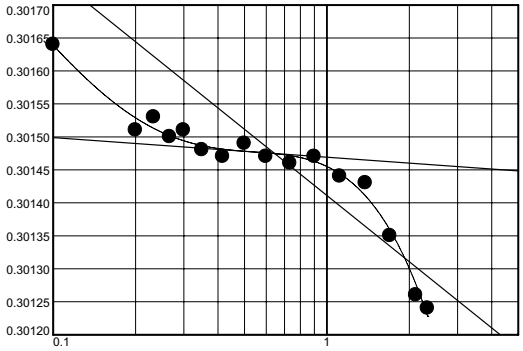


Void Ratio = 0.727 **Swell =** 0.0%

D_0 = 0.3016 **D_{50} =** 0.3017 **D_{100} =** 0.3017 **C_v at 0.14 min. =** 3.573 ft.^{2}/day

Pressure: 500 psf	TEST READINGS	Load No. 2

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.30104	11	0.7333	0.30146
2	0.1000	0.30164	12	0.9000	0.30147
3	0.2000	0.30151	13	1.1167	0.30144
4	0.2333	0.30153	14	1.3833	0.30143
5	0.2667	0.30150	15	1.7000	0.30135
6	0.3000	0.30151	16	2.1167	0.30126
7	0.3500	0.30148	17	2.3333	0.30124
8	0.4167	0.30147			
9	0.5000	0.30149			
10	0.6000	0.30147			

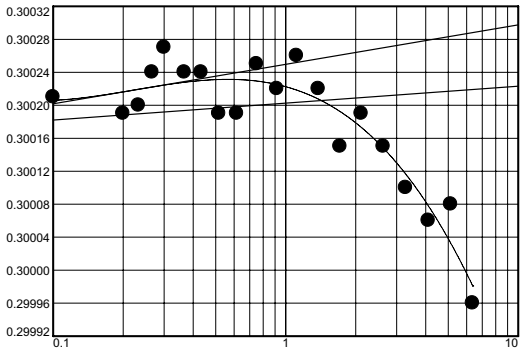


Void Ratio = 0.727 **Swell =** 0.0%

D_0 = 0.3010 **D_{50} =** 0.3013 **D_{100} =** 0.3015 **C_v at 2.20 min. =** 0.224 ft.^{2}/day

Pressure: 1000 psf — **TEST READINGS** — **Load No. 3**

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.29994	12	0.9167	0.30022
2	0.1000	0.30021	13	1.1167	0.30026
3	0.2000	0.30019	14	1.3833	0.30022
4	0.2333	0.30020	15	1.7167	0.30015
5	0.2667	0.30024	16	2.1167	0.30019
6	0.3000	0.30027	17	2.6333	0.30015
7	0.3667	0.30024	18	3.2833	0.30010
8	0.4333	0.30024	19	4.1167	0.30006
9	0.5167	0.30019	20	5.1333	0.30008
10	0.6167	0.30019	21	6.3667	0.29996
11	0.7500	0.30025			



Void Ratio = 0.729 **Swell =** 0.2%

D_0 = 0.2999 **D_{50} =** 0.3001 **D_{100} =** 0.3002 **C_v at 4.65 min. =** 0.106 ft.^{2}/day **C_α =** 0.000

Pressure: 2000 psf — **TEST READINGS** — **Load No. 4**

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.29933	11	0.7500	0.30076	21	6.4333	0.30055
2	0.1000	0.30078	12	0.9167	0.30074	22	8.0667	0.30046
3	0.2000	0.30074	13	1.1167	0.30075	23	8.9833	0.30040
4	0.2333	0.30076	14	1.3833	0.30076			
5	0.2667	0.30076	15	1.7000	0.30071			
6	0.3000	0.30075	16	2.1167	0.30071			
7	0.3667	0.30074	17	2.6333	0.30074			
8	0.4333	0.30076	18	3.2833	0.30070			
9	0.5167	0.30076	19	4.1000	0.30057			
10	0.6167	0.30072	20	5.1333	0.30059			

Void Ratio = 0.728 **Swell =** 0.1%

Pressure: 4000 psf	TEST READINGS	Load No. 5

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.29906	11	0.7333	0.30093	21	6.4333	0.30133
2	0.1000	0.30076	12	0.9000	0.30097	22	8.0667	0.30143
3	0.2000	0.30085	13	1.1167	0.30101	23	10.1333	0.30158
4	0.2333	0.30085	14	1.3667	0.30103	24	12.7167	0.30162
5	0.2667	0.30088	15	1.7000	0.30106	25	15.9833	0.30173
6	0.3000	0.30092	16	2.1167	0.30105	26	20.0833	0.30174
7	0.3500	0.30094	17	2.6333	0.30120	27	25.2500	0.30176
8	0.4167	0.30093	18	3.2833	0.30129	28	31.7500	0.30186
9	0.5000	0.30096	19	4.1000	0.30127	29	36.4667	0.30206
10	0.6167	0.30096	20	5.1333	0.30130			

Void Ratio = 0.725 **Compression =** 0.1%

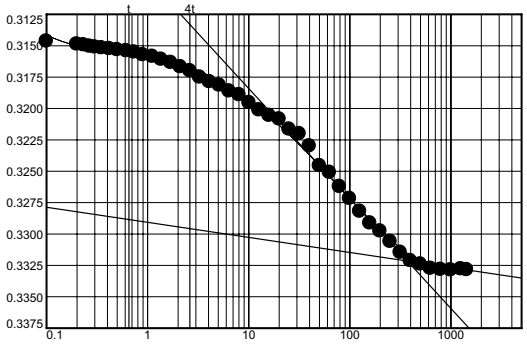
Pressure: 8000 psf	TEST READINGS	Load No. 6

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.29949	15	1.7000	0.30346	29	39.9500	0.30770
2	0.1167	0.30212	16	2.1167	0.30358	30	50.2500	0.30865
3	0.2167	0.30246	17	2.6333	0.30374	31	63.2333	0.30949
4	0.2333	0.30258	18	3.2833	0.30398	32	79.5667	0.31001
5	0.2667	0.30266	19	4.1000	0.30430	33	100.1333	0.31059
6	0.3167	0.30266	20	5.1333	0.30469	34	126.0333	0.31088
7	0.3667	0.30274	21	6.4333	0.30479	35	158.6333	0.31132
8	0.4333	0.30279	22	8.0667	0.30500	36	199.6667	0.31212
9	0.5167	0.30283	23	10.1167	0.30570	37	251.3333	0.31259
10	0.6167	0.30292	24	12.7167	0.30605	38	316.3667	0.31283
11	0.7500	0.30298	25	15.9667	0.30639	39	398.2500	0.31292
12	0.9167	0.30314	26	20.0833	0.30655	40	501.3333	0.31311
13	1.1167	0.30321	27	25.2500	0.30677	41	600.3833	0.31322
14	1.3833	0.30337	28	31.7500	0.30711			

Void Ratio = 0.706 **Compression =** 1.2%

Pressure: 16000 psf | **TEST READINGS** | **Load No. 7**

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.30989	24	12.7167	0.32014
2	0.1000	0.31466	25	15.9833	0.32057
3	0.2000	0.31489	26	20.0833	0.32086
4	0.2333	0.31495	27	25.2500	0.32167
5	0.2667	0.31506	28	31.7500	0.32203
6	0.3000	0.31513	29	39.9500	0.32301
7	0.3500	0.31518	30	50.2500	0.32457
8	0.4167	0.31524	31	63.2333	0.32511
9	0.5000	0.31534	32	79.5667	0.32624
10	0.6167	0.31541	33	100.1333	0.32719
11	0.7333	0.31552	34	126.0333	0.32821
12	0.9000	0.31573	35	158.6333	0.32915
13	1.1167	0.31586	36	199.6667	0.32978
14	1.3667	0.31609	37	251.3333	0.33061
15	1.7000	0.31635	38	316.3667	0.33148
16	2.1167	0.31669	39	398.2500	0.33214
17	2.6333	0.31702	40	501.3333	0.33241
18	3.2833	0.31752	41	631.1000	0.33276
19	4.1000	0.31788	42	794.4833	0.33285
20	5.1333	0.31815	43	1000.1500	0.33288
21	6.4333	0.31862	44	1259.0833	0.33279
22	8.0667	0.31893	45	1440.2333	0.33286
23	10.1333	0.31955			

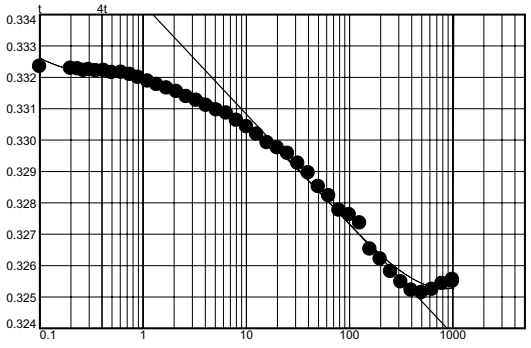


Void Ratio = 0.672 **Compression =** 3.1%

D_0 = 0.3145 **D_{50} =** 0.3233 **D_{100} =** 0.3322 **C_v at 36.04 min. =** 0.013 ft.^{2}/day **C_α =** 0.001

Pressure: 8000 psf | **TEST READINGS** | **Load No. 8**

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.33552	13	1.1167	0.33187
2	0.1000	0.33234	14	1.3667	0.33176
3	0.2000	0.33228	15	1.7000	0.33165
4	0.2333	0.33226	16	2.1167	0.33154
5	0.2667	0.33221	17	2.6333	0.33138
6	0.3000	0.33224	18	3.2833	0.33126
7	0.3500	0.33220	19	4.1000	0.33110
8	0.4167	0.33221	20	5.1333	0.33095
9	0.5000	0.33214	21	6.4333	0.33085
10	0.6167	0.33215	22	8.0667	0.33062
11	0.7500	0.33208	23	10.1333	0.33042
12	0.9000	0.33199	24	12.7167	0.33018



Pressure: 8000 psf	TEST READINGS (continued)	Load No. 8

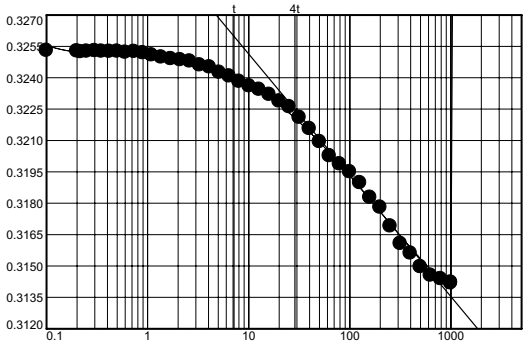
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
25	15.9833	0.32991	35	158.6333	0.32652
26	20.0833	0.32975	36	199.6667	0.32620
27	25.2500	0.32957	37	251.3333	0.32580
28	31.7500	0.32925	38	316.3833	0.32547
29	39.9500	0.32895	39	398.2500	0.32521
30	50.2500	0.32851	40	501.3333	0.32513
31	63.2333	0.32822	41	631.1167	0.32523
32	79.5667	0.32776	42	794.4833	0.32542
33	100.1500	0.32761	43	1000.1500	0.32549
34	126.0333	0.32735	44	1000.3000	0.32555

Void Ratio = 0.685 **Compression =** 2.4%

D_0 = 0.3332 D_{50} = 0.3285 D_{100} = 0.3238 C_v **at 46.38 min. =** 0.010 ft.^{2}/day C_α = 0.921

Pressure: 4000 psf	TEST READINGS	Load No. 9

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.32742	23	10.1167	0.32360
2	0.1000	0.32529	24	12.7000	0.32343
3	0.2000	0.32527	25	15.9667	0.32319
4	0.2167	0.32523	26	20.0667	0.32287
5	0.2500	0.32526	27	25.2333	0.32260
6	0.3000	0.32528	28	31.7500	0.32209
7	0.3500	0.32526	29	39.9333	0.32156
8	0.4167	0.32525	30	50.2500	0.32093
9	0.5000	0.32526	31	63.2167	0.32026
10	0.6000	0.32521	32	79.5667	0.31987
11	0.7333	0.32524	33	100.1333	0.31950
12	0.9000	0.32518	34	126.0167	0.31897
13	1.1000	0.32508	35	158.6167	0.31827
14	1.3667	0.32498	36	199.6667	0.31780
15	1.7000	0.32490	37	251.3167	0.31690
16	2.1000	0.32485	38	316.3667	0.31606
17	2.6167	0.32479	39	398.2500	0.31561
18	3.2667	0.32460	40	501.3333	0.31496
19	4.1000	0.32450	41	631.1000	0.31455
20	5.1167	0.32425	42	794.4667	0.31438
21	6.4167	0.32407	43	1000.1500	0.31418
22	8.0500	0.32382	44	1000.2500	0.31422

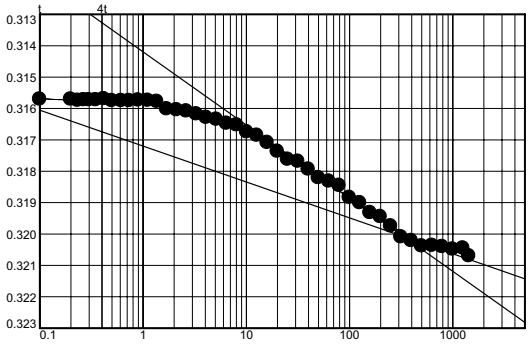


Void Ratio = 0.704 **Compression =** 1.3%

D_0 = 0.3262 D_{50} = 0.3199 D_{100} = 0.3135 C_v **at 79.86 min. =** 0.006 ft.^{2}/day C_α = 0.921

Pressure: 8000 psf	TEST READINGS	Load No. 10

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.31256	24	12.7167	0.31686
2	0.1000	0.31571	25	15.9833	0.31709
3	0.2000	0.31571	26	20.0833	0.31737
4	0.2333	0.31575	27	25.2500	0.31763
5	0.2667	0.31573	28	31.7500	0.31769
6	0.3000	0.31573	29	39.9500	0.31794
7	0.3500	0.31573	30	50.2500	0.31821
8	0.4167	0.31570	31	63.2333	0.31832
9	0.5000	0.31576	32	79.5667	0.31846
10	0.6167	0.31576	33	100.1333	0.31884
11	0.7333	0.31576	34	126.0333	0.31901
12	0.9000	0.31574	35	158.6333	0.31933
13	1.1167	0.31575	36	199.6667	0.31945
14	1.3667	0.31578	37	251.3333	0.31975
15	1.7000	0.31602	38	316.3667	0.32010
16	2.1167	0.31605	39	398.2500	0.32022
17	2.6333	0.31609	40	501.3333	0.32039
18	3.2833	0.31618	41	631.1000	0.32037
19	4.1000	0.31629	42	794.4833	0.32041
20	5.1333	0.31635	43	1000.1500	0.32049
21	6.4333	0.31648	44	1259.0833	0.32046
22	8.0667	0.31653	45	1440.3333	0.32070
23	10.1333	0.31675			

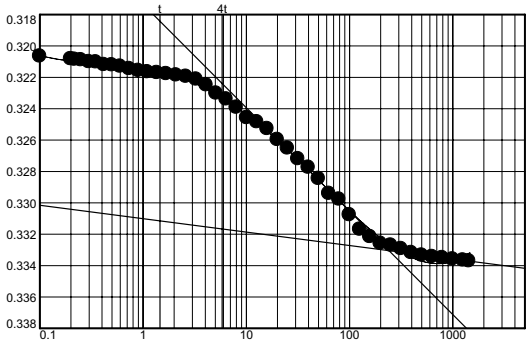


Void Ratio = 0.693 **Compression =** 1.9%

D_0 = 0.3156 **D_{50} =** 0.3179 **D_{100} =** 0.3201 **C_v at 36.66 min. =** 0.013 ft.^{2}/day **C_α =** 0.001

Pressure: 16000 psf	TEST READINGS	Load No. 11

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.31759	13	1.1000	0.32167
2	0.1000	0.32066	14	1.3667	0.32171
3	0.2000	0.32083	15	1.6833	0.32178
4	0.2167	0.32086	16	2.1000	0.32187
5	0.2500	0.32090	17	2.6167	0.32195
6	0.3000	0.32102	18	3.2667	0.32213
7	0.3500	0.32104	19	4.1000	0.32250
8	0.4167	0.32121	20	5.1167	0.32302
9	0.5000	0.32122	21	6.4167	0.32340
10	0.6000	0.32131	22	8.0500	0.32392
11	0.7333	0.32146	23	10.1167	0.32459
12	0.9000	0.32158	24	12.7000	0.32485



Pressure: 16000 psf	TEST READINGS (continued)	Load No. 11

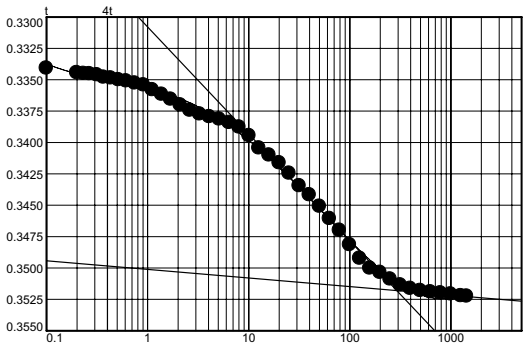
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
25	15.9667	0.32528	35	158.6167	0.33217	45	1440.3500	0.33371
26	20.0667	0.32598	36	199.6500	0.33259			
27	25.2333	0.32652	37	251.3167	0.33271			
28	31.7500	0.32720	38	316.3500	0.33293			
29	39.9333	0.32775	39	398.2333	0.33319			
30	50.2333	0.32846	40	501.3167	0.33335			
31	63.2167	0.32942	41	631.0833	0.33344			
32	79.5500	0.32978	42	794.4667	0.33351			
33	100.1167	0.33077	43	1000.1333	0.33359			
34	126.0167	0.33170	44	1259.0667	0.33366			

Void Ratio = 0.671 **Compression =** 3.2%

D_0 = 0.3199 **D_{50} =** 0.3265 **D_{100} =** 0.3330 **C_v at 23.98 min. =** 0.020 ft.^{2}/day **C_α =** 0.001

Pressure: 32000 psf	TEST READINGS	Load No. 12

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.32747	24	12.7167	0.34046
2	0.1000	0.33409	25	15.9833	0.34102
3	0.2000	0.33445	26	20.0833	0.34164
4	0.2333	0.33452	27	25.2500	0.34246
5	0.2667	0.33455	28	31.7500	0.34346
6	0.3167	0.33463	29	39.9500	0.34418
7	0.3667	0.33481	30	50.2500	0.34510
8	0.4333	0.33488	31	63.2333	0.34608
9	0.5167	0.33502	32	79.5667	0.34701
10	0.6167	0.33511	33	100.1333	0.34816
11	0.7500	0.33528	34	126.0333	0.34925
12	0.9167	0.33544	35	158.6333	0.35004
13	1.1167	0.33581	36	199.6667	0.35038
14	1.3833	0.33617	37	251.3333	0.35090
15	1.7000	0.33657	38	316.3667	0.35137
16	2.1167	0.33703	39	398.2500	0.35165
17	2.6333	0.33745	40	501.3333	0.35181
18	3.2833	0.33775	41	631.1000	0.35193
19	4.1000	0.33797	42	794.4833	0.35200
20	5.1333	0.33815	43	1000.1500	0.35209
21	6.4333	0.33843	44	1259.0833	0.35223
22	8.0667	0.33880	45	1440.2333	0.35227
23	10.1333	0.33948			

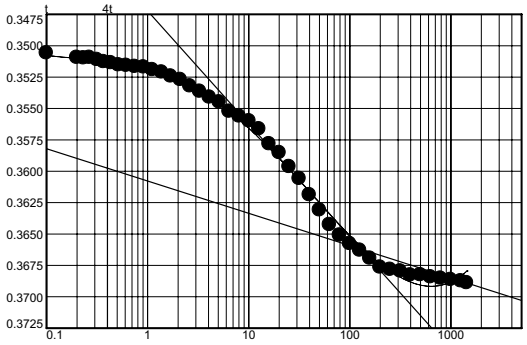


Void Ratio = 0.639 **Compression =** 5.1%

D_0 = 0.3325 **D_{50} =** 0.3421 **D_{100} =** 0.3518 **C_v at 20.78 min. =** 0.022 ft.^{2}/day **C_α =** 0.001

Pressure: 64000 psf	TEST READINGS	Load No. 13

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.34048	24	12.7167	0.35665
2	0.1000	0.35058	25	15.9833	0.35784
3	0.2000	0.35094	26	20.0833	0.35854
4	0.2333	0.35100	27	25.2500	0.35965
5	0.2667	0.35094	28	31.7667	0.36059
6	0.3167	0.35111	29	39.9500	0.36189
7	0.3667	0.35128	30	50.2667	0.36311
8	0.4333	0.35137	31	63.2500	0.36427
9	0.5167	0.35154	32	79.5833	0.36511
10	0.6167	0.35159	33	100.1500	0.36578
11	0.7500	0.35167	34	126.0500	0.36631
12	0.9167	0.35171	35	158.6500	0.36695
13	1.1167	0.35192	36	199.6833	0.36766
14	1.3833	0.35212	37	251.3500	0.36784
15	1.7000	0.35244	38	316.3833	0.36797
16	2.1167	0.35272	39	398.2667	0.36829
17	2.6333	0.35322	40	501.3500	0.36827
18	3.2833	0.35364	41	631.1167	0.36844
19	4.1000	0.35412	42	794.5000	0.36855
20	5.1333	0.35450	43	1000.1667	0.36864
21	6.4333	0.35524	44	1259.1000	0.36875
22	8.0667	0.35562	45	1440.0667	0.36890
23	10.1333	0.35600			



Void Ratio = 0.610 **Compression =** 6.7%

D_0 = 0.3503 **D_{50} =** 0.3583 **D_{100} =** 0.3662 **C_v at 16.43 min. =** 0.027 ft.^{2}/day **C_α =** 0.003

Pressure: 16000 psf	TEST READINGS	Load No. 14

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.38549	13	1.1000	0.36859	25	15.9667	0.36488
2	0.1000	0.37100	14	1.3667	0.36836	26	20.0833	0.36439
3	0.2000	0.37035	15	1.7000	0.36821	27	25.2500	0.36371
4	0.2167	0.37030	16	2.1000	0.36812	28	31.7500	0.36263
5	0.2500	0.37018	17	2.6167	0.36797	29	39.9333	0.36224
6	0.3000	0.36993	18	3.2833	0.36771	30	50.2500	0.36138
7	0.3500	0.36984	19	4.1000	0.36742	31	63.2167	0.36063
8	0.4167	0.36960	20	5.1333	0.36717	32	79.5667	0.35979
9	0.5000	0.36948	21	6.4333	0.36670	33	100.1333	0.35917
10	0.6000	0.36931	22	8.0667	0.36598	34	126.0167	0.35836
11	0.7333	0.36899	23	10.1167	0.36554	35	158.6167	0.35786
12	0.9000	0.36892	24	12.7167	0.36519	36	199.6667	0.35740

Pressure: 16000 psf	TEST READINGS (continued)	Load No. 14

No.	Elapsed Time	Dial Reading
37	251.3167	0.35695
38	316.3667	0.35687
39	398.2500	0.35675
40	501.3167	0.35661
41	631.1000	0.35642
42	794.4667	0.35632
43	1000.1500	0.35627
44	1259.0667	0.35609
45	1406.3500	0.35594

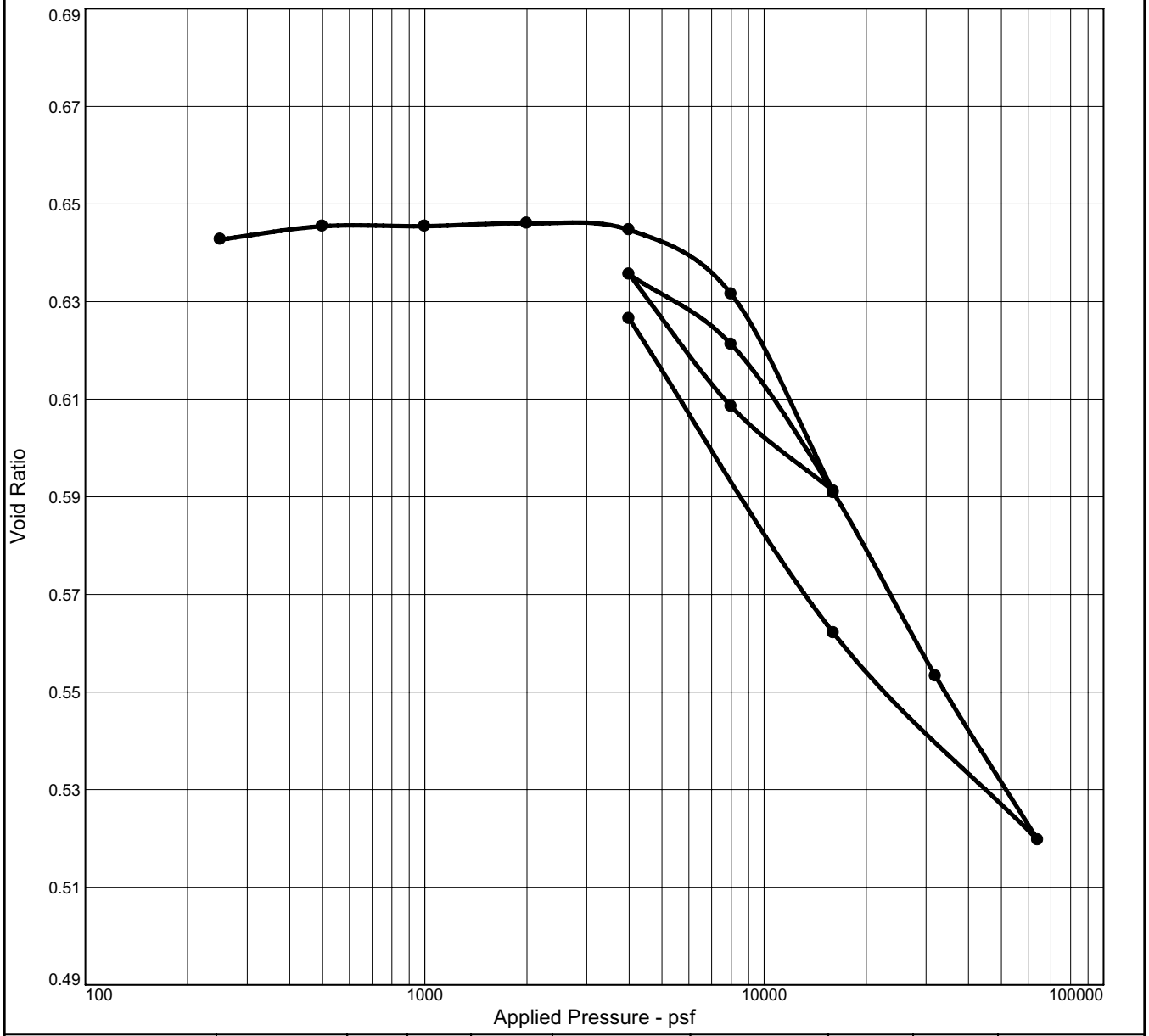
Void Ratio = 0.632 **Compression =** 5.4%

Pressure: 4000 psf	TEST READINGS	Load No. 15

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.36134	17	2.6333	0.35388	33	100.1500	0.34251
2	0.1000	0.35612	18	3.2833	0.35370	34	126.0500	0.34101
3	0.2000	0.35587	19	4.1167	0.35353	35	158.6333	0.33998
4	0.2333	0.35585	20	5.1500	0.35311	36	199.6833	0.33782
5	0.2667	0.35577	21	6.4333	0.35249	37	251.3500	0.33679
6	0.3167	0.35572	22	8.0667	0.35198	38	316.3833	0.33600
7	0.3667	0.35565	23	10.1333	0.35148	39	398.2667	0.33406
8	0.4333	0.35549	24	12.7167	0.35113	40	501.3500	0.33316
9	0.5167	0.35535	25	15.9833	0.35057	41	631.1167	0.33197
10	0.6167	0.35527	26	20.0833	0.34930	42	794.5000	0.33125
11	0.7500	0.35517	27	25.2500	0.34871	43	1000.1667	0.33069
12	0.9167	0.35504	28	31.7667	0.34817	44	1259.1000	0.33028
13	1.1167	0.35472	29	39.9500	0.34732	45	1585.0667	0.33009
14	1.3833	0.35457	30	50.2667	0.34586	46	1995.4333	0.33004
15	1.7000	0.35436	31	63.2500	0.34481	47	2000.0667	0.33006
16	2.1167	0.35404	32	79.5833	0.34354			

Void Ratio = 0.677 **Compression =** 2.9%

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_r	Initial Void Ratio
Saturation	Moisture									
98.8 %	23.2 %	103.8			2.73		6436	0.13	0.09	0.642

MATERIAL DESCRIPTION	USCS	AASHTO
Dark gray Fat Clay		

Project No. M2205062 **Client:** Fluor Enterprises Inc Greenville, SC

Project: Project Tundra

Location: B-2 **Depth:** 12-13 ft.

Terracon Consultants, Inc.

Houston, TX

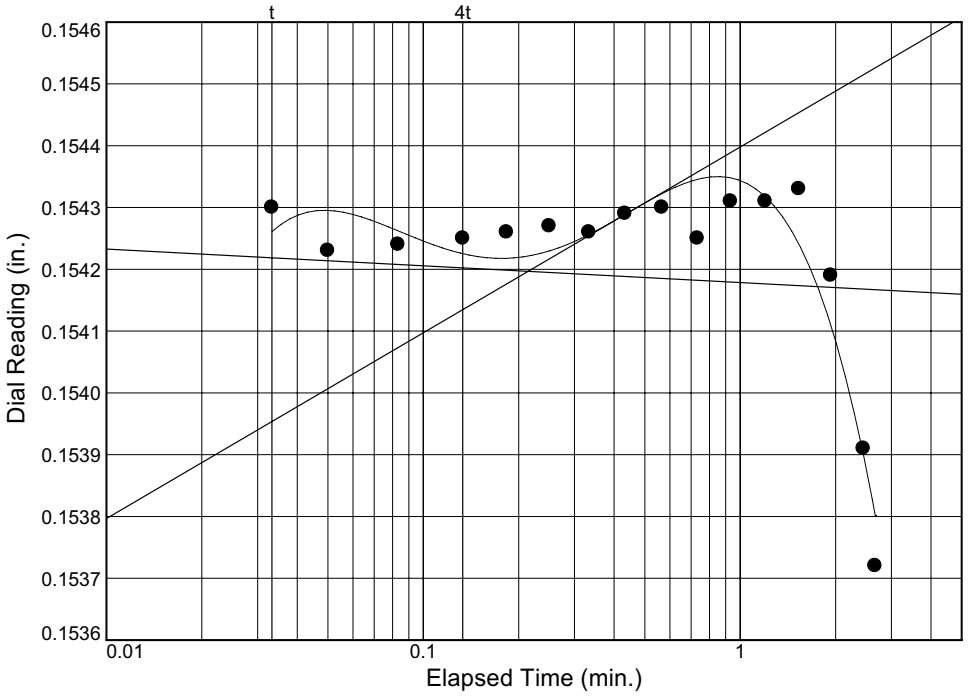
Remarks:

ASTM D2435
Specific gravity assumed

Dial Reading vs. Time

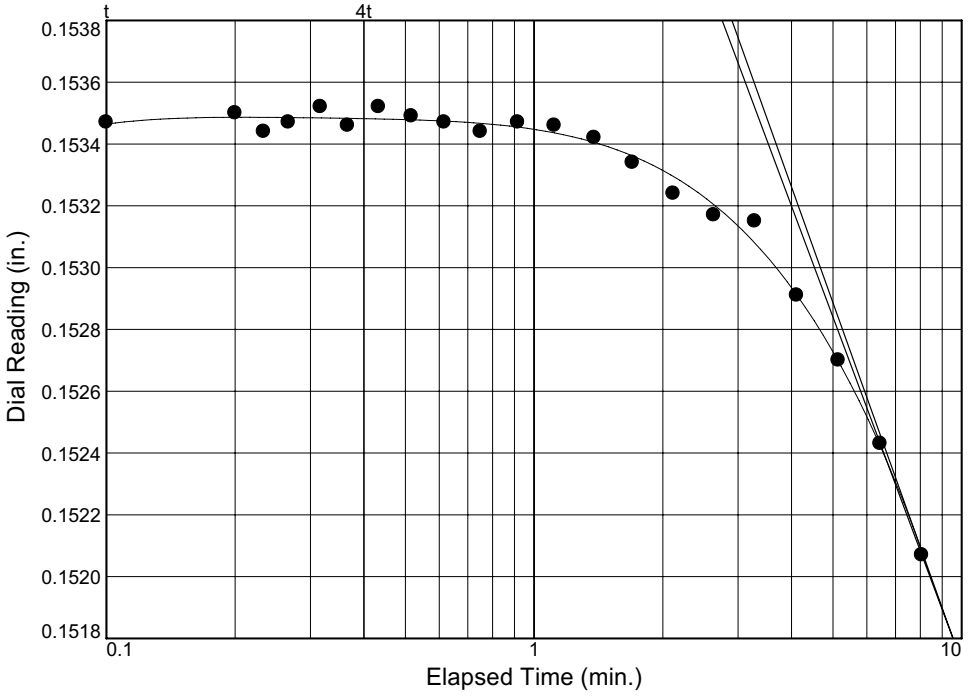
Project No.: M2205062
Project: Project Tundra

Location: B-2 Depth: 12-13 ft.



Load No.= 1
Load= 250 psf
D_0 = 0.1543
D_{50} = 0.1542
D_{100} = 0.1542
T_{50} = 0.10 min.

C_v @ T_{50}
4.980 ft.^{2}/day



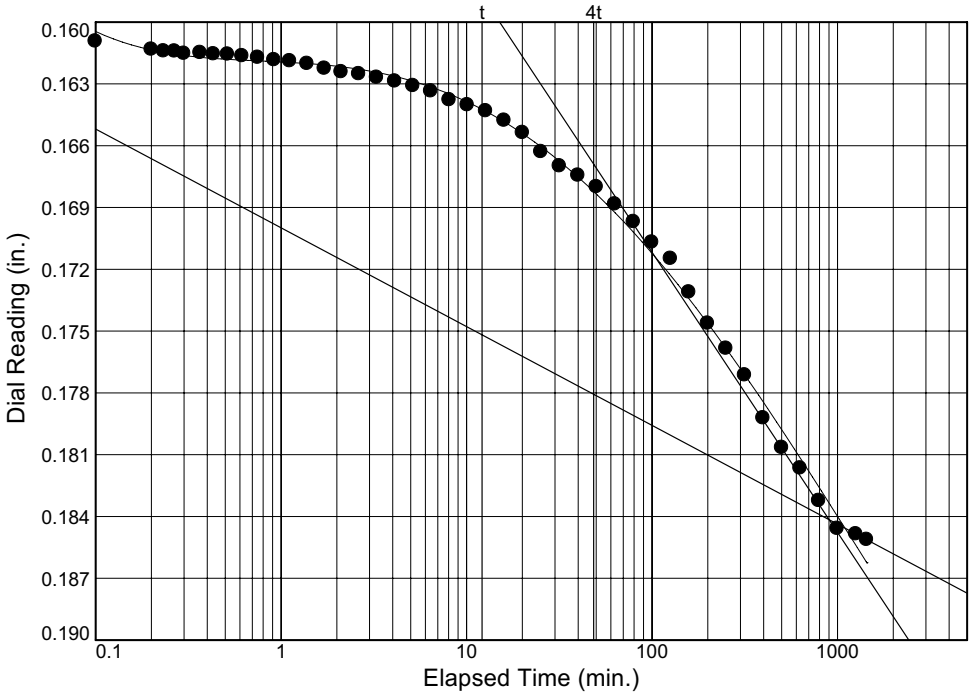
Load No.= 2
Load= 500 psf
D_0 = 0.1534
D_{50} = 0.1526
D_{100} = 0.1518
T_{50} = 5.60 min.

C_v @ T_{50}
0.088 ft.^{2}/day

Dial Reading vs. Time

Project No.: M2205062
Project: Project Tundra

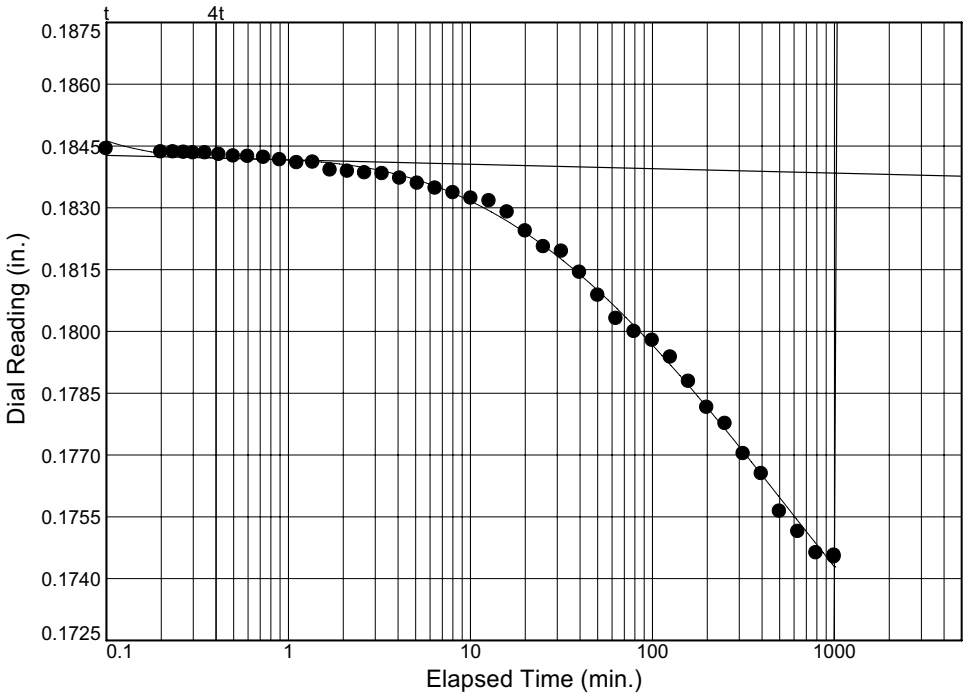
Location: B-2 Depth: 12-13 ft.



Load No.= 7
Load= 16000 psf
D_0 = 0.1602
D_{50} = 0.1722
D_{100} = 0.1842
T_{50} = 123.31 min.

C_v @ T_{50}
0.004 ft.^{2}/day

C_α = 0.005



Load No.= 8
Load= 8000 psf
D_0 = 0.1850
D_{50} = 0.1844
D_{100} = 0.1838
T_{50} = 0.14 min.

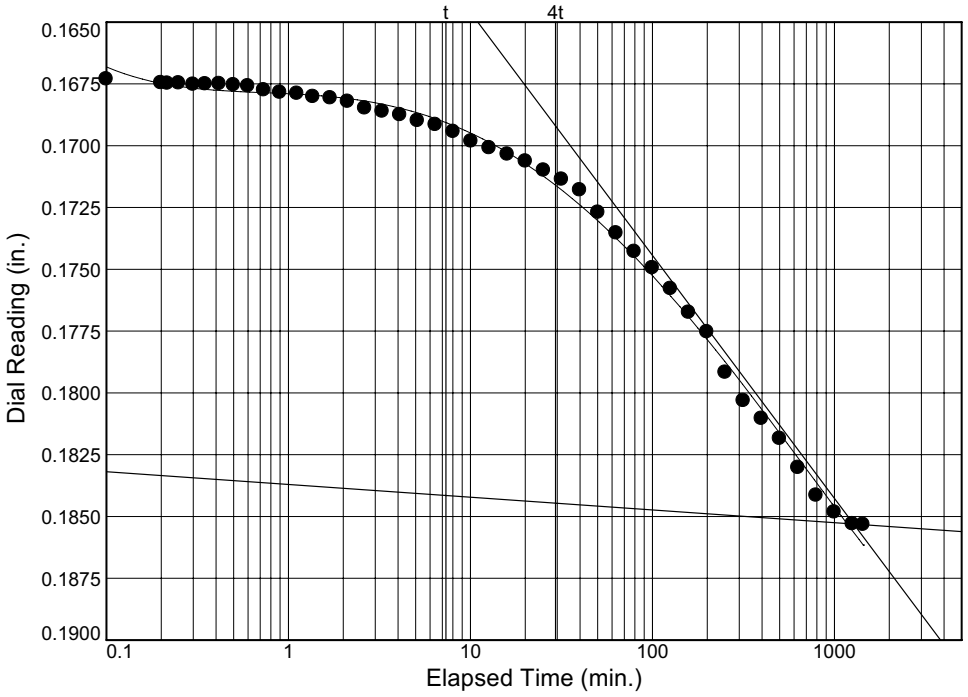
C_v @ T_{50}
3.308 ft.^{2}/day

C_α = 0.921

Dial Reading vs. Time

Project No.: M2205062
Project: Project Tundra

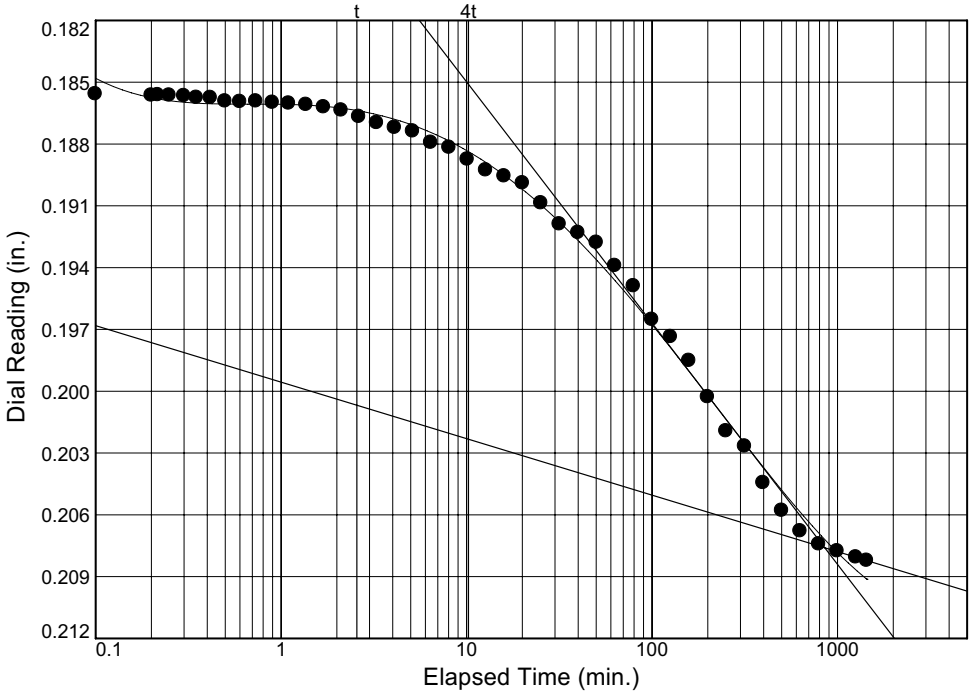
Location: B-2 Depth: 12-13 ft.



Load No.= 11
Load= 16000 psf
D_0 = 0.1665
D_{50} = 0.1759
D_{100} = 0.1853
T_{50} = 120.19 min.

C_v @ T_{50}
0.004 ft.^{2}/day

C_α = 0.001



Load No.= 12
Load= 32000 psf
D_0 = 0.1844
D_{50} = 0.1960
D_{100} = 0.2076
T_{50} = 84.96 min.

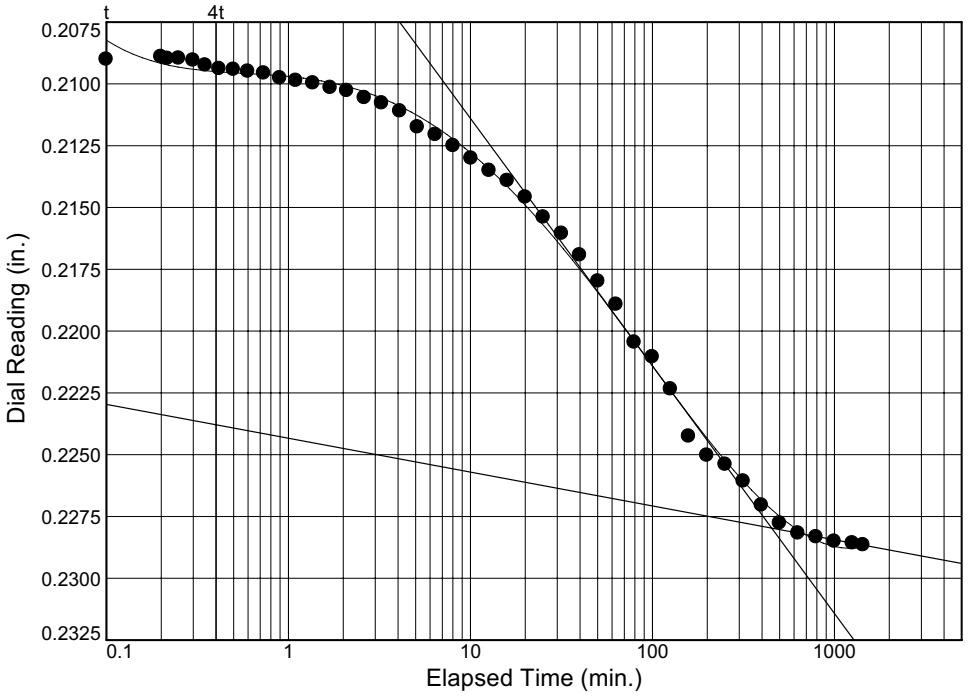
C_v @ T_{50}
0.005 ft.^{2}/day

C_α = 0.003

Dial Reading vs. Time

Project No.: M2205062
Project: Project Tundra

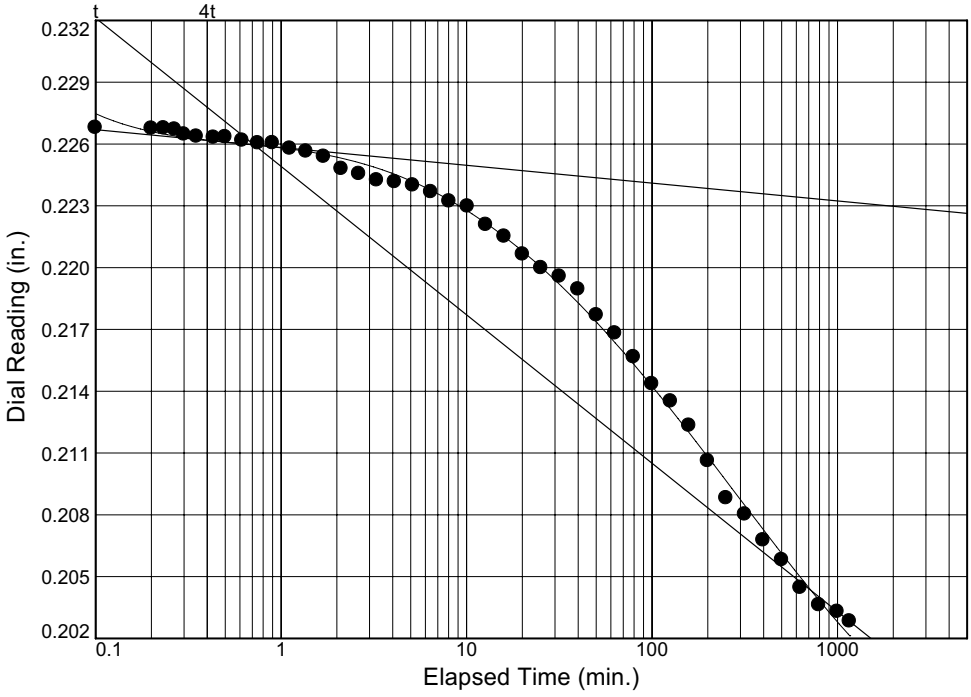
Location: B-2 Depth: 12-13 ft.



Load No.= 13
Load= 64000 psf
D_0 = 0.2070
D_{50} = 0.2175
D_{100} = 0.2280
T_{50} = 39.58 min.

C_v @ T_{50}
0.011 ft.^{2}/day

C_α = 0.001



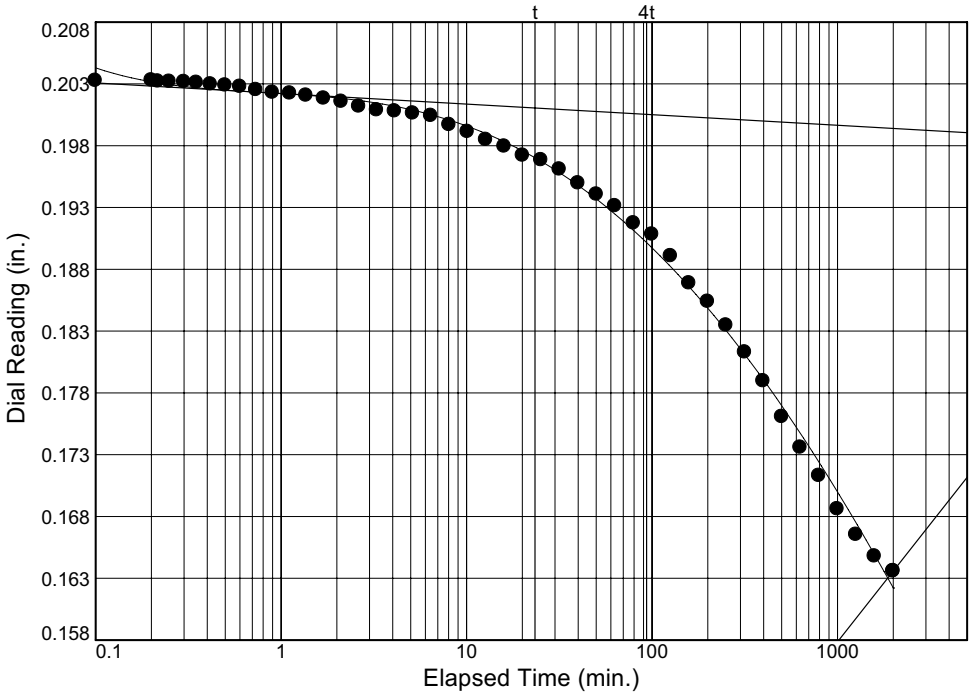
Load No.= 14
Load= 16000 psf
D_0 = 0.2288
D_{50} = 0.2274
D_{100} = 0.2260
T_{50} = 0.11 min.

C_v @ T_{50}
3.989 ft.^{2}/day

Dial Reading vs. Time

Project No.: M2205062
Project: Project Tundra

Location: B-2 Depth: 12-13 ft.



Load No.= 15
Load= 4000 psf
D_0 = 0.2039
D_{50} = 0.2009
D_{100} = 0.1979
T_{50} = 5.15 min.

C_v @ T_{50}
0.090 ft.^{2}/day

C_α = 0.019

CONSOLIDATION TEST DATA

10/12/2020

Client: Fluor Enterprises Inc Greenville, SC
Project: Project Tundra
Project Number: M2205062
Location: B-2
Depth: 12-13 ft.
Material Description: Dark gray Fat Clay
Testing Remarks: ASTM D2435
Specific gravity assumed

Test Specimen Data

NATURAL MOISTURE		VOID RATIO		AFTER TEST	
Wet w+t =	208.00 g.	Spec. Gr. =	2.73	Wet w+t =	227.92 g.
Dry w+t =	178.02 g.	Est. Ht. Solids =	0.609 in.	Dry w+t =	195.35 g.
Tare Wt. =	48.90 g.	Init. V.R. =	0.642	Tare Wt. =	63.09 g.
Moisture =	23.2 %	Init. Sat. =	98.8 %	Moisture =	24.6 %

UNIT WEIGHT		TEST START			
Height =	1.000 in.	Height =	1.000 in.	Dry Wt. =	132.26 g.
Diameter =	2.500 in.	Diameter =	2.500 in.		
Weight =	164.82 g.				
Dry Dens. =	103.8 pcf				

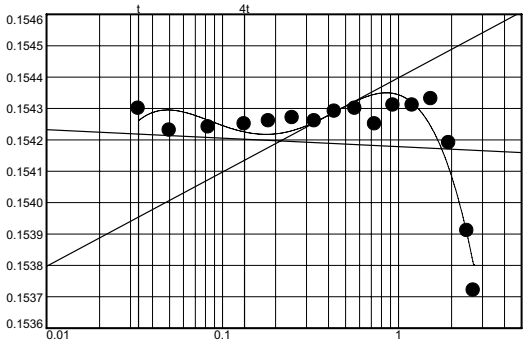
End-Of-Load Summary

Pressure (psf)	Final Dial (in.)	Deformation (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Strain
start	0.15433	0.00000			0.642	
250	0.15372	-0.00061	4.980		0.643	0.1 Swell
500	0.15207	-0.00226	0.088		0.645	0.2 Swell
1000	0.15206	-0.00227			0.645	0.2 Swell
2000	0.15171	-0.00262		0.000	0.646	0.3 Swell
4000	0.15253	-0.00180		0.001	0.645	0.2 Swell
8000	0.16053	0.00620		0.002	0.632	0.6 Comprs.
16000	0.18513	0.03080	0.004	0.005	0.591	3.1 Comprs.
8000	0.17456	0.02023	3.308	0.921	0.609	2.0 Comprs.
4000	0.15807	0.00374			0.636	0.4 Comprs.
8000	0.16681	0.01248		0.003	0.621	1.2 Comprs.
16000	0.18533	0.03100	0.004	0.001	0.591	3.1 Comprs.
32000	0.20822	0.05389	0.005	0.003	0.553	5.4 Comprs.
64000	0.22866	0.07433	0.011	0.001	0.520	7.4 Comprs.
16000	0.20283	0.04850	3.989		0.562	4.9 Comprs.
4000	0.16359	0.00926	0.090	0.019	0.627	0.9 Comprs.

Compression index (C_c), psf = 0.13 **Preconsolidation pressure (P_p), psf =** 6436 **Void ratio at P_p (e_m) =** 0.639
Recompression index (C_r) = 0.09

Pressure: 250 psf	TEST READINGS	Load No. 1

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.15433	11	0.7333	0.15425
2	0.0333	0.15430	12	0.9333	0.15431
3	0.0500	0.15423	13	1.2000	0.15431
4	0.0833	0.15424	14	1.5333	0.15433
5	0.1333	0.15425	15	1.9333	0.15419
6	0.1833	0.15426	16	2.4500	0.15391
7	0.2500	0.15427	17	2.6667	0.15372
8	0.3333	0.15426			
9	0.4333	0.15429			
10	0.5667	0.15430			

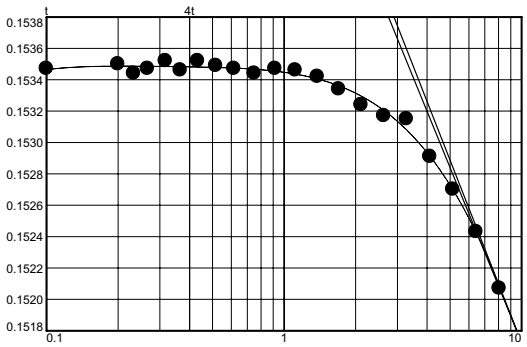


Void Ratio = 0.643 **Swell =** 0.1%

D_0 = 0.1543 **D_{50} =** 0.1542 **D_{100} =** 0.1542 **C_V at 0.10 min. =** 4.980 ft.^{2}/day

Pressure: 500 psf	TEST READINGS	Load No. 2

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.15334	12	0.9167	0.15347
2	0.1000	0.15347	13	1.1167	0.15346
3	0.2000	0.15350	14	1.3833	0.15342
4	0.2333	0.15344	15	1.7000	0.15334
5	0.2667	0.15347	16	2.1167	0.15324
6	0.3167	0.15352	17	2.6333	0.15317
7	0.3667	0.15346	18	3.2833	0.15315
8	0.4333	0.15352	19	4.1167	0.15291
9	0.5167	0.15349	20	5.1500	0.15270
10	0.6167	0.15347	21	6.4500	0.15243
11	0.7500	0.15344	22	8.0667	0.15207



Void Ratio = 0.645 **Swell =** 0.2%

D_0 = 0.1534 **D_{50} =** 0.1526 **D_{100} =** 0.1518 **C_V at 5.60 min. =** 0.088 ft.^{2}/day

Pressure: 1000 psf	TEST READINGS	Load No. 3

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.15161	11	0.7500	0.15235
2	0.1167	0.15202	12	0.9167	0.15234
3	0.2167	0.15209	13	1.1167	0.15233
4	0.2333	0.15211	14	1.3833	0.15233
5	0.2667	0.15202	15	1.7167	0.15234
6	0.3167	0.15210	16	2.1167	0.15229
7	0.3667	0.15219	17	2.6333	0.15227
8	0.4333	0.15211	18	3.0833	0.15206
9	0.5167	0.15211			
10	0.6167	0.15236			

Void Ratio = 0.645 **Swell =** 0.2%

Pressure: 2000 psf	TEST READINGS	Load No. 4

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.15100	11	0.7333	0.15236	21	6.4333	0.15252
2	0.1000	0.15227	12	0.9000	0.15239	22	8.0667	0.15249
3	0.2000	0.15230	13	1.1000	0.15244	23	10.1167	0.15240
4	0.2167	0.15232	14	1.3667	0.15242	24	12.7167	0.15229
5	0.2500	0.15230	15	1.7000	0.15263	25	15.9667	0.15212
6	0.3000	0.15232	16	2.1000	0.15258	26	20.0833	0.15180
7	0.3500	0.15231	17	2.6167	0.15254	27	22.0000	0.15171
8	0.4167	0.15231	18	3.2667	0.15259			
9	0.5000	0.15232	19	4.1000	0.15257			
10	0.6000	0.15238	20	5.1333	0.15249			

Void Ratio = 0.646 **Swell =** 0.3%

Pressure: 4000 psf	TEST READINGS	Load No. 5

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.15018	11	0.7500	0.15183	21	6.4333	0.15234
2	0.1000	0.15171	12	0.9167	0.15186	22	8.0667	0.15230
3	0.2000	0.15172	13	1.1167	0.15191	23	10.1333	0.15240
4	0.2333	0.15172	14	1.3833	0.15199	24	12.7167	0.15244
5	0.2667	0.15176	15	1.7000	0.15200	25	15.9833	0.15246
6	0.3167	0.15173	16	2.1167	0.15201	26	20.0833	0.15248
7	0.3667	0.15171	17	2.6333	0.15216	27	23.2667	0.15253
8	0.4333	0.15178	18	3.2833	0.15216			
9	0.5167	0.15179	19	4.1000	0.15221			
10	0.6167	0.15182	20	5.1333	0.15224			

Void Ratio = 0.645 **Swell =** 0.2%

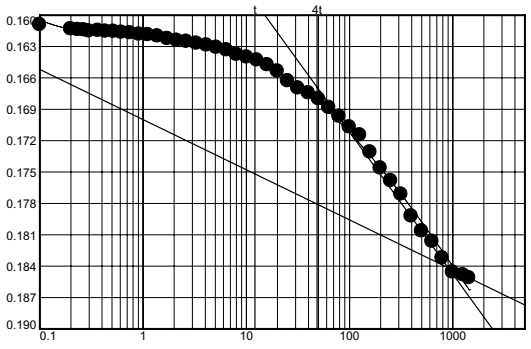
Pressure: 8000 psf	TEST READINGS	Load No. 6

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.15018	15	1.7000	0.15399	29	39.9333	0.15675
2	0.1000	0.15288	16	2.1167	0.15413	30	50.2500	0.15718
3	0.2000	0.15311	17	2.6333	0.15431	31	63.2333	0.15743
4	0.2333	0.15314	18	3.2833	0.15446	32	79.5667	0.15794
5	0.2667	0.15321	19	4.1000	0.15456	33	100.1333	0.15846
6	0.3000	0.15324	20	5.1333	0.15472	34	126.0333	0.15876
7	0.3500	0.15329	21	6.4333	0.15490	35	158.6167	0.15951
8	0.4167	0.15336	22	8.0667	0.15512	36	199.6667	0.15990
9	0.5000	0.15345	23	10.1167	0.15529	37	251.3333	0.16016
10	0.6167	0.15349	24	12.7167	0.15564	38	316.3667	0.16034
11	0.7500	0.15352	25	15.9667	0.15594	39	398.2500	0.16055
12	0.9000	0.15365	26	20.0833	0.15611	40	420.4667	0.16053
13	1.1167	0.15374	27	25.2500	0.15625			
14	1.3667	0.15383	28	31.7500	0.15640			

Void Ratio = 0.632 **Compression =** 0.6%

Pressure: 16000 psf	TEST READINGS	Load No. 7

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.15727	23	10.1333	0.16403
2	0.1000	0.16093	24	12.7167	0.16432
3	0.2000	0.16133	25	15.9833	0.16478
4	0.2333	0.16141	26	20.1000	0.16537
5	0.2667	0.16142	27	25.2500	0.16630
6	0.3000	0.16153	28	31.7667	0.16699
7	0.3667	0.16149	29	39.9500	0.16745
8	0.4333	0.16156	30	50.2667	0.16800
9	0.5167	0.16157	31	63.2333	0.16884
10	0.6167	0.16165	32	79.5833	0.16970
11	0.7500	0.16172	33	100.1500	0.17070
12	0.9167	0.16184	34	126.0333	0.17148
13	1.1167	0.16189	35	158.6333	0.17311
14	1.3833	0.16202	36	199.6667	0.17463
15	1.7167	0.16226	37	251.3333	0.17585
16	2.1167	0.16242	38	316.3833	0.17714
17	2.6333	0.16252	39	398.2500	0.17923
18	3.2833	0.16270	40	501.3333	0.18066
19	4.1167	0.16288	41	631.1000	0.18166
20	5.1500	0.16310	42	794.4833	0.18324
21	6.4333	0.16335	43	1000.1500	0.18459
22	8.0833	0.16378	44	1259.0833	0.18485



Pressure: 16000 psf	TEST READINGS (continued)	Load No. 7

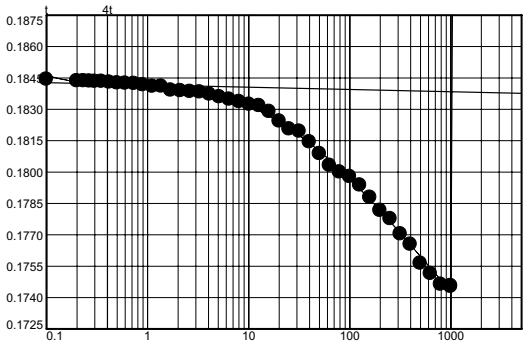
No.	Elapsed Time	Dial Reading
45	1440.3333	0.18513

Void Ratio = 0.591 **Compression =** 3.1%

D_0 = 0.1602 **D_{50} =** 0.1722 **D_{100} =** 0.1842 **C_v at 123.31 min. =** 0.004 ft.^{2}/day **C_α =** 0.005

Pressure: 8000 psf	TEST READINGS	Load No. 8

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.18826	23	10.1167	0.18323
2	0.1000	0.18443	24	12.7167	0.18316
3	0.2000	0.18435	25	15.9667	0.18289
4	0.2333	0.18435	26	20.0833	0.18243
5	0.2667	0.18434	27	25.2500	0.18205
6	0.3000	0.18433	28	31.7500	0.18194
7	0.3500	0.18433	29	39.9333	0.18143
8	0.4167	0.18429	30	50.2500	0.18087
9	0.5000	0.18425	31	63.2333	0.18031
10	0.6000	0.18424	32	79.5667	0.17999
11	0.7333	0.18422	33	100.1333	0.17978
12	0.9000	0.18416	34	126.0333	0.17937
13	1.1167	0.18409	35	158.6333	0.17878
14	1.3667	0.18410	36	199.6667	0.17815
15	1.7000	0.18391	37	251.3333	0.17776
16	2.1167	0.18388	38	316.3667	0.17703
17	2.6333	0.18384	39	398.2500	0.17654
18	3.2833	0.18382	40	501.3333	0.17563
19	4.1000	0.18371	41	631.1000	0.17514
20	5.1333	0.18359	42	794.4833	0.17462
21	6.4333	0.18347	43	1000.1500	0.17452
22	8.0667	0.18336	44	1000.2500	0.17456



Void Ratio = 0.609 **Compression =** 2.0%

D_0 = 0.1850 **D_{50} =** 0.1844 **D_{100} =** 0.1838 **C_v at 0.14 min. =** 3.308 ft.^{2}/day **C_α =** 0.921

Pressure: 4000 psf	TEST READINGS	Load No. 9

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.17661	16	2.1167	0.17418	31	63.2333	0.17030
2	0.1000	0.17464	17	2.6333	0.17414	32	79.5667	0.16980
3	0.2000	0.17468	18	3.2833	0.17408	33	100.1333	0.16932
4	0.2333	0.17472	19	4.1000	0.17392	34	126.0333	0.16855
5	0.2667	0.17470	20	5.1333	0.17380	35	158.6333	0.16782
6	0.3000	0.17469	21	6.4333	0.17365	36	199.6667	0.16721
7	0.3500	0.17464	22	8.0667	0.17348	37	251.3333	0.16612
8	0.4167	0.17465	23	10.1167	0.17327	38	316.3667	0.16518
9	0.5000	0.17459	24	12.7167	0.17315	39	398.2500	0.16412
10	0.6167	0.17453	25	15.9667	0.17285	40	501.3333	0.16285
11	0.7500	0.17454	26	20.0833	0.17267	41	631.1000	0.16227
12	0.9000	0.17447	27	25.2500	0.17240	42	794.4667	0.16122
13	1.1167	0.17443	28	31.7500	0.17206	43	1000.1500	0.15987
14	1.3667	0.17432	29	39.9500	0.17182	44	1259.0667	0.15820
15	1.7000	0.17435	30	50.2500	0.17084	45	1440.3167	0.15807

Void Ratio = 0.636 **Compression =** 0.4%

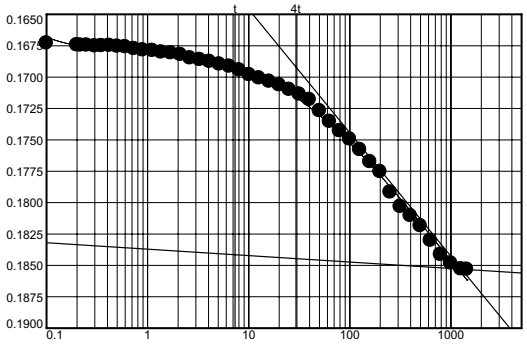
Pressure: 8000 psf	TEST READINGS	Load No. 10

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.15601	16	2.1000	0.15887	31	63.2167	0.16163
2	0.1000	0.15824	17	2.6167	0.15893	32	79.5667	0.16187
3	0.2000	0.15819	18	3.2833	0.15923	33	100.1333	0.16221
4	0.2167	0.15830	19	4.1000	0.15947	34	126.0333	0.16263
5	0.2667	0.15826	20	5.1333	0.15961	35	158.6333	0.16325
6	0.3000	0.15828	21	6.4333	0.15970	36	199.6667	0.16369
7	0.3500	0.15839	22	8.0667	0.15984	37	251.3333	0.16436
8	0.4167	0.15831	23	10.1167	0.16001	38	316.3667	0.16490
9	0.5000	0.15850	24	12.7167	0.16025	39	398.2500	0.16522
10	0.6000	0.15849	25	15.9667	0.16039	40	501.3333	0.16563
11	0.7333	0.15849	26	20.0833	0.16047	41	631.1000	0.16580
12	0.9000	0.15854	27	25.2500	0.16065	42	794.4833	0.16618
13	1.1000	0.15856	28	31.7500	0.16074	43	1000.1500	0.16630
14	1.3667	0.15864	29	39.9333	0.16100	44	1259.0833	0.16667
15	1.7000	0.15878	30	50.2500	0.16116	45	1440.3667	0.16681

Void Ratio = 0.621 **Compression =** 1.2%

Pressure: 16000 psf | **TEST READINGS** | **Load No. 11**

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.16364	24	12.7167	0.17009
2	0.1000	0.16731	25	15.9667	0.17035
3	0.2000	0.16746	26	20.0833	0.17063
4	0.2167	0.16748	27	25.2500	0.17100
5	0.2500	0.16747	28	31.7500	0.17137
6	0.3000	0.16753	29	39.9333	0.17180
7	0.3500	0.16751	30	50.2500	0.17270
8	0.4167	0.16750	31	63.2333	0.17354
9	0.5000	0.16755	32	79.5667	0.17429
10	0.6000	0.16759	33	100.1333	0.17495
11	0.7333	0.16775	34	126.0333	0.17579
12	0.9000	0.16785	35	158.6333	0.17675
13	1.1167	0.16789	36	199.6667	0.17754
14	1.3667	0.16802	37	251.3333	0.17918
15	1.7000	0.16808	38	316.3667	0.18032
16	2.1167	0.16822	39	398.2500	0.18104
17	2.6333	0.16849	40	501.3333	0.18185
18	3.2833	0.16862	41	631.1167	0.18303
19	4.1000	0.16876	42	794.4833	0.18415
20	5.1333	0.16899	43	1000.1500	0.18483
21	6.4333	0.16916	44	1259.0833	0.18530
22	8.0667	0.16944	45	1440.0000	0.18533
23	10.1167	0.16982			

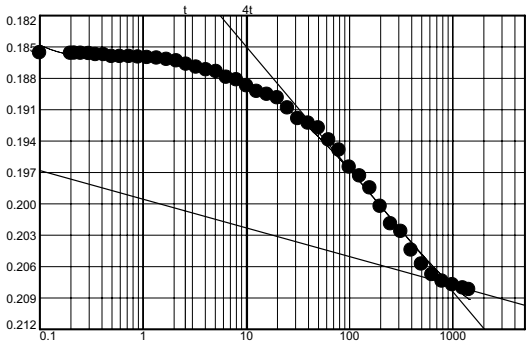


Void Ratio = 0.591 **Compression =** 3.1%

D_0 = 0.1665 **D_{50} =** 0.1759 **D_{100} =** 0.1853 **C_v at 120.19 min. =** 0.004 ft.^{2}/day **C_α =** 0.001

Pressure: 32000 psf | **TEST READINGS** | **Load No. 12**

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.17909	13	1.1000	0.18603
2	0.1000	0.18558	14	1.3667	0.18609
3	0.2000	0.18564	15	1.7000	0.18621
4	0.2167	0.18562	16	2.1167	0.18636
5	0.2500	0.18564	17	2.6333	0.18668
6	0.3000	0.18567	18	3.2833	0.18697
7	0.3500	0.18575	19	4.1000	0.18721
8	0.4167	0.18576	20	5.1333	0.18738
9	0.5000	0.18593	21	6.4333	0.18793
10	0.6000	0.18595	22	8.0667	0.18817
11	0.7333	0.18593	23	10.1167	0.18875
12	0.9000	0.18599	24	12.7167	0.18927



Pressure: 32000 psf	TEST READINGS (continued)	Load No. 12

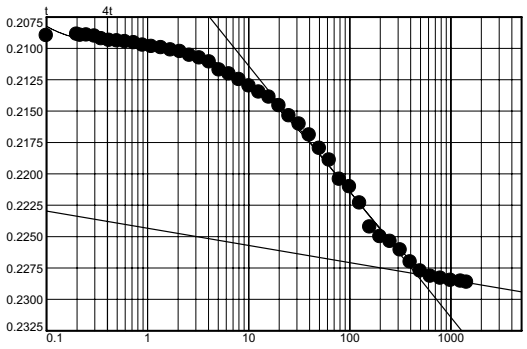
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
25	15.9667	0.18956	35	158.6333	0.19852	45	1440.1500	0.20822
26	20.0833	0.18990	36	199.6667	0.20028			
27	25.2500	0.19087	37	251.3333	0.20194			
28	31.7500	0.19189	38	316.3667	0.20267			
29	39.9333	0.19231	39	398.2500	0.20445			
30	50.2500	0.19278	40	501.3333	0.20579			
31	63.2333	0.19391	41	631.1000	0.20679			
32	79.5667	0.19490	42	794.4667	0.20742			
33	100.1333	0.19652	43	1000.1500	0.20776			
34	126.0333	0.19736	44	1259.0667	0.20806			

Void Ratio = 0.553 **Compression =** 5.4%

D_0 = 0.1844 **D_{50} =** 0.1960 **D_{100} =** 0.2076 **C_v at 84.96 min. =** 0.005 ft.^{2}/day **C_α =** 0.003

Pressure: 64000 psf	TEST READINGS	Load No. 13

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.19771	24	12.7167	0.21351
2	0.1000	0.20901	25	15.9667	0.21392
3	0.2000	0.20890	26	20.0667	0.21459
4	0.2167	0.20898	27	25.2333	0.21540
5	0.2500	0.20897	28	31.7500	0.21606
6	0.3000	0.20905	29	39.9333	0.21693
7	0.3500	0.20925	30	50.2500	0.21799
8	0.4167	0.20939	31	63.2167	0.21893
9	0.5000	0.20942	32	79.5667	0.22046
10	0.6000	0.20950	33	100.1333	0.22105
11	0.7333	0.20957	34	126.0167	0.22235
12	0.9000	0.20977	35	158.6167	0.22426
13	1.1000	0.20987	36	199.6667	0.22503
14	1.3667	0.20997	37	251.3333	0.22540
15	1.7000	0.21016	38	316.3667	0.22608
16	2.1000	0.21028	39	398.2500	0.22705
17	2.6167	0.21057	40	501.3333	0.22777
18	3.2667	0.21078	41	631.1000	0.22818
19	4.1000	0.21111	42	794.4667	0.22833
20	5.1333	0.21175	43	1000.1500	0.22851
21	6.4333	0.21206	44	1259.0667	0.22858
22	8.0667	0.21251	45	1440.2667	0.22866
23	10.1167	0.21301			

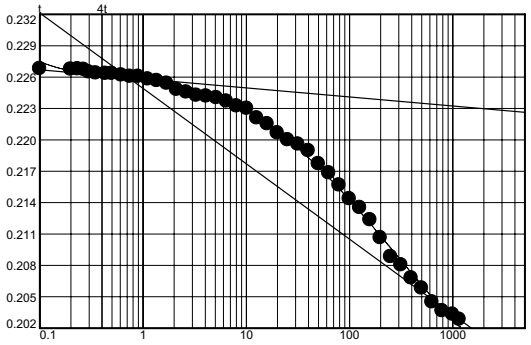


Void Ratio = 0.520 **Compression =** 7.4%

D_0 = 0.2070 **D_{50} =** 0.2175 **D_{100} =** 0.2280 **C_v at 39.58 min. =** 0.011 ft.^{2}/day **C_α =** 0.001

Pressure: 16000 psf	TEST READINGS	Load No. 14

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.24491	23	10.1333	0.22298
2	0.1000	0.22679	24	12.7167	0.22208
3	0.2000	0.22675	25	15.9833	0.22151
4	0.2333	0.22677	26	20.0833	0.22065
5	0.2667	0.22671	27	25.2500	0.21998
6	0.3000	0.22647	28	31.7500	0.21957
7	0.3500	0.22637	29	39.9500	0.21895
8	0.4333	0.22632	30	50.2500	0.21770
9	0.5000	0.22634	31	63.2333	0.21681
10	0.6167	0.22617	32	79.5667	0.21566
11	0.7500	0.22604	33	100.1333	0.21435
12	0.9000	0.22605	34	126.0333	0.21351
13	1.1167	0.22579	35	158.6333	0.21233
14	1.3667	0.22564	36	199.6667	0.21062
15	1.7000	0.22539	37	251.3333	0.20882
16	2.1167	0.22480	38	316.3667	0.20802
17	2.6333	0.22455	39	398.2500	0.20677
18	3.2833	0.22425	40	501.3333	0.20581
19	4.1000	0.22416	41	631.1000	0.20447
20	5.1333	0.22400	42	794.4833	0.20363
21	6.4333	0.22368	43	1000.1500	0.20330
22	8.0667	0.22322	44	1162.2500	0.20283

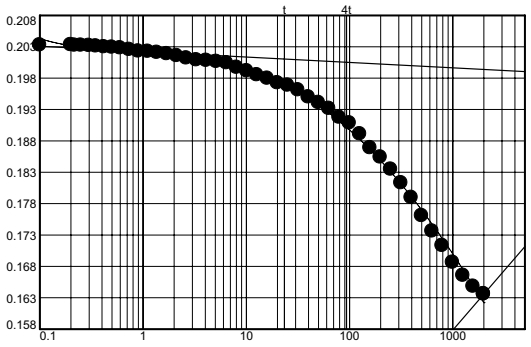


Void Ratio = 0.562 **Compression =** 4.9%

D_0 = 0.2288 **D_{50} =** 0.2274 **D_{100} =** 0.2260 **C_v at 0.11 min. =** 3.989 ft.^{2}/day

Pressure: 4000 psf	TEST READINGS	Load No. 15

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.20817	14	1.3667	0.20207
2	0.1000	0.20326	15	1.7000	0.20183
3	0.2000	0.20330	16	2.1167	0.20157
4	0.2167	0.20320	17	2.6333	0.20118
5	0.2500	0.20319	18	3.2833	0.20087
6	0.3000	0.20316	19	4.1000	0.20078
7	0.3500	0.20310	20	5.1333	0.20061
8	0.4167	0.20297	21	6.4333	0.20042
9	0.5000	0.20289	22	8.0667	0.19968
10	0.6000	0.20277	23	10.1167	0.19913
11	0.7333	0.20252	24	12.7167	0.19848
12	0.9000	0.20229	25	15.9833	0.19794
13	1.1167	0.20224	26	20.0833	0.19720



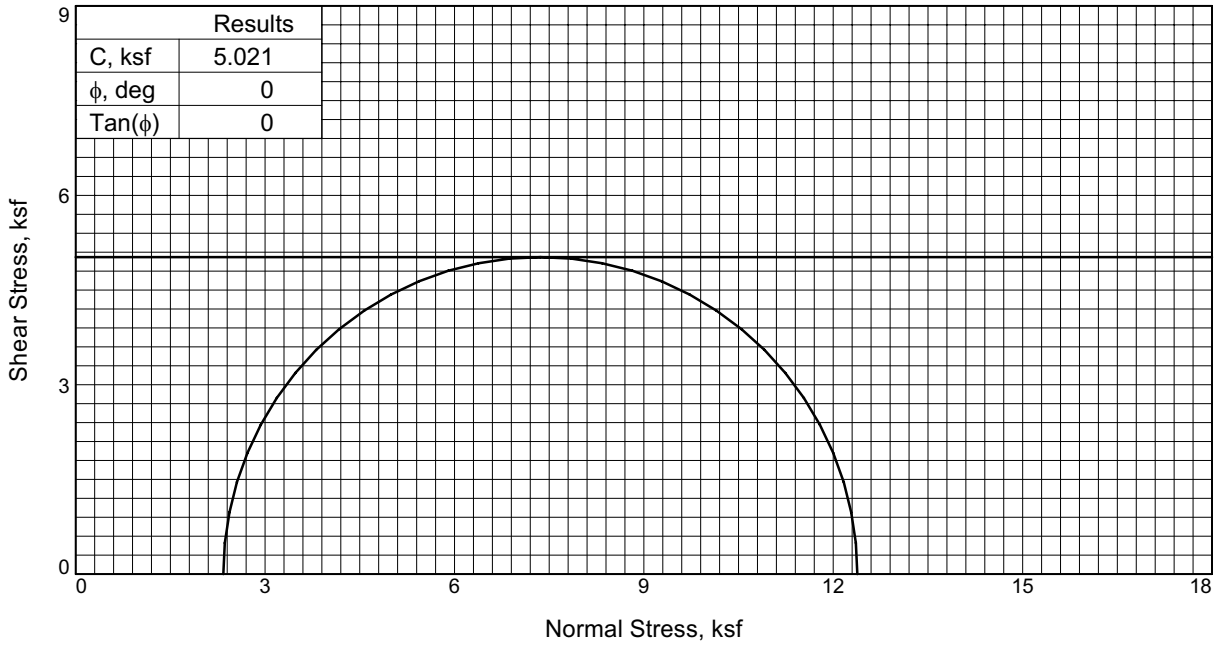
Pressure: 4000 psf	TEST READINGS (continued)	Load No. 15

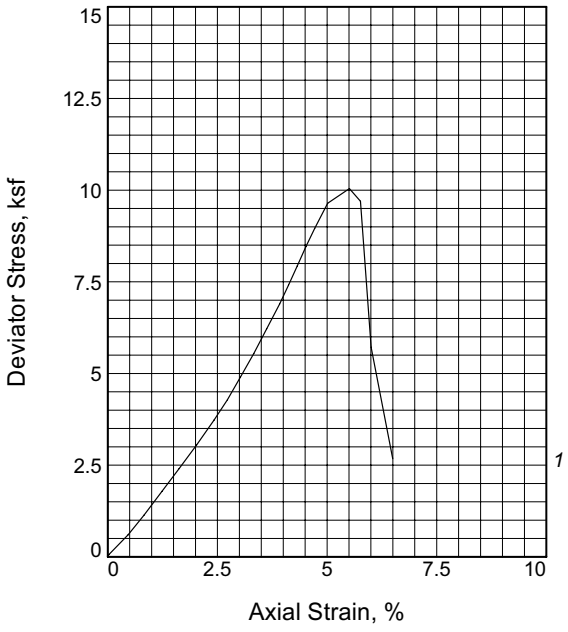
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
27	25.2500	0.19685	37	251.3333	0.18346	47	2000.2500	0.16359
28	31.7500	0.19609	38	316.3667	0.18128			
29	39.9500	0.19497	39	398.2500	0.17895			
30	50.2500	0.19406	40	501.3333	0.17607			
31	63.2333	0.19312	41	631.1167	0.17359			
32	79.5667	0.19172	42	794.4833	0.17130			
33	100.1333	0.19082	43	1000.1500	0.16860			
34	126.0333	0.18908	44	1259.0833	0.16653			
35	158.6333	0.18687	45	1585.0500	0.16479			
36	199.6667	0.18538	46	1995.4167	0.16357			

Void Ratio = 0.627 **Compression =** 0.9%

D_0 = 0.2039 **D_{50} =** 0.2009 **D_{100} =** 0.1979 **C_v at 5.15 min. =** 0.090 ft.^{2}/day **C_α =** 0.019

APPENDIX D
UU TEST RESULTS





Sample No.		1
Initial	Water Content, %	24.4
	Dry Density, pcf	103.8
	Saturation, %	99.6
	Void Ratio	0.6845
	Diameter, in.	2.830
	Height, in.	5.690
At Test	Water Content, %	24.4
	Dry Density, pcf	103.8
	Saturation, %	99.6
	Void Ratio	0.6845
	Diameter, in.	2.830
	Height, in.	5.690
Strain rate, in./min.		0.000
Back Pressure, psi		0.000
Cell Pressure, psi		16.240
Fail. Stress, ksf		10.04
Ult. Stress, ksf		
σ_1 Failure, ksf		12.38
σ_3 Failure, ksf		2.34

Type of Test:
Unconsolidated Undrained

Sample Type: Undisturbed

Description: Dark gray Fat Clay

Assumed Specific Gravity= 2.80

Remarks: ASTM D2850

Client: Fluor Enterprises Inc Greenville, SC

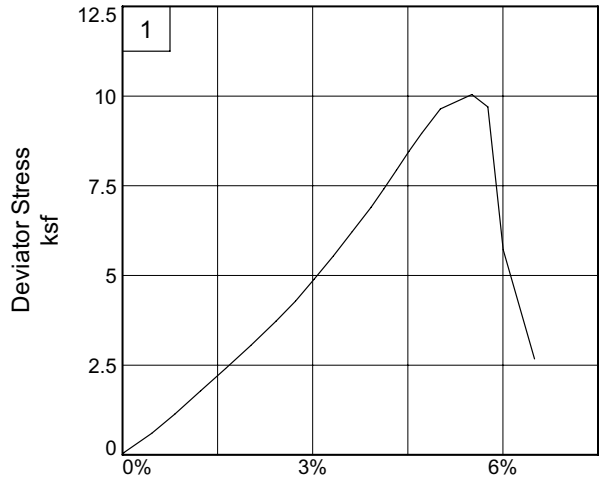
Project: Project Tundra

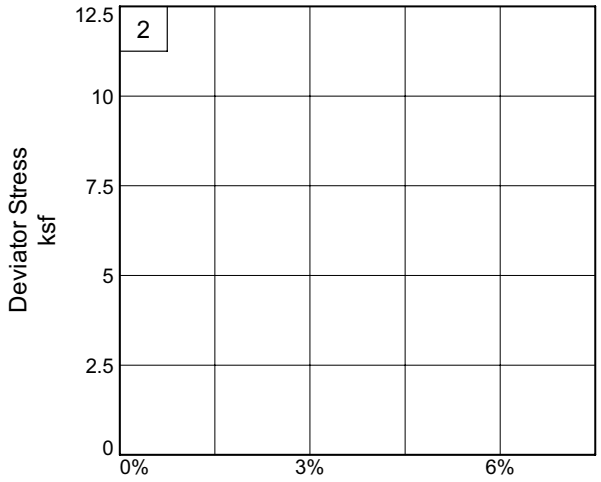
Location: B-1

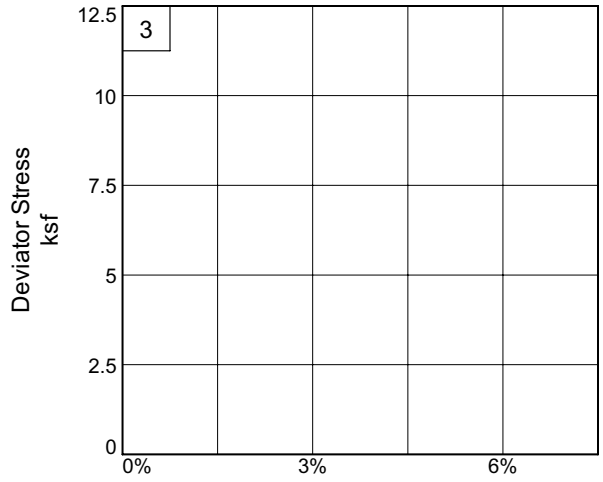
Depth: 24.5-26 ft.

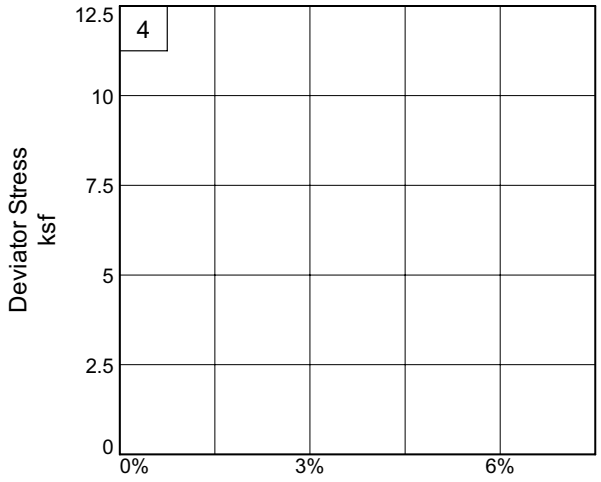
Proj. No.: M2205062 **Date Sampled:**

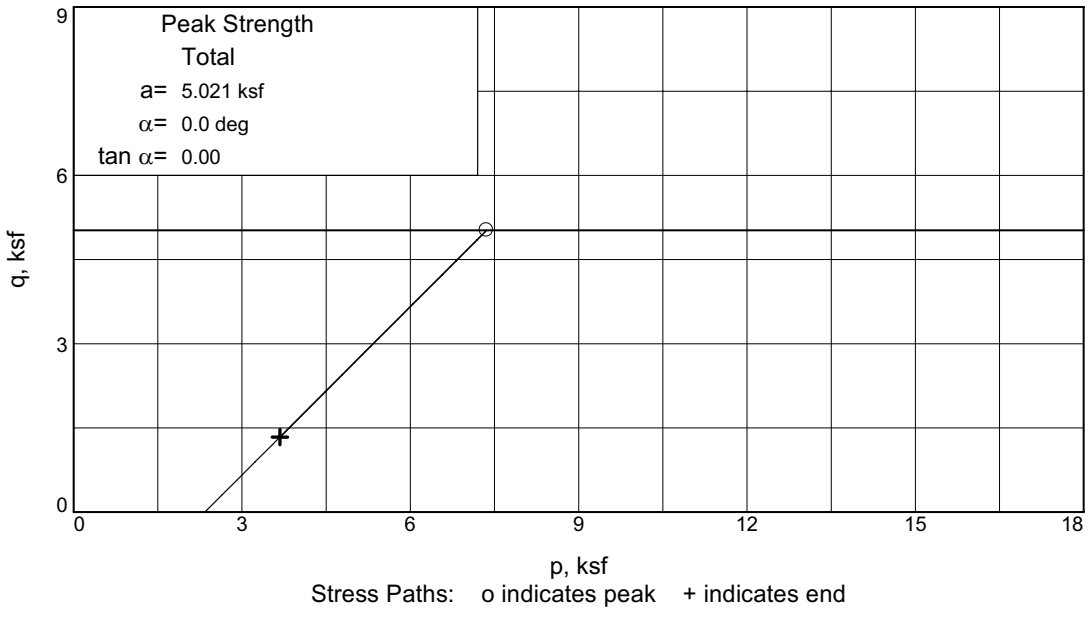
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Houston, TX





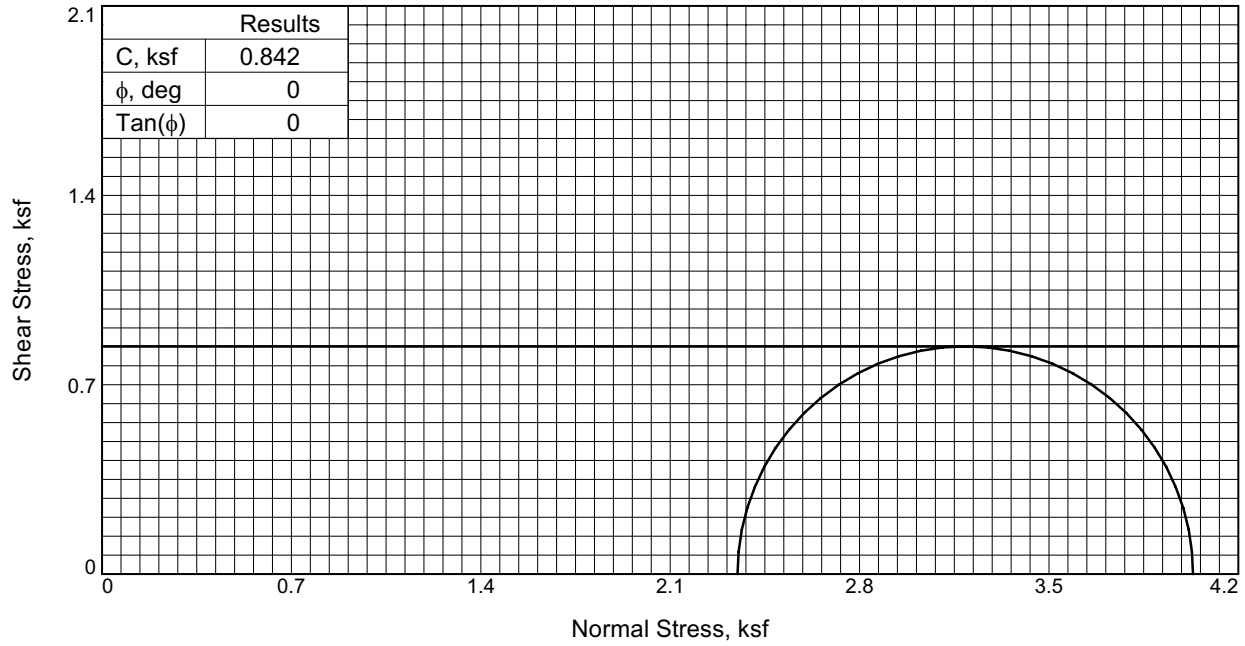


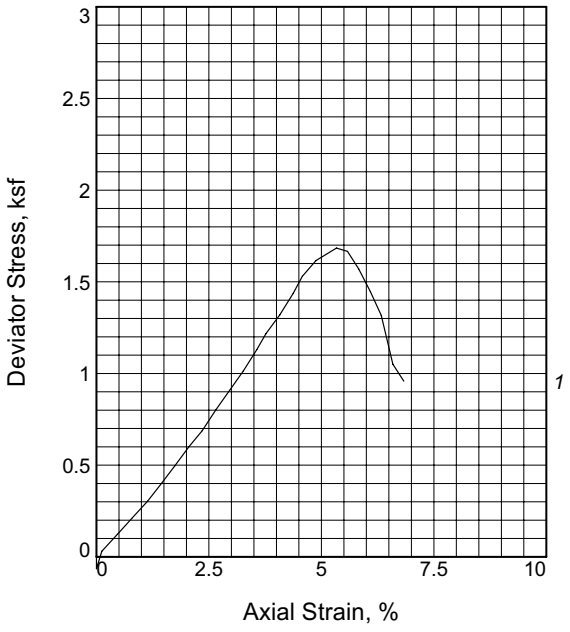




Client: Fluor Enterprises Inc Greenville, SC
Project: Project Tundra
Location: B-1 **Depth:** 24.5-26 ft.
Project No.: M2205062

Terracon Consultants, Inc.





Sample No.		1
Initial	Water Content, %	21.8
	Dry Density, pcf	101.2
	Saturation, %	86.9
	Void Ratio	0.6846
	Diameter, in.	2.820
	Height, in.	5.280
At Test	Water Content, %	21.8
	Dry Density, pcf	101.2
	Saturation, %	86.9
	Void Ratio	0.6846
	Diameter, in.	2.820
	Height, in.	5.280
Strain rate, in./min.		0.055
Back Pressure, psi		0.000
Cell Pressure, psi		16.310
Fail. Stress, ksf		1.684
Ult. Stress, ksf		
σ_1 Failure, ksf		4.033
σ_3 Failure, ksf		2.349

Type of Test:
Unconsolidated Undrained

Sample Type: Undisturbed

Description: Gray Lean Clay w/sand and silt pockets

Assumed Specific Gravity= 2.73

Remarks:

Client: Fluor Enterprises Inc Greenville, SC

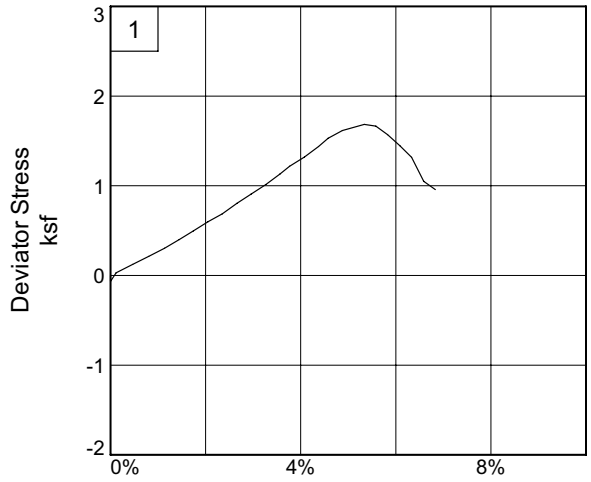
Project: Project Tundra

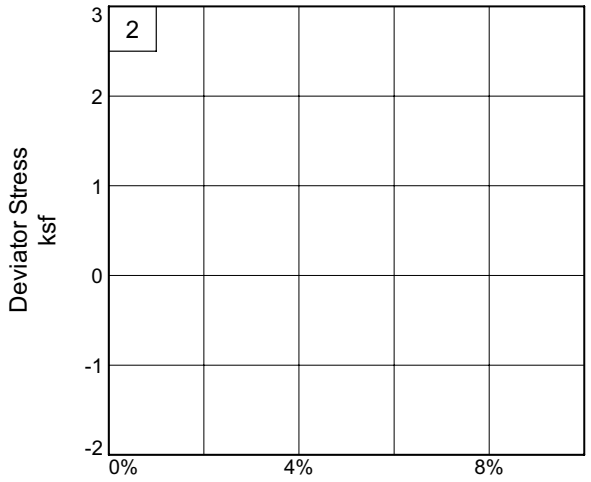
Location: B-2

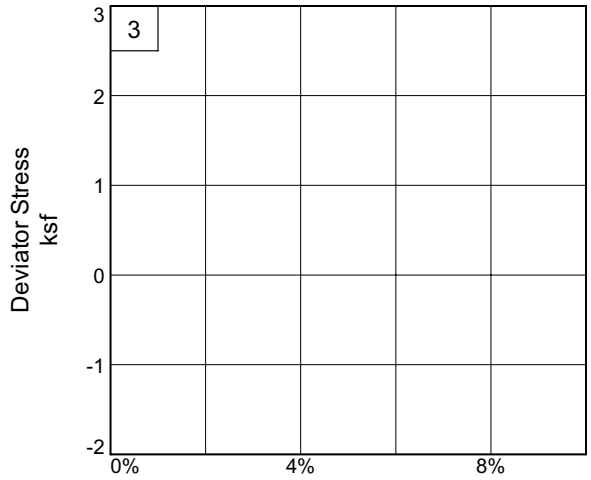
Depth: 19.5-21 ft.

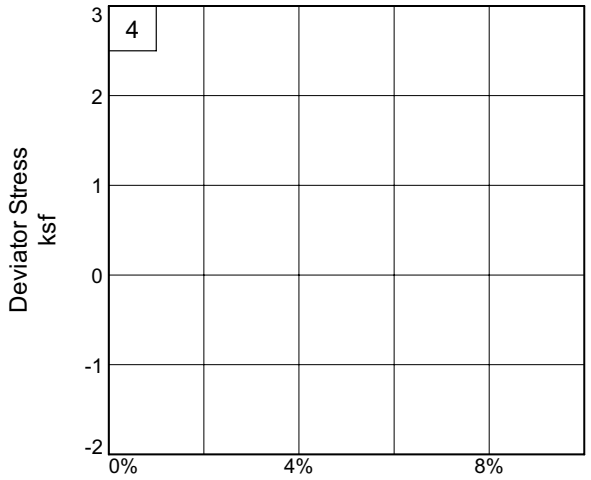
Proj. No.: M2205062 **Date Sampled:**

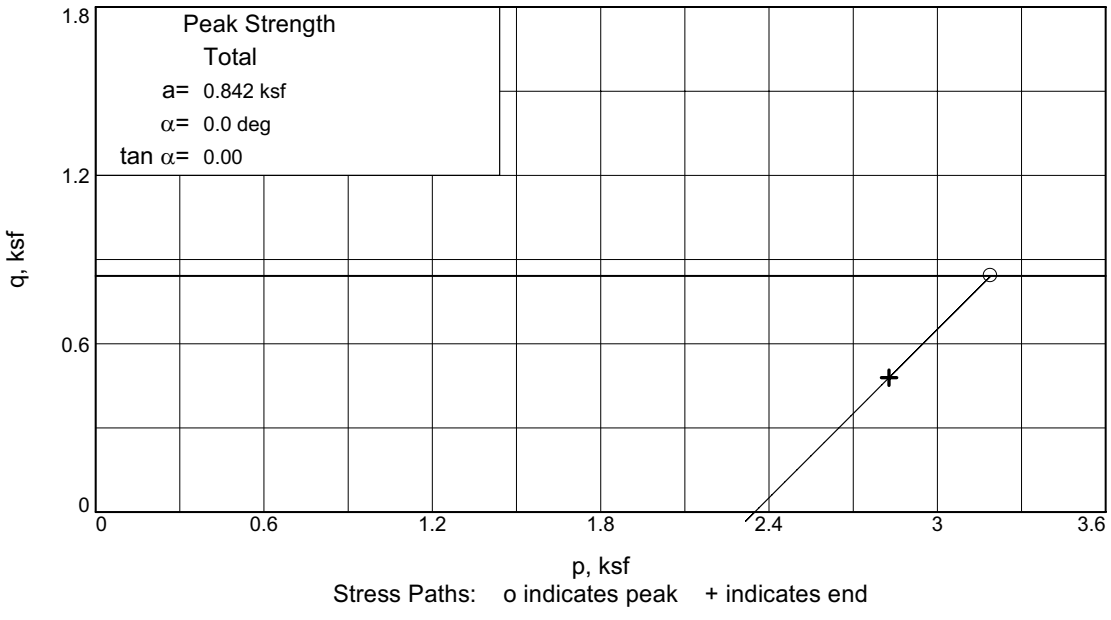
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Terracon Consultants, Inc.
Houston, TX





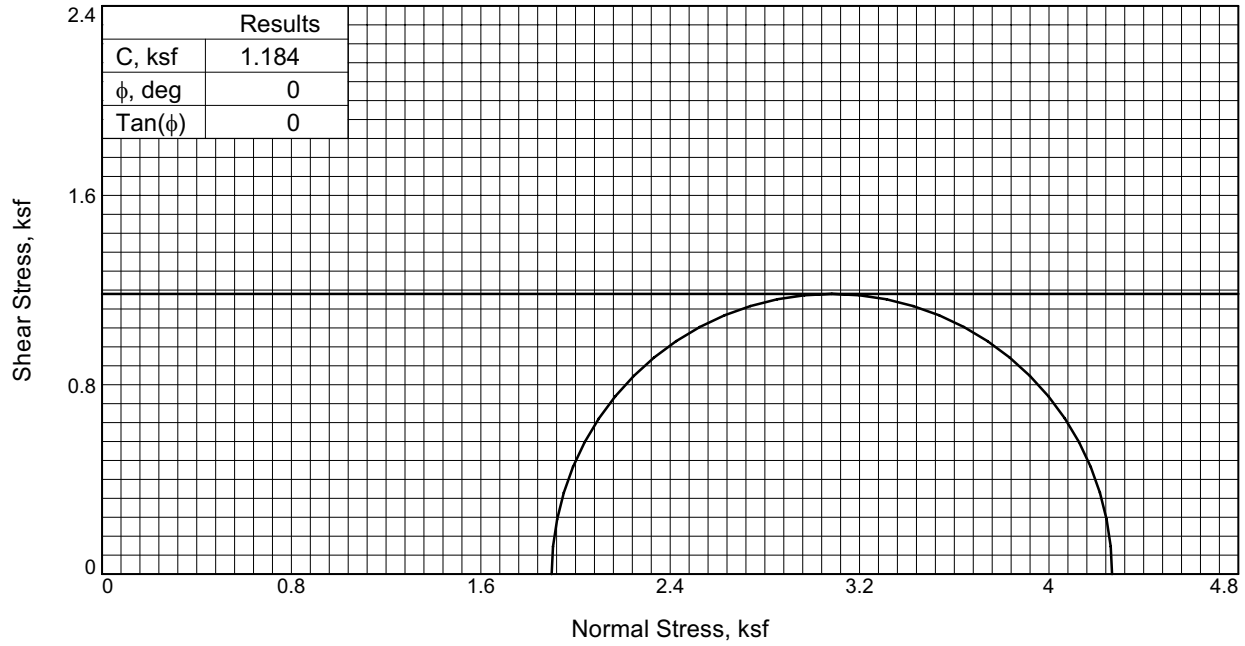


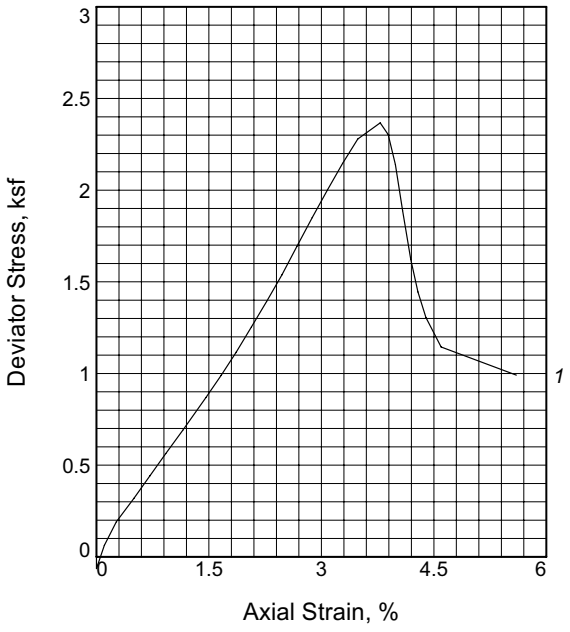




Client: Fluor Enterprises Inc Greenville, SC
Project: Project Tundra
Location: B-2 **Depth:** 19.5-21 ft.
Project No.: M2205062

Terracon Consultants, Inc.





Sample No.		1
Initial	Water Content, %	21.0
	Dry Density, pcf	99.3
	Saturation, %	80.2
	Void Ratio	0.7160
	Diameter, in.	2.850
	Height, in.	5.580
At Test	Water Content, %	21.0
	Dry Density, pcf	99.3
	Saturation, %	80.2
	Void Ratio	0.7160
	Diameter, in.	2.850
	Height, in.	5.580
Strain rate, in./min.		0.055
Back Pressure, psi		0.000
Cell Pressure, psi		13.190
Fail. Stress, ksf		2.367
Ult. Stress, ksf		
σ_1 Failure, ksf		4.266
σ_3 Failure, ksf		1.899

Type of Test:
Unconsolidated Undrained

Sample Type: Undisturbed

Description: Dark gray Fat Clay w/silt pockets

Assumed Specific Gravity= 2.73

Remarks:

Client: Fluor Enterprises Inc Greenville, SC

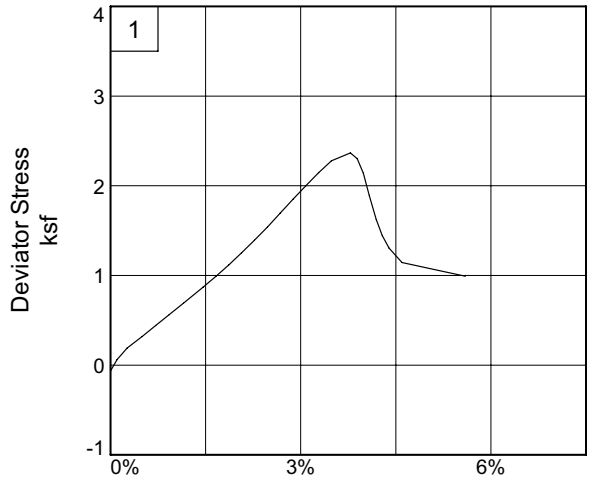
Project: Project Tundra

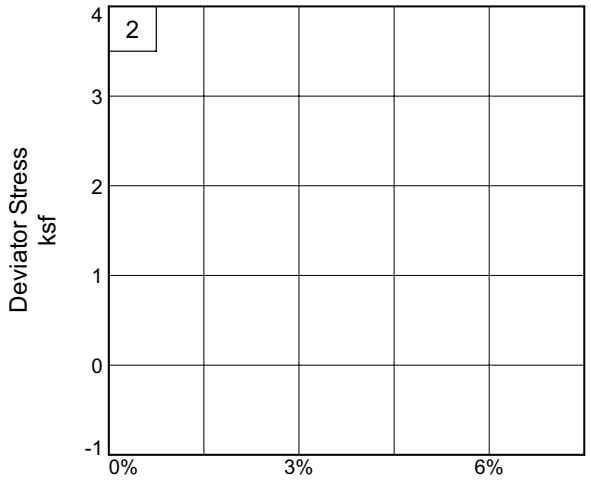
Location: B-3

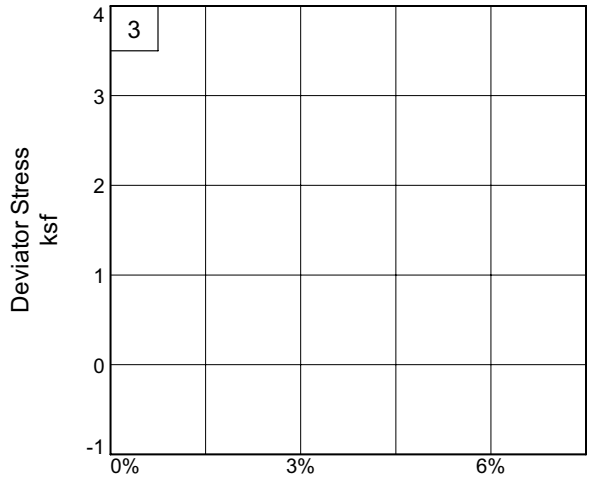
Depth: 14.5-16 ft.

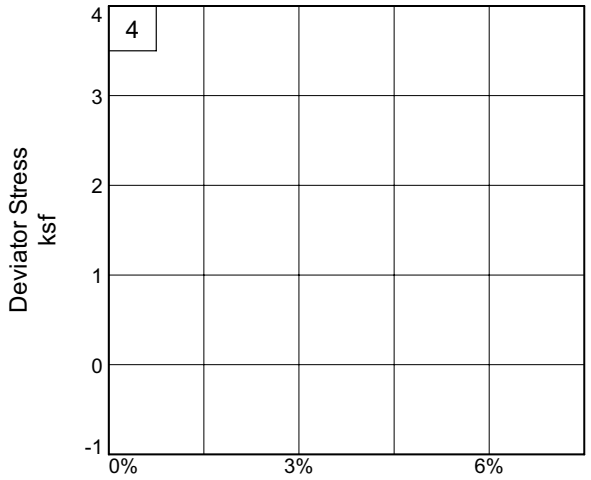
Proj. No.: M2205062 **Date Sampled:**

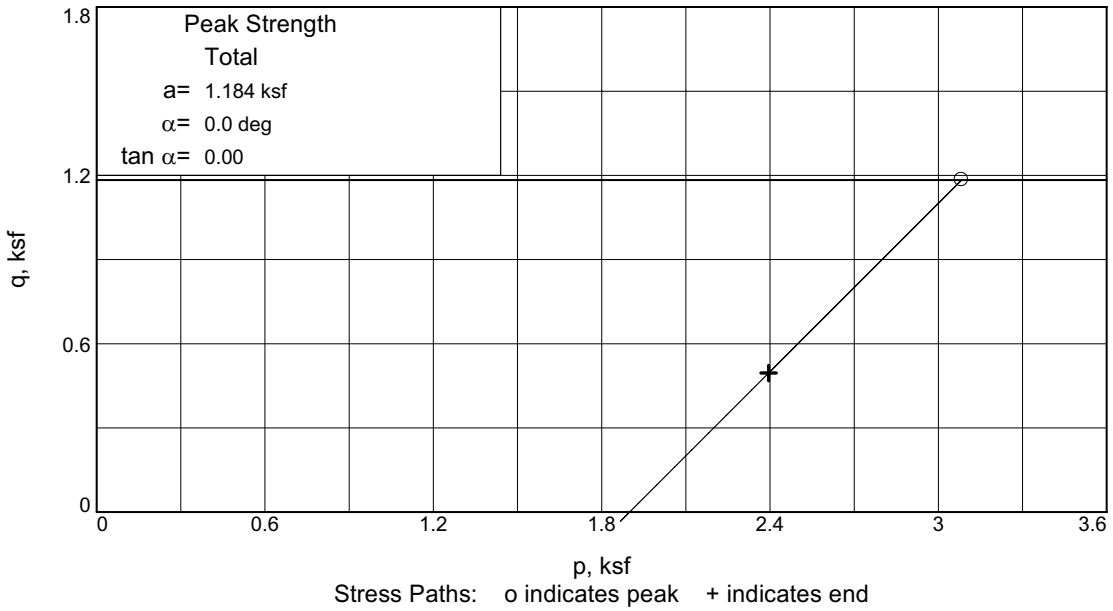
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Terracon Consultants, Inc.
Houston, TX











Client: Fluor Enterprises Inc Greenville, SC
Project: Project Tundra
Location: B-3 **Depth:** 14.5-16 ft.
Project No.: M2205062

Terracon Consultants, Inc.

APPENDIX E
CORROSION POTENTIAL TEST RESULTS

MVTL

MINNESOTA VALLEY TESTING LABORATORIES, INC.

1126 N. Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
2616 E. Broadway Ave. ~ Bismarck, ND 58501 ~ 800-279-6885 ~ Fax 701-258-9724
51 W. Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885

MEMBER ACIL

MVTL guarantees the accuracy of the analysis done on the sample submitted for testing. It is not possible for MVTL to guarantee that a test result obtained on a particular sample will be the same on any other sample unless all conditions affecting the sample are the same, including sampling by MVTL. As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of clients, and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval.

AN EQUAL OPPORTUNITY EMPLOYER

Report Date: 7 Oct 20
Lab Number: 20-M1949
Work Order #:81-0804
Account #: 002148
Date Sampled: 22 Sep 20
Date Received: 2 Oct 20 12:23
Sampled By: Client

Chad Cowley
Terracon
PO Box 2084
Bismarck ND 58502

Project Name: M2205062
Sample Description: DH-1 9 1/2-11

Temp at Receipt: Ambient

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH-Environmental	8.7	units	N/A	SW 846 9045D	2 Oct 20 16:24	HT
Sulfate	227	ug/g	12.3	ASTM D516-11	7 Oct 20 9:20	EV
Chloride	22.6	ug/g	2.49	SM4500-Cl-E	5 Oct 20 8:21	EV

Approved by: Claudette K. Carroll

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix # = Due to concentration of other analytes
! = Due to sample quantity + = Due to internal standard response

CERTIFICATION: ND # ND-00016

APPENDIX E

MVTL

MINNESOTA VALLEY TESTING LABORATORIES, INC.

1126 N. Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
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51 W. Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885

MEMBER ACIL

MVTL guarantees the accuracy of the analysis done on the sample submitted for testing. It is not possible for MVTL to guarantee that a test result obtained on a particular sample will be the same on any other sample unless all conditions affecting the sample are the same, including sampling by MVTL. As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of clients, and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval.

AN EQUAL OPPORTUNITY EMPLOYER

Report Date: 7 Oct 20
Lab Number: 20-M1950
Work Order #:81-0804
Account #: 002148
Date Sampled: 22 Sep 20
Date Received: 2 Oct 20 12:23
Sampled By: Client

Chad Cowley
Terracon
PO Box 2084
Bismarck ND 58502

Project Name: M2205062
Sample Description: B-2 4 1/2-6

Temp at Receipt: Ambient

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH-Environmental	8.0	units	N/A	SW 846 9045D	2 Oct 20 16:24	HT
Sulfate	357	ug/g	12.0	ASTM D516-11	7 Oct 20 9:20	EV
Chloride	92.7	ug/g	2.40	SM4500-Cl-E	5 Oct 20 8:21	EV

Approved by: Claudette K. Carroll

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix # = Due to concentration of other analytes
! = Due to sample quantity + = Due to internal standard response

CERTIFICATION: ND # ND-00016

APPENDIX F
PERMEABILITY TEST RESULTS

Terracon
1805 Hancock Dr / PO Box 2084 / Bismarck, North Dakota 58502
Telephone (701) 258-2833 / Fax (701) 258-2857

REPORT OF: TESTS OF SOILS - PERMEABILITY

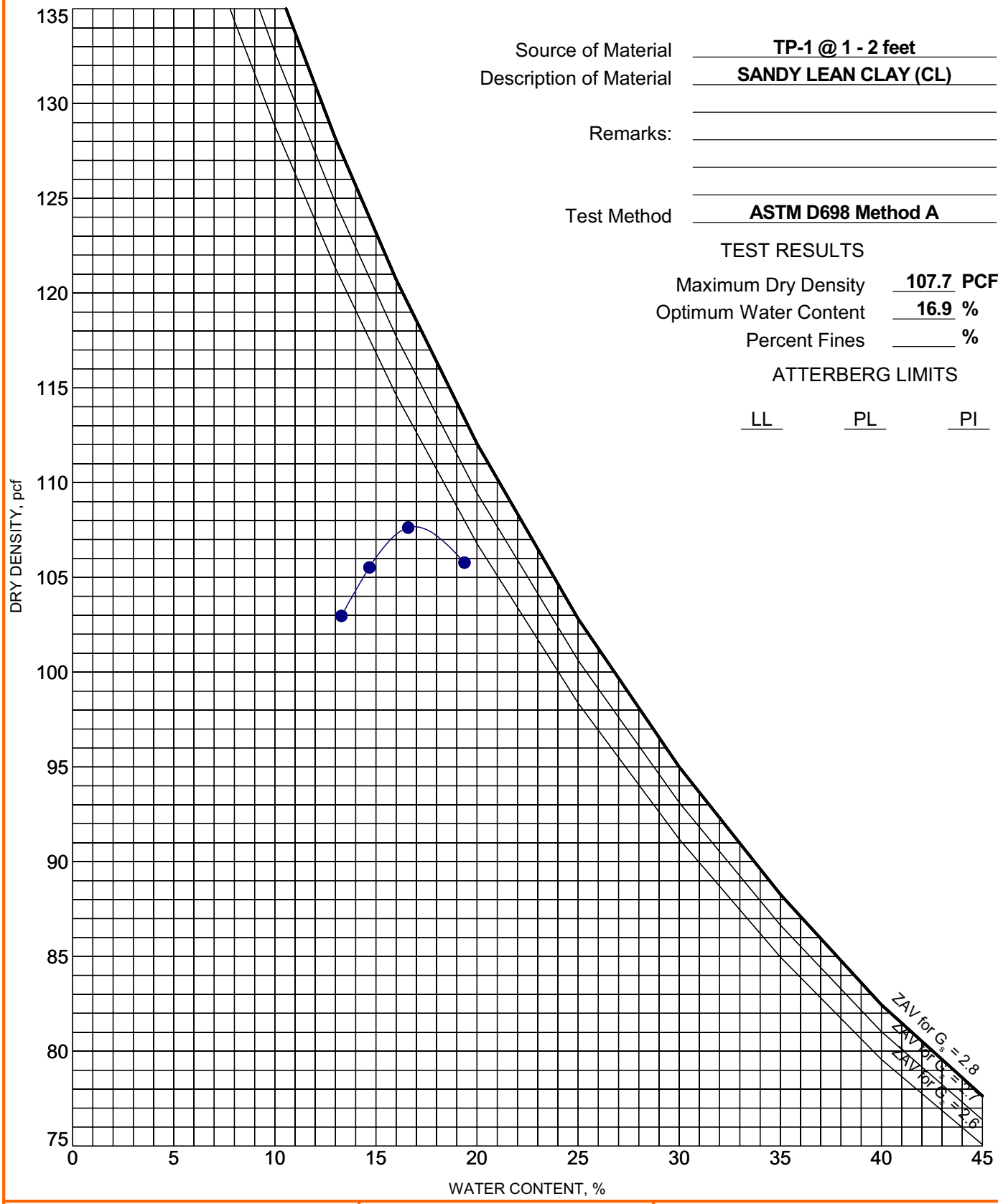
PROJECT:	Project Tundra 3401 24th St SW Center, North Dakota	DATE:	October 12, 2020
REPORTED TO:	Fluor Corporation Attn: David Alewine 100 Fluor Daniel Dr Mail Code C104B Greenville, SC 29607-2761	COPIES:	
PROJECT NO:	M2205052		

SAMPLE NUMBER:	TOS #1	TOS #2
LOCATION:	Borehole #1, depth 14½-16’	Borehole #4, depth 4-6’
CLASSIFICATION:	SILTY SAND (SM)	SILTY CLAYEY SAND (SC-SM)
COLOR:	Brown	Light brown
PARTICLE DISTRIBUTION:		
Gravel (%)	0	0
Sand (%)	60	66
Fines (%)	40	34
LABORATORY PERMEABILITY:		
Method	ASTM:D5856, Falling head Method	US Army Corps of Engineers, EM1110-2-1906 Appendix VII – Permeability Tests (modified)
Specimen Density (pcf)	105.4	98.2
Specimen Moisture Content (%)	19.2	17.8
Final Moisture Content (%)	23.0	20.1
Coefficient of Permeability (cm/sec)	8.7×10^{-5}	3.0×10^{-7}

APPENDIX G
PROCTOR TEST RESULTS

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material	**TP-1 @ 1 - 2 feet**
Description of Material	**SANDY LEAN CLAY (CL)**
Remarks:	
Test Method	**ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density	**107.7**	**PCF**
Optimum Water Content	**16.9**	**%**
Percent Fines		**%**

ATTERBERG LIMITS

LL	PL	PI

PROJECT: Project Tundra

SITE: 3401 24th Street SW
Center, ND

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

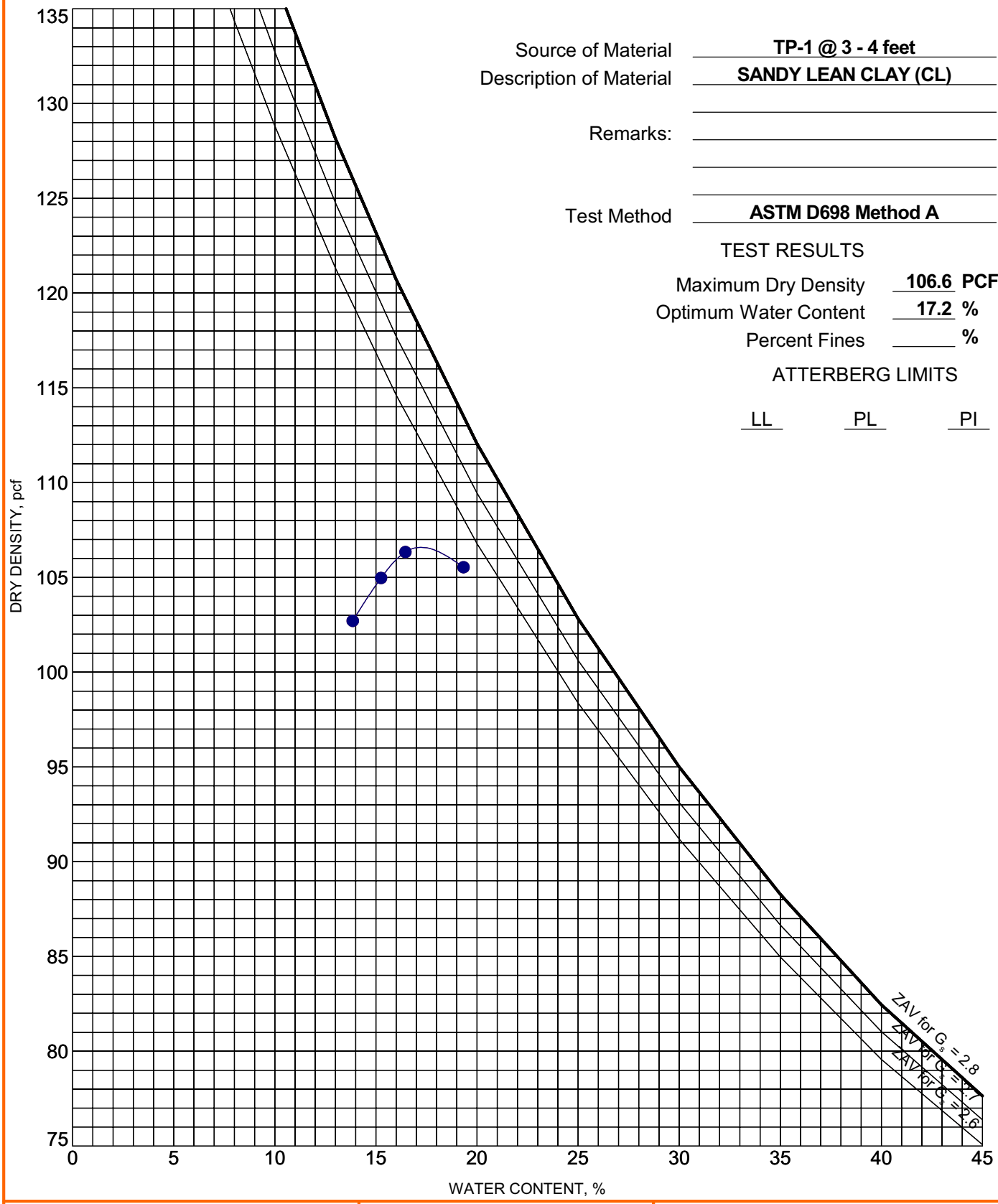
PROJECT NUMBER: M2205062
CLIENT: Fluor Enterprises Inc
Greenville, SC

APPENDIX G

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. COMPACTION - V2 M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/7/20

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material: **TP-1 @ 3 - 4 feet**

Description of Material: **SANDY LEAN CLAY (CL)**

Remarks:

Test Method: **ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density	**106.6**	**PCF**
Optimum Water Content	**17.2**	**%**
Percent Fines		**%**

ATTERBERG LIMITS

LL	PL	PI

PROJECT: Project Tundra

SITE: 3401 24th Street SW
Center, ND

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

PROJECT NUMBER: M2205062
CLIENT: Fluor Enterprises Inc
Greenville, SC

APPENDIX G

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. COMPACTION - V2 M2205062 PROJECT TUNDRA.GPJ TERRACON_DATATEMPLATE.GDT 10/7/20

APPENDIX H
CBR RESULTS

California Bearing Ratio of Laboratory-Compacted Soils

Client

Fluor Enterprises Inc
Greenville, SC

Project

Geotechnical Engineering Report
Project Tundra
Center, North Dakota

Project No. M2205062

SAMPLE INFORMATION

Sample Type:	Bulk Sample	Proctor Method:	ASTM D698-Method A
Boring Number:	TP-1	Maximum Dry Density (pcf):	107.7
Sample Location:	See Exploration Plan	Optimum Moisture (%):	16.9
Depth (ft.):	1-2	Liquid Limit:	NT
Material Description:	Sandy Lean Clay	Plasticity Index:	NT
		Percent Passing No. 200 Sieve:	NT

CBR TEST DATA

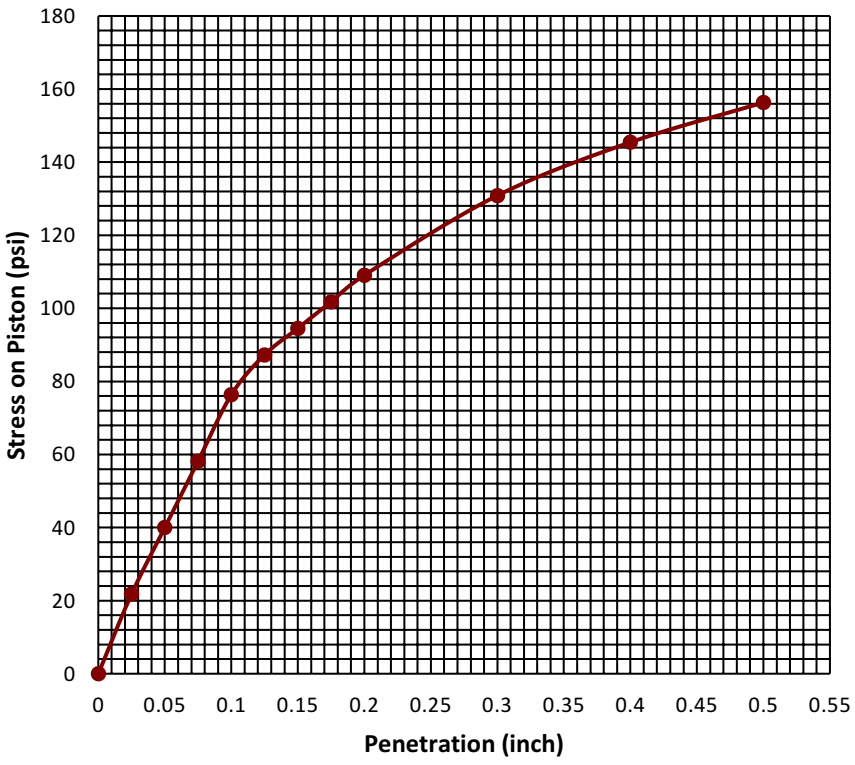
CBR Value at 0.100 inch:	**7.6**
CBR Value at 0.200 inch:	**7.3**
Surcharge Weight (lbs):	10
Soaking Condition:	Soaked
Length of Soaking (hours):	96
Swell (%):	3.4

DENSITY DATA

Dry Density Before Soaking (pcf):	102.6
Compaction of Proctor (%):	95.3

MOISTURE DATA

Before Compaction (%):	16.9
After Compaction (%):	16.9
Top 1" After Soaking (%):	25.9
Average After Soaking (%):	21.6



Comments:

Test Methods: ASTM D1883

California Bearing Ratio of Laboratory-Compacted Soils

Client

Fluor Enterprises Inc
Greenville, SC

Project

Geotechnical Engineering Report
Project Tundra
Center, North Dakota

Project No. M2205062

SAMPLE INFORMATION

Sample Type:	Bulk Sample	Proctor Method:	ASTM D698-Method A
Boring Number:	TP-1	Maximum Dry Density (pcf):	106.6
Sample Location:	See Exploration Plan	Optimum Moisture (%):	17.2
Depth (ft.):	3-4	Liquid Limit:	NT
Material Description:	Sandy Lean Clay	Plasticity Index:	NT
		Percent Passing No. 200 Sieve:	NT

CBR TEST DATA

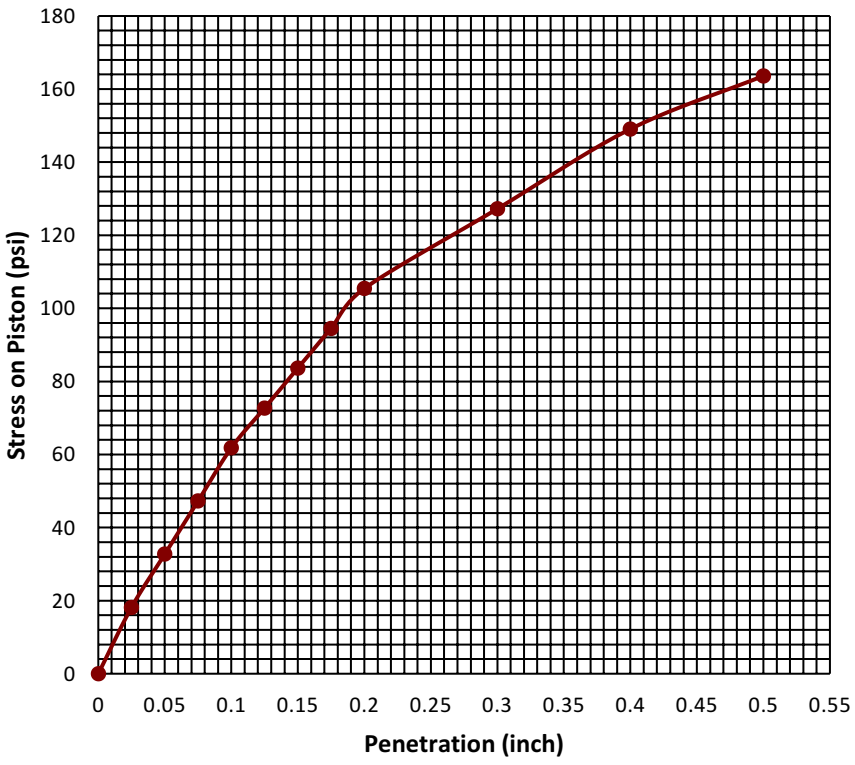
CBR Value at 0.100 inch:	**6.2**
CBR Value at 0.200 inch:	**7.0**
Surcharge Weight (lbs):	10
Soaking Condition:	Soaked
Length of Soaking (hours):	96
Swell (%):	3.6

DENSITY DATA

Dry Density Before Soaking (pcf):	102.0
Compaction of Proctor (%):	95.7

MOISTURE DATA

Before Compaction (%):	16.9
After Compaction (%):	16.9
Top 1" After Soaking (%):	23.9
Average After Soaking (%):	21.6



Comments:

Test Methods: ASTM D1883

APPENDIX I
SOIL LIQUEFACTION REPORT

16 October 2020

Project No. 2020-0008

PROJECT MEMORANDUM

To: **Rao Gudavalli, Terracon Consultants**

CC.:

From: **Spyros Giannakos and Jacob Chacko, GR8 GEO**

Subject: **Liquefaction Triggering Hazard Assessment for the Tundra Project, North Dakota, USA**

1 INTRODUCTION

The Tundra project is located near the south shoreline of Nelson Lake near Center, North Dakota (Figure 1). Terracon Consultants is conducting geotechnical assessment for the proposed carbon capture facility at the site. As part of the geotechnical program, Terracon Consultants has performed 5 borings and 9 Cone Penetration Tests (CPTs). GR8 GEO is supporting Terracon by performing liquefaction triggering hazard assessment for the project site in accordance with the requirements of the International Building code (IBC, 2018)

This memo presents the results of the liquefaction triggering assessment.



Figure 1. Project Location

2 DEVELOPMENT OF DESIGN SPECTRA

2.1 Site Class Assessment

Site classification of the project site per International Building Code (IBC, 2018) which is based on the provisions of ASCE 7-16 was performed for existing site grades using the subsurface information collected from the site investigation. Geotechnical boreholes (5 in total) with Standard Penetration

Tests (SPT) and nine (9) Cone Penetration Tests (CPT) were performed by Terracon Consultants. Borings were drilled to depths ranging from 61 to 121 ft while the Cone Penetration Tests (CPT) were conducted to depths ranging from 16 to 55 ft. The top layer consists of fill material of mainly silty sand of varying thickness with a maximum thickness of 12ft. This layer is underlain by a sand layer with varying fines content which overlies a very stiff to very hard clay layer. The surface elevation of the performed explorations ranges from approximately 1983 to 2039 ft while we understand the final site grade will be 1988 ft.

Table 1. Empirical Shear Wave Velocity Correlations from SPT Data

Reference	Soil Type	Correlated Parameters	Correlations
Ohta and Goto (1978)	All	SPT blow count (N_{60}) Depth, D	$66.9*N_{60}^{0.21}*D^{0.19}$
Wair et al. (2012)	All	SPT blow count (N_{60}) Effective vertical stress, σ'_v	$Vs = a*N_{60}^{b}*\sigma'^{c}_{v}*d$ where V_s – Shear wave velocity in m/s a, b, and c – Regression parameters depend on soil type d – Age Scaling Factor

Table 2. Empirical Shear Wave Velocity Correlations from CPT Data

Reference	Soil Type	Correlated Parameters	Correlations
Mayne (2006)	All	• Sleeve friction, fs	$V_s = 118.8 * \log(f_s)+18.5$ where V_s in m/s, and f_s in kilopascals (kPa).
Andrus et al. (2007)	All	• Total cone tip resistance, q_t • Soil behavior type index, I_c • Depth, D • Age scaling factor, SF	$Vs = 2.62\ (q_t)^{0.395} * I_c^{0.912} * D^{0.124} * SF$ where; V_s in m/s depth D in m q_t in kilopascals (kPa) SF = 0.92 for Holocene soil and 1.12 for Pleistocene soil.
Robertson (2009)	All	• Total cone tip resistance, q_t • Soil behavior type index, I_c • Effective vertical stress, σ'_v	$Vs = [(10^{(0.55Ic+1.68)})\ (q_t - \sigma_v) / pa]^{0.5}$ where; V_s in m/s σ_v and q_t in kilopascals (kPa) pa = 100 kPa SF = 0.92 for Holocene soil and 1.12 for Pleistocene soil.

The time-weighted average shear wave velocity in the top 30 meters (V_{s30}) is an important input parameter for the purpose of assigning a Site Class. V_{s30} is calculated using the shear wave velocity (V_s) data to a depth of 30 meters (100 ft). Dynamic subsurface conditions were characterized by means of: a) empirical correlations between SPT data from 5 borings extending to a maximum depth of 121 ft depth and shear wave velocity V_s from Ohta and Goto (1978) and Wair et al (2012), and b) empirical correlations between CPT data extending to approximately 61 ft depth and shear wave velocity V_s from Mayne (2006), Andrus et al (2007) and Robertson (2009). Table 1 and Table 2 present the empirical correlations between SPT and CPT tip resistance to shear wave velocity, respectively.

Figure 2-1 presents the development of the shear wave velocity profile based on the available geotechnical data. Shown on this figure are: (a) V_s estimates from the CPT data using empirical correlations, (b) V_s estimates from the SPT data using empirical correlations, and (c) the idealized shear wave velocity profile for the existing site conditions. The estimated V_{s30} value for the existing grades is approximately 820 ft/s while the estimated V_{s30} value for the final grade is approximately 987 ft/s. Thus, for both as-is and final grades, the project site is categorized as Site Class D per ASCE 7-16.

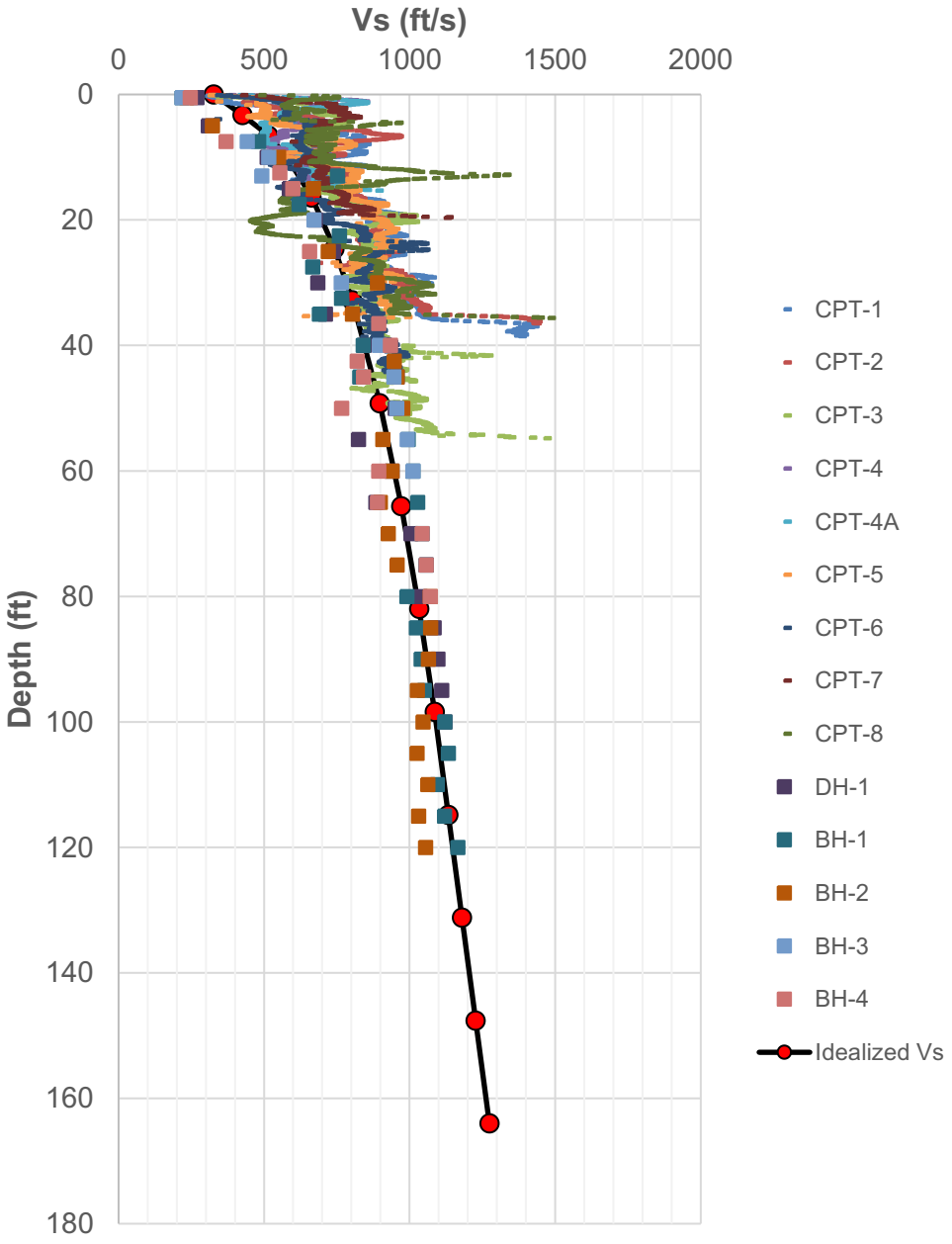


Figure 2. Development of Idealized Shear Wave Velocity Profile

2.2 Code-based Spectra

Design acceleration parameters and spectra were developed per the requirements of the International Building Code (IBC, 2018) which is based on the provisions of ASCE 7-16. For this study, code-based ground motion criteria were developed per the provisions of Chapter 11 of ASCE 7-16.

Design ground motion criteria were developed for Site Class D based on the site classification described above.

ASCE 7-16 defines a Risk-adjusted Maximum Considered Earthquake (MCE_R) spectrum and a Design Spectrum. The MCE_R corresponds to the lesser of: (a) the risk-adjusted UHS corresponding to a return period of 2,475-years (i.e., 2 percent probability of exceedance in 50 years); and (b) the median + 1 standard deviation deterministic spectrum calculated for characteristic earthquakes on all known active faults within the region (Section 21.2.2 of ASCE 7-16). The spectra are computed for the direction of the maximum component of ground motion. The design earthquake (DE) response spectrum is calculated as 2/3 of MCE_R, along with some other checks pertaining to spectral shape.

For this study, code-based ground motion design parameters and spectra were developed using the online U.S. ASCE 7 Hazard Tool web application (ASCE) (https://asce7hazardtool.online) recommended by USGS. The geographical coordinates of the project location used for the development of the code-based design parameters are tabulated in Table 3.

Table 3. Project Location Coordinates

Longitude	Latitude
47.065000	-101.216667

The resulting seismic design criteria are presented in Table 4 for Site Class D (Stiff Soil).

Table 4. Summary of IBC (2018)/ASCE 7-16 Seismic Design Parameters

Parameter	Value
Site Class	D
Mapped MCE_R, 5% Damped, Spectral Response Acceleration Parameter at Short Period (0.2 Second), S_S (g)	0.052
Mapped MCE_R, 5% Damped, Spectral Response Acceleration Parameter at 1.0 Second, S_1 (g)	0.022
MCE_R, 5% Damped, Spectral Response Acceleration at Short Period (0.2 Second) Adjusted for Site Class Effects, S_{MS} (g)	0.083
MCE_R, 5% Damped, Spectral Response Acceleration at a Period of 1.0 Second Adjusted for Site Class Effects, S_{M1} (g)	0.054
Design, 5% Damped, Spectral Response Acceleration at Short Period (0.2 Second), S_{DS} (g)	0.055
Design, 5% Damped, Spectral Response Acceleration at a Period of 1.0 Second, S_{D1} (g)	0.036
Long-period Transition Period, T_L (sec)	4
Short Period Site Coefficient (0.2 Second), F_a	1.6
Long Period Site Coefficient at 1.0 Second, F_v	2.4
Mapped MCE_G Peak Ground Acceleration, PGA	0.023
MCE_G Peak Ground Acceleration Adjusted for Site Class Effects, PGA_M	0.037
Site Coefficient for Peak Ground Acceleration, F_{PGA}	1.6
Vertical Coefficient, C_v	0.7

3 LIQUEFACTION TRIGGERING HAZARD ASSESSMENT

3.1 Introduction

As very loose to medium dense saturated granular soils are shaken, their tendency to contract and compress may lead to the development of positive pore pressures. If the seismic shaking is strong

and long enough, the build-up in pore pressure can produce a significant loss of shear strength. Liquefaction occurs when the excess pore pressure equals the initial effective stress in the soil. If the shaking continues after the onset of liquefaction, ground distress may occur (e.g., sand boils, settlement, lurching, and lateral deformation). Liquefaction may also cause a loss of axial capacity of shallow or deep foundations, loss of lateral pile capacity or stiffness, and lateral ground spreading.

The susceptibility of a granular soil to liquefaction is a function of the gradation, density, aging/cementation, and fines content of the soil. The resistance to liquefaction increases with respective increases in: a) distribution of grain size, b) soil density, c) aging/cementation, d) fines content, and e) plasticity characteristics of the fines.

This section presents a summary of the procedures adopted and the results from the liquefaction potential evaluations at the site.

3.2 Basis of Evaluation

The liquefaction analyses presented herein are based on:

- Cyclic stress ratio (CSR) evaluated from the earthquake parameters based on ground motion evaluations presented in Section 2.
- Cyclic resistance of the deposit evaluated from cone penetration test (CPT) tip resistance data and from standard penetration test (SPT) data.

The Peak Ground Acceleration (PGA) and earthquake magnitude are used to estimate the seismically induced demand or cyclic stress ratio (CSR). The CPT data and SPT data were used to evaluate the liquefaction resistance or cyclic resistance ratio (CRR) in the liquefiable layers. The factor of safety (FOS) against liquefaction was then calculated as the ratio of the CRR to the CSR (FOS = CRR/CSR). Liquefaction evaluation was conducted based on Boulanger and Idriss (2014) method. This method is largely based on databases of liquefaction/non-liquefaction of Holocene-age siliceous sands.

Accurate depths to the ground water table were not available from the site geotechnical data as ground water was not observed in the boreholes. This may in part be due to the primarily fine-grained nature of the site for which long term measurements (perhaps with piezometers) would be required to assess the water level. We note, however, that in a few CPTs pore pressure responses were observed at shallow depth. For these evaluations, existing site grades were considered and the water table was conservatively assumed to be at the ground surface.

The liquefaction triggering hazard evaluation was performed for the MCE_G level (Maximum Considered Earthquake Geometric Mean Peak Ground Acceleration) per ASCE 7-16. Based on the deaggregation from the online Unified Hazard USGS web application (USGS) (https://earthquake.usgs.gov/hazards/interactive) the majority of the hazard for the project site derives from M_w 6.5 magnitude earthquakes. The Peak Ground Acceleration (PGA) for MCE_G level as presented in Section 2 is 0.037 g. This PGA value was used for the liquefaction evaluations (Table 5).

Table 5. Earthquake Scenarios for Liquefaction Evaluation Analyses

EQ Event	PGA (g)	Magnitude
MCE_G	0.037	6.5

3.3 Evaluation of Seismically Induced Cyclic Demand

In liquefaction triggering evaluations, the seismic demand is expressed by means of the earthquake induced cyclic stress ratio (CSR)

$$CSR = 0.65 \cdot \frac{\sigma_{vo}}{\sigma'_{vo}} \cdot \frac{a_{\max}}{g} \cdot r_d \quad (3\text{-}1)$$

where: σ_{vo} and σ'_{vo} are the vertical total and effective stress, respectively; a_{max} is the peak ground acceleration; and r_d is a depth varying acceleration reduction factor.

The magnitude of the seismically induced shear stresses was estimated according to the Boulanger and Idriss (2014) procedures through the estimation of the Cyclic Stress Ratio (CSR). The estimated earthquake and depth-specific CSR is converted to a reference magnitude of 7.5 and effective vertical effective stress of 1 atm by means of the magnitude scaling factor (MSF) and overburden correction factor (K_σ) as shown in the following equation.

$$CSR_{M=7.5,\sigma'=1atm} = CSR \cdot \frac{1}{MSF} \cdot \frac{1}{K_\sigma} \quad (3\text{-}2)$$

For example, if the controlling magnitude event is greater than the reference magnitude of 7.5, a MSF less than 1 is applied to increase the equivalent cyclic stress ratio due to the higher number of cycles imparted by the larger magnitude event. As tabulated in Table 5, a controlling magnitude of 6.5 was used in the liquefaction potential evaluation.

Magnitude scaling factors (MSF) were estimated using the Boulanger and Idriss (2014) procedure. The calculated CSR values were multiplied by the appropriate magnitude weighting factor to obtain equivalent CSR for a reference magnitude 7.5 earthquake (CSR7.5). Magnitude 7.5 earthquakes are estimated to produce about 15 equivalent cycles of uniform loading.

3.4 Cyclic Resistance to Liquefaction From CPT Data

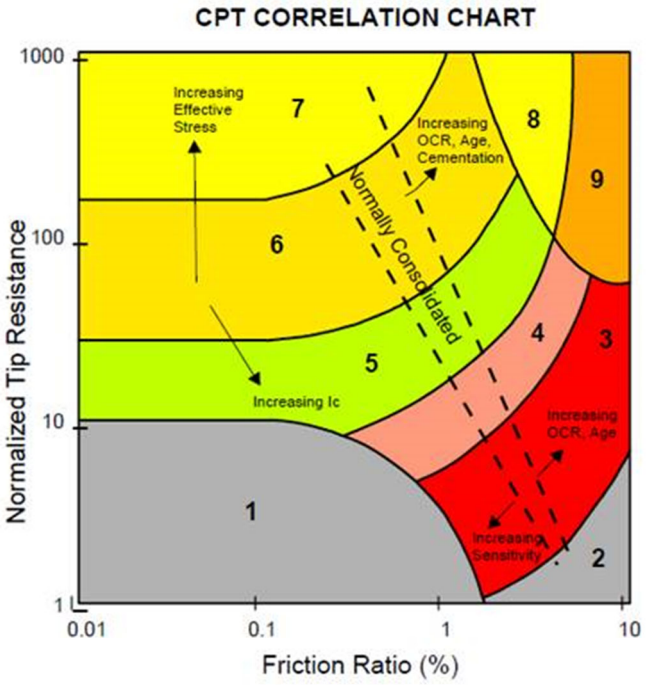
The evaluation of the liquefaction resistance of cohesionless layers from cone penetration test (CPT) data was based on the empirical procedures recommended by Boulanger and Idriss (2014). For these analyses, the measured tip resistances were corrected for fines content and normalized to an overburden pressure of 1 atmosphere (~0.1 MPa).

The site conditions indicate the presence of lignite and coal layers within the strata indicating that the native soils are most likely older than Holocene age. For this study the additional cyclic resistance due to ageing has conservatively been ignored.

The fines content was estimated from the CPT measured tip resistance and sleeve friction ratio using the procedure suggested in Boulanger and Idriss (2014). Based on this procedure the CPT friction ratio (sleeve resistance f_s divided by cone tip resistance q_c) generally increases with increasing fines content and soil plasticity, allowing rough estimates of soil type and fines content to be estimated from CPT data. Figure 3 presents the key to CPT characterization per Robertson (1990).

The available cyclic shear resistance of the potentially liquefiable strata encountered was compared to the estimated cyclic shear stress that would be induced for a given design level. The estimated factor of safety against liquefaction is the ratio of the available cyclic shear resistance to the induced cyclic shear stress.

In some cases, a thin layer correction factor is applied to the raw cone tip resistance using methods described in Youd et al. (2001). This correction was applied if a thin (i.e., less than 1 meter thick) sand layer existed immediately above a softer clay or silt layer.



Zone	Soil Behavior Type
1	Sensitive Fine-grained
2	Peats
3	Silty Clay to Clay
4	Clayey Silt to Silty Clay
5	Silty Sand to Sandy Silt
6	Clean Sand to Silty Sand
7	Gravelly Sand to Dense Sand
8	Very Stiff Sand to Clayey Sand*
9	Very Stiff Fine-Grained*

*heavily overconsolidated or cemented

Figure 3. Key to CPT Characterization

3.5 Cyclic Resistance to Liquefaction from SPT Data

The evaluation of the liquefaction resistance of cohesionless layers from SPT data from the borings was based on the empirical procedures recommended by Boulanger and Idriss (2014). Correction factors proposed by this method were applied on the SPT N values measured in the field to derive the N_{60} values. The N_{60} values were corrected for overburden ($N_{1,60}$) and for fines content. The fine content values used for each layer was based on the characterization of each layer from the boring logs.

3.6 Results

3.6.1 Results from CPT Data

CPT-based simplified liquefaction triggering evaluations were performed using Boulanger and Idriss (2014) empirical correlation for MCE_G shaking level. CSR was estimated based on a PGA value of 0.037g. Results of the liquefaction triggering analyses of 9 CPTs from the site (i.e. CPT-1, CPT-2, CPT-3, CPT-4, CPT-4A, CPT-5, CPT-6, CPT-7 and CPT-8) for the existing conditions are included in Appendix A for the MCE_G shaking level.

Example results are shown for CPT-1 on Figure 4. Shown for the CPT data on this figure and in Appendix A are:

- Panel 1 - the measured CPT tip resistance together with the tip resistance required to produce a factor of safety against liquefaction of 1. When the latter is lower than the measured tip resistance, the area between the two lines is shaded blue (denoting liquefiable soils).
- Panel 2 - The measured friction ratio;
- Panel 3 - The estimated soil behaviour index (I_c);
- Panel 4 - The estimated CSR from Boulanger and Idriss (2014) (blue line) and the estimated CRR (red line) using Boulanger and Idriss (2014) correlation with Youd et al (2001) thin layer correction; and
- Panel 5 - The estimated factor of safety against liquefaction

The colour coding used on Panels 1 to 3 for the CPT data are the soil behaviour types per the classification chart of Robertson (1990) as shown on Figure 3. A review of the CPT liquefaction triggering evaluation results for MCE_G shaking level indicates liquefaction is not expected to occur.

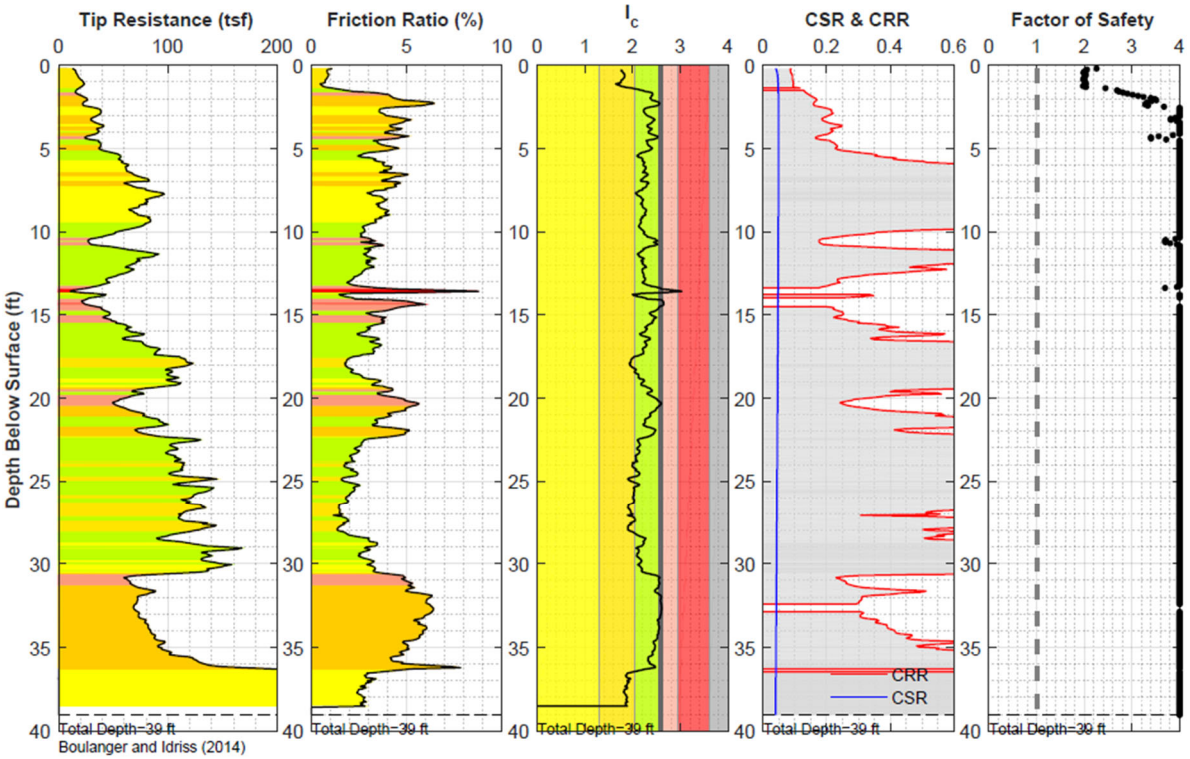


Figure 4. Liquefaction Triggering Assessment CPT Log, CPT-1, Boulanger and Idriss (2014)

3.6.2 Results from SPT Data

SPT-based simplified liquefaction triggering evaluations were performed using Boulanger and Idriss (2014) empirical correlation for MCE_G shaking level. CSR was estimated based on a PGA value of 0.037g. Results of the liquefaction triggering analyses of 5 boreholes with SPT data from the site (i.e. BH-1, BH-2, BH-3, BH-4 and DH-1) for the existing conditions are included in Appendix B for the MCE_G shaking level. The safety factor is provided for the cases where it is less than two.

Example results are shown for DH-1 on Figure 5. Shown for the SPT data on this figure and in Appendix B are:

- Panel 1 – Measured N_{60} values.
- Panel 2 - The estimated CSR from Boulanger and Idriss (2014) (blue line) and the estimated CRR (red points) using Boulanger and Idriss (2014); and
- Panel 3 - The estimated factor of safety against liquefaction

A review of the SPT liquefaction triggering evaluation results for MCE_G shaking level indicates liquefaction is not expected to occur.

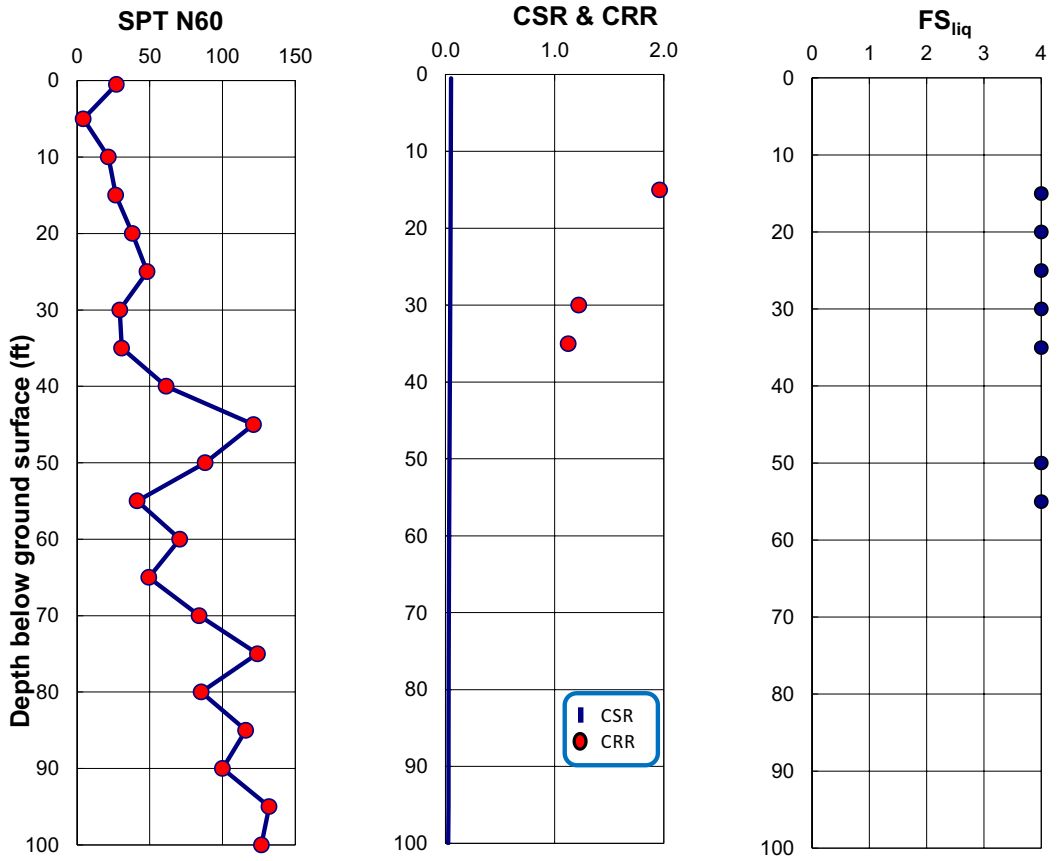


Figure 5. Liquefaction Triggering Assessment SPT Log, DH-1, Boulanger and Idriss (2014)

3.6.3 Consideration of Changes in Site Grades

The above evaluations were conducted using existing site grades. We note that in areas where the site grades will be lowered, somewhat higher cyclic stresses could be computed as the depth to a given soil layer reduces, however the overburden and fines corrected cyclic resistance will largely be

unchanged or slightly increased. Figure 6 shows a comparison of the CSR for existing grades compared with the CSR for final grades for the exploration with the highest existing site grades. As shown on this figure the ratio of the CSR for the final site grades versus existing site grades is typically less than 1.5. Given that the factors of safety are high typically > 3, even increasing the cyclic stress ratio by a factor of 1.5 will not alter the conclusions derived from the analyses for existing site grades.

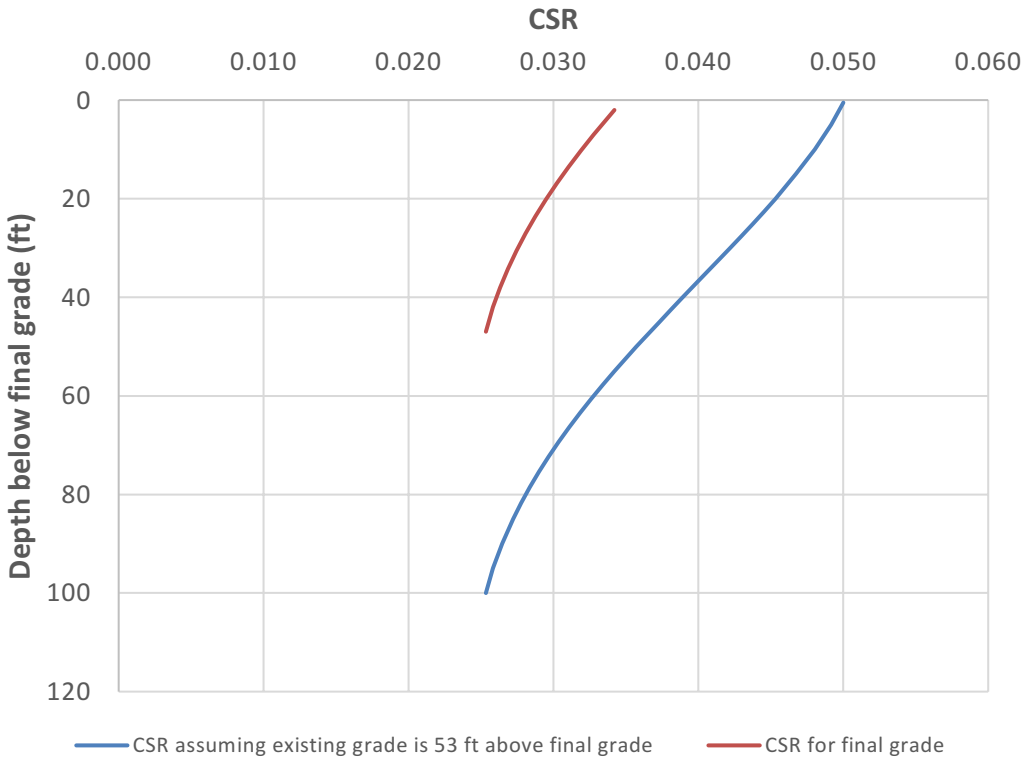


Figure 6. Comparison of CSR at the existing and final grade from DH-1

3.6.4 Summary

As shown on the figures of Appendix A and B, liquefaction is not expected to occur at the coarse-grained layers encountered at the project site as the estimated factors of safety against liquefaction is larger than 2.0 throughout the site. These results suggest that liquefaction is unlikely under both MCE_G and Design Earthquake levels. The analyses conservatively assume that the soil layers below surface are submerged. We note that in cut areas, a higher cyclic stress level maybe considered for layers that are now closer to the ground surface. However, even considering a worst case scenario, this increase in demand does not impact the main conclusions related to liquefaction.

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APPENDIX A
CPT-BASED LIQUEFACTION TRIGGERING HAZARD ASSESSMENT RESULTS

Soil Liquefaction Report
Tundra Carbon Capture & Sequestration (CSS) Project
Center, North Dakota
Terracon Report No. M2205062

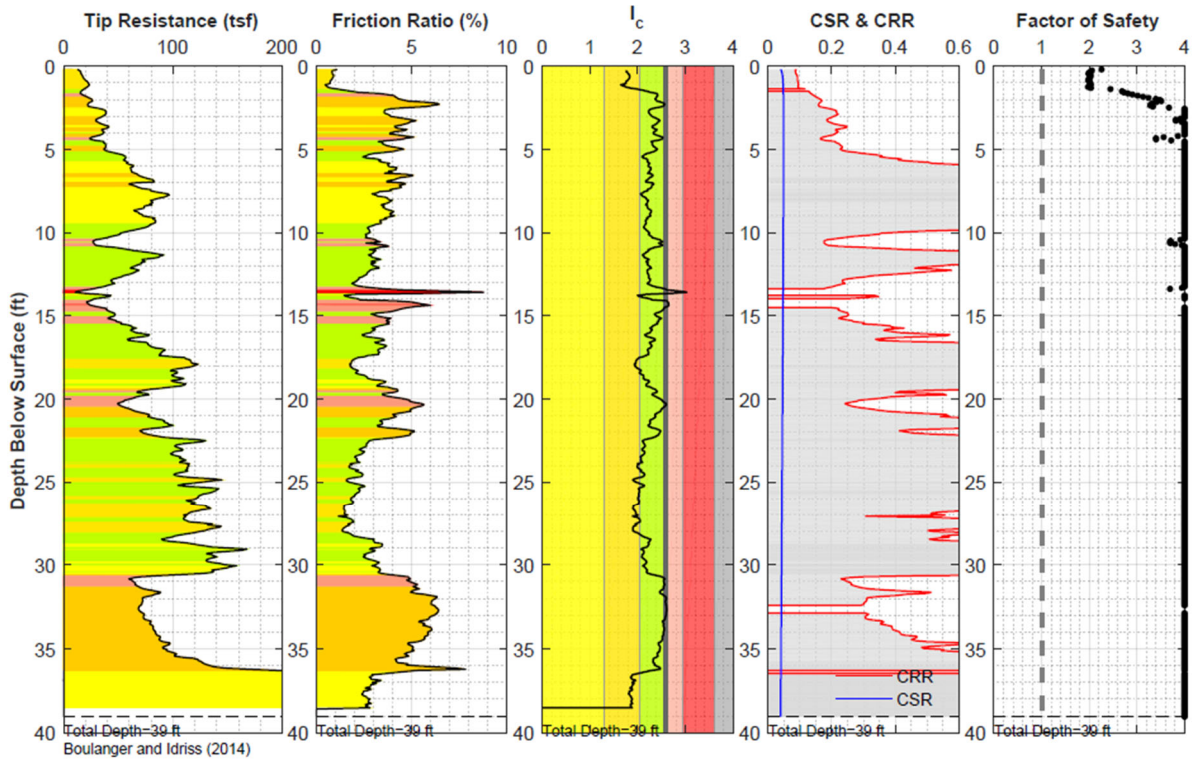


Figure A-1. CPT-Based Liquefaction Triggering Assessment of Boring CPT-1 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

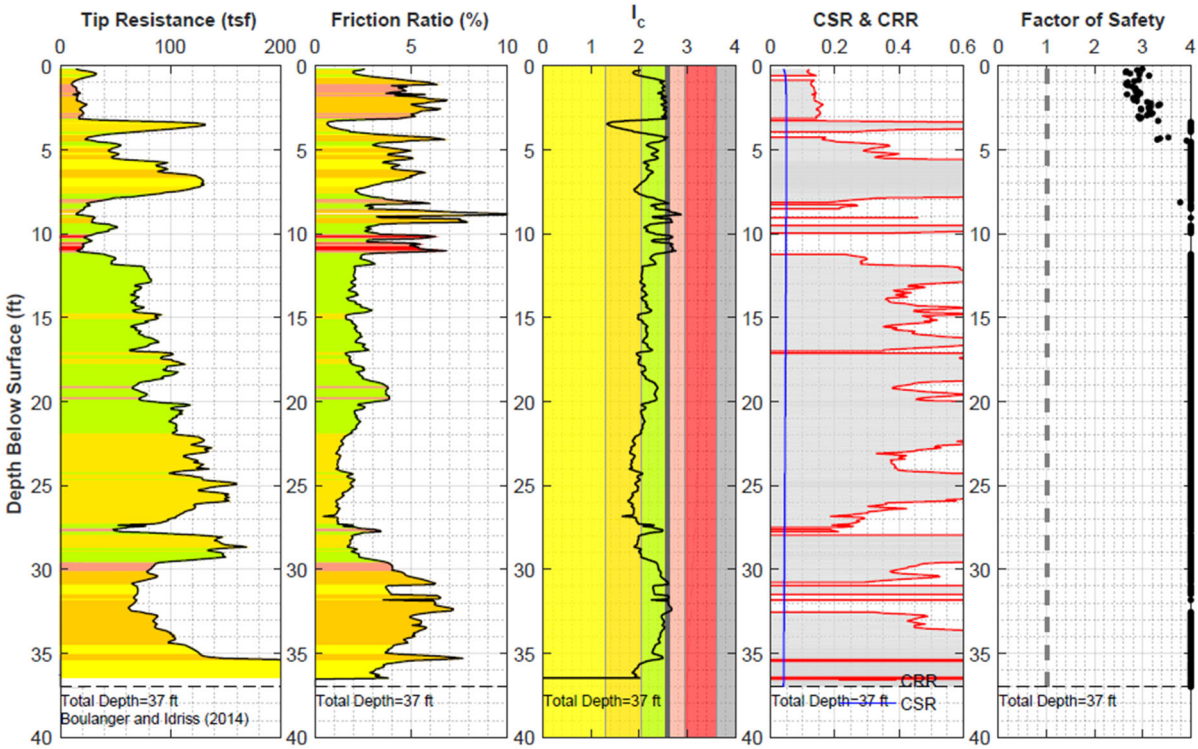


Figure A-2. CPT-Based Liquefaction Triggering Assessment of Boring CPT-2 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

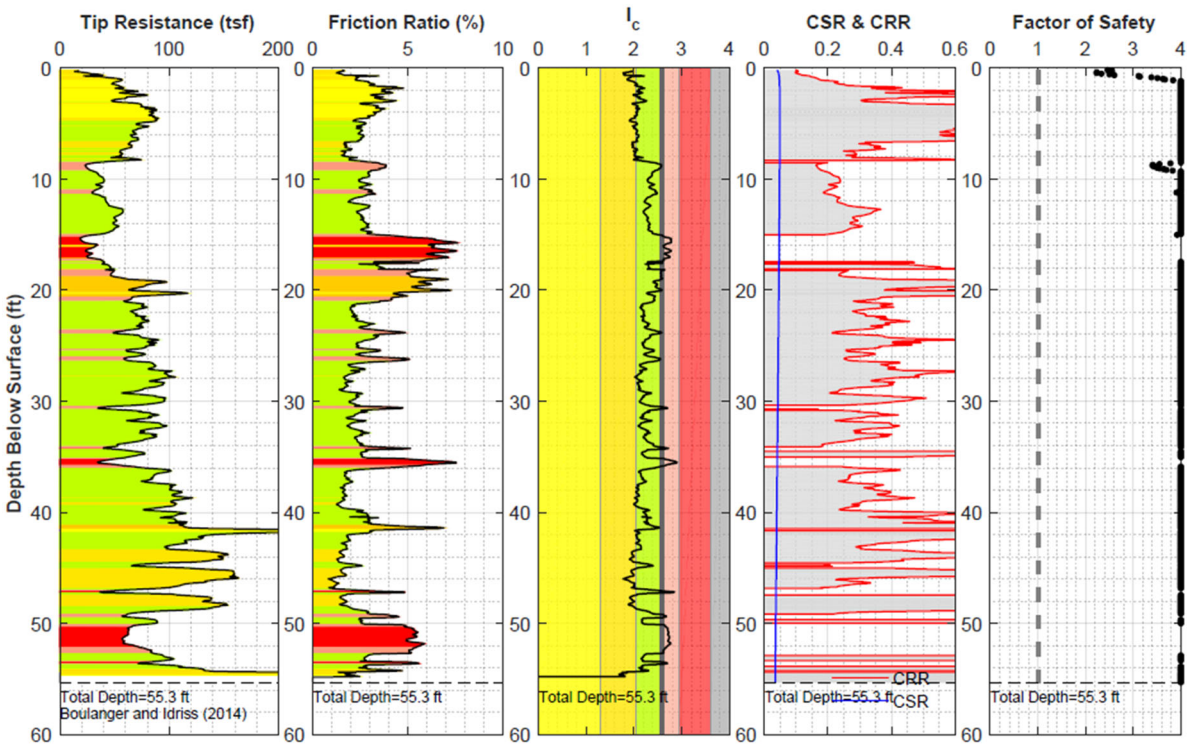


Figure A-3. CPT-Based Liquefaction Triggering Assessment of Boring CPT-3 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

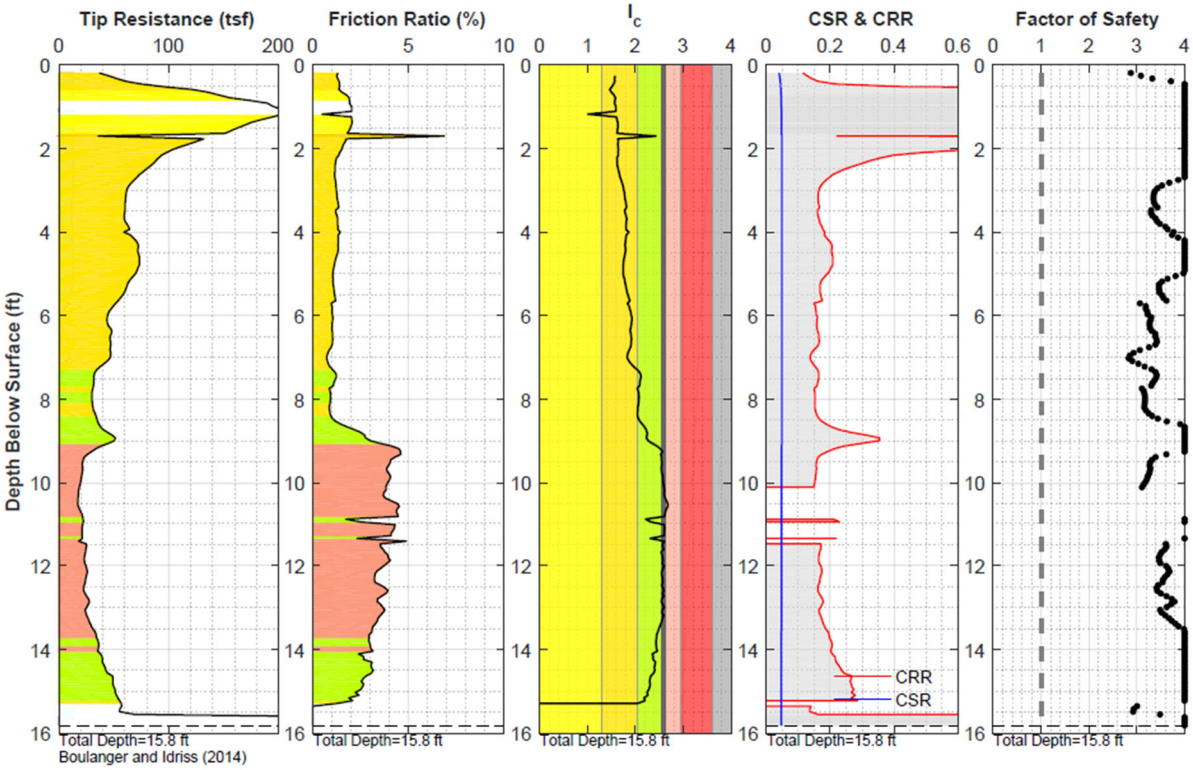


Figure A-4. CPT-Based Liquefaction Triggering Assessment of Boring CPT-4 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

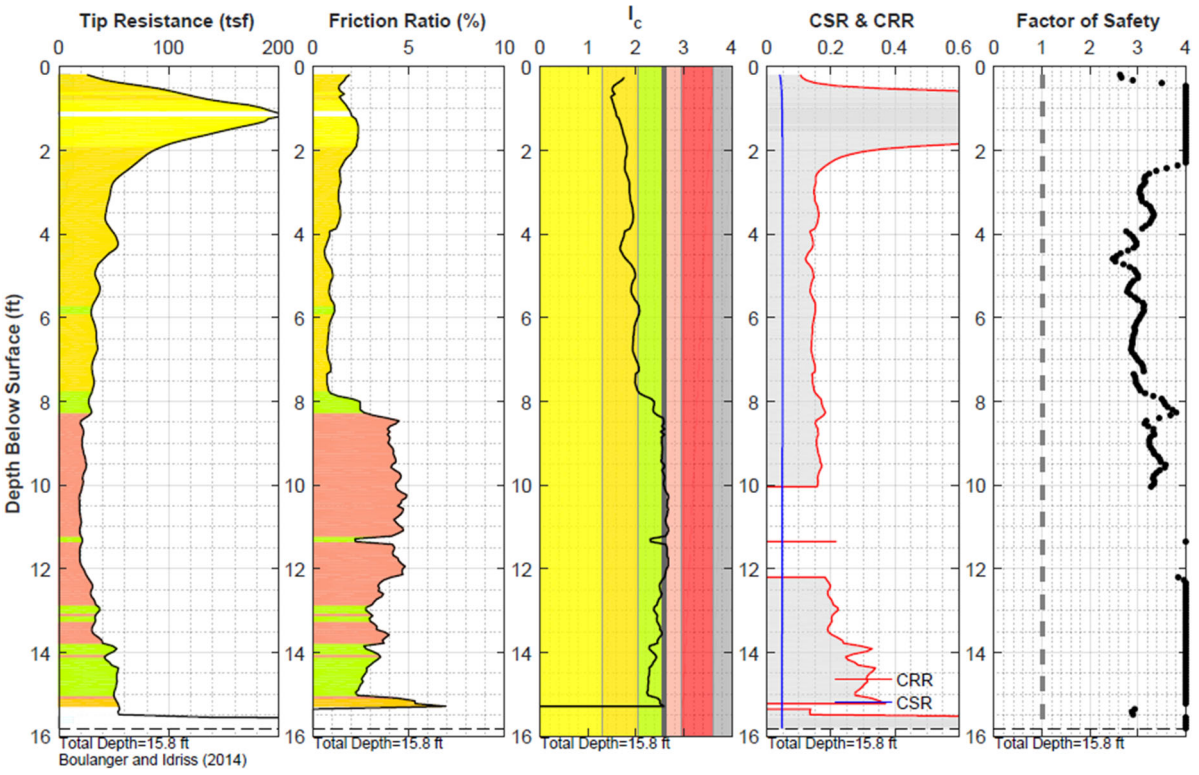


Figure A-5. CPT-Based Liquefaction Triggering Assessment of Boring CPT-4A for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

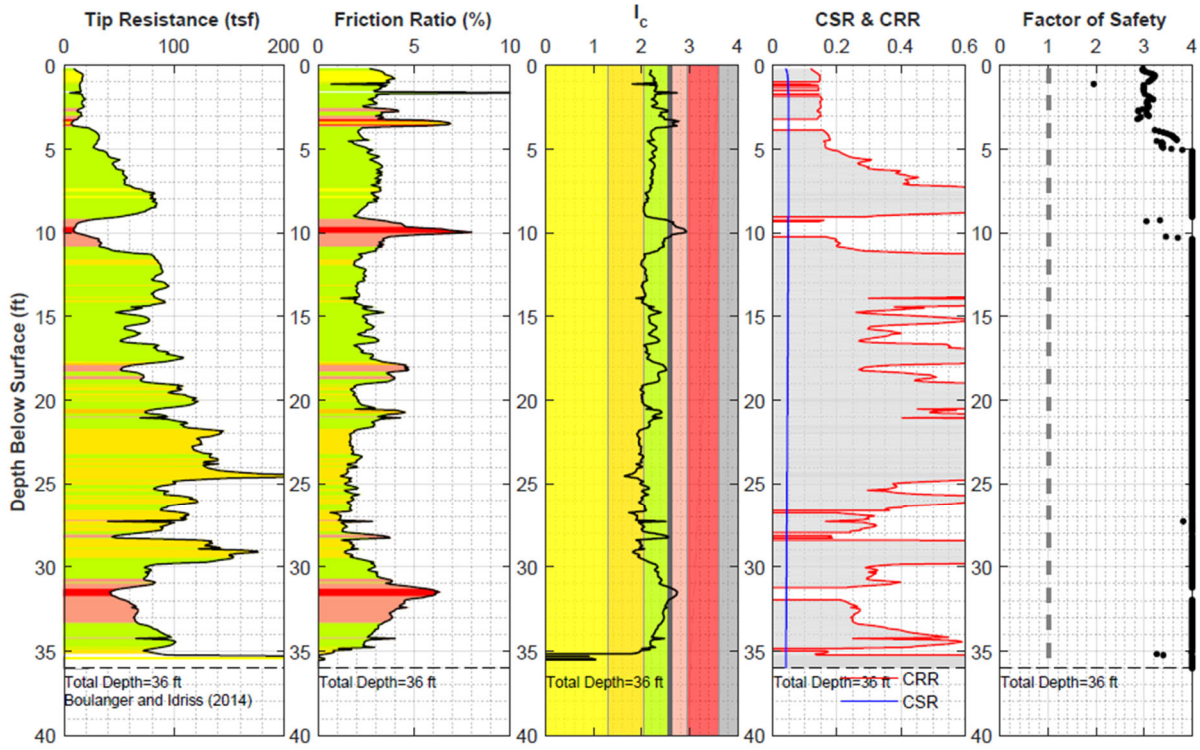


Figure A-6. CPT-Based Liquefaction Triggering Assessment of Boring CPT-5 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

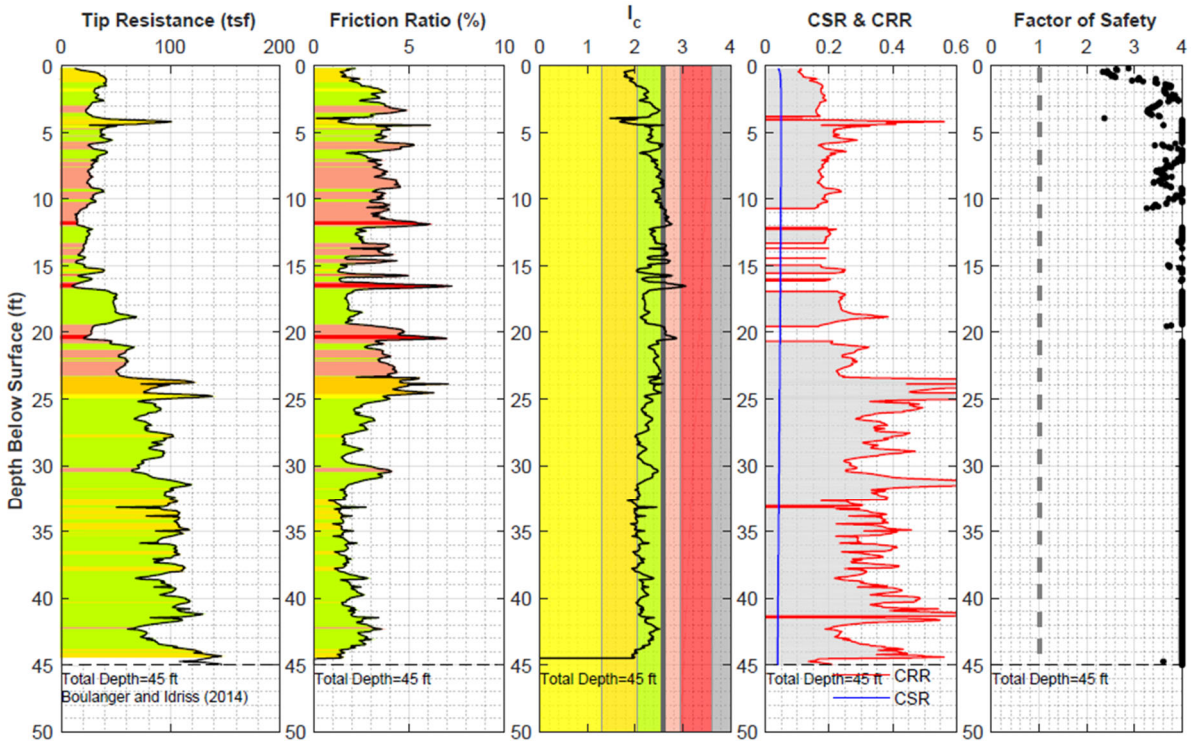


Figure A-7. CPT-Based Liquefaction Triggering Assessment of Boring CPT-6 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

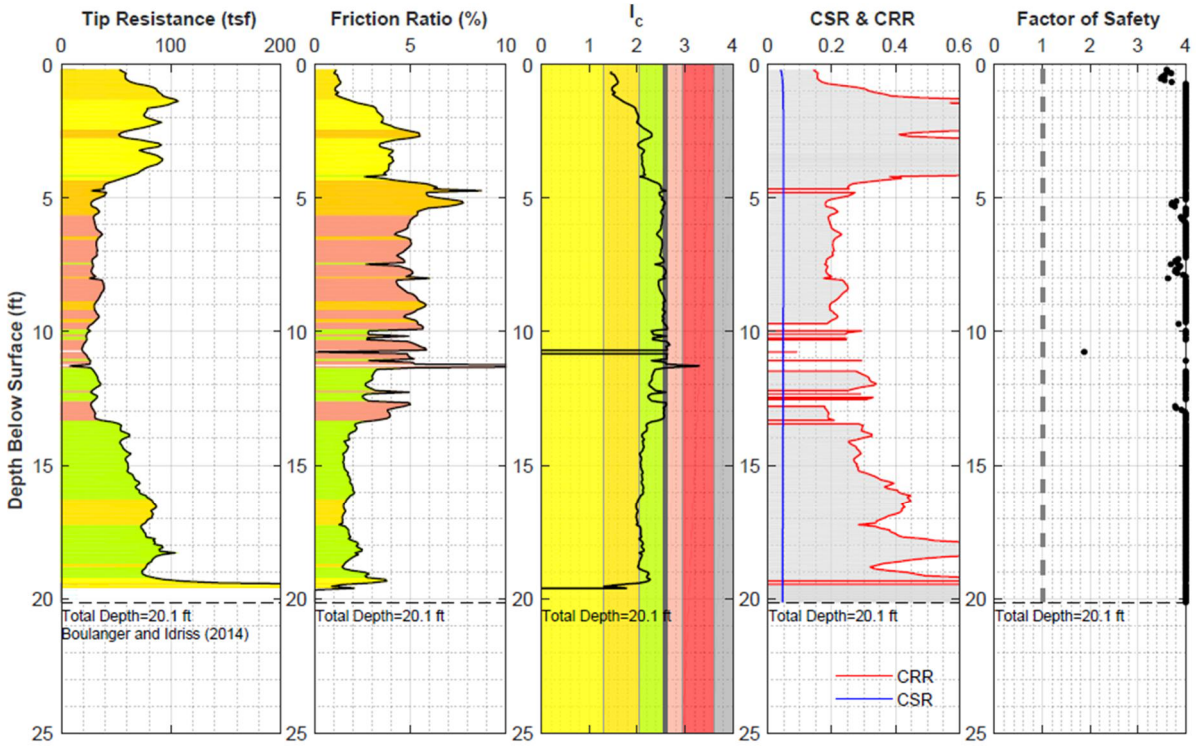


Figure A-8. CPT-Based Liquefaction Triggering Assessment of Boring CPT-7 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

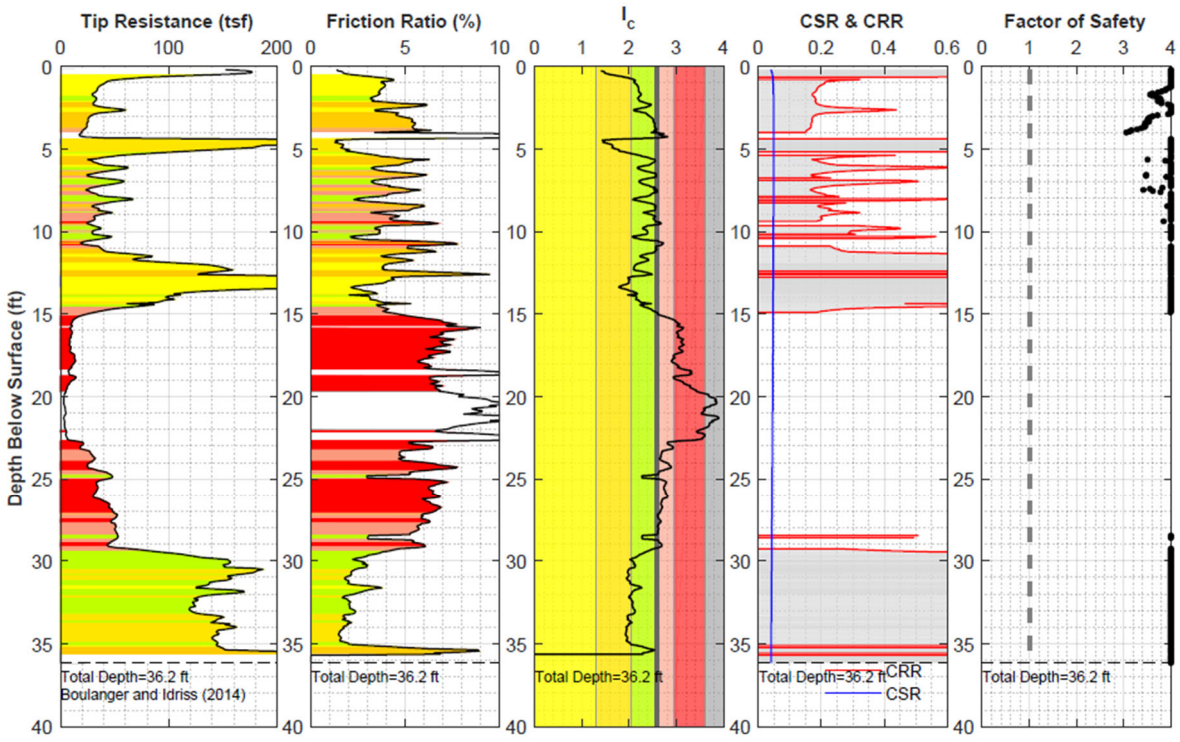


Figure A-9. CPT-Based Liquefaction Triggering Assessment of Boring CPT-8 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

APPENDIX B
SPT-BASED LIQUEFACTION TRIGGERING HAZARD ASSESSMENT RESULTS

Soil Liquefaction Report
Tundra Carbon Capture & Sequestration (CSS) Project
Center, North Dakota
Terracon Report No. M2205062

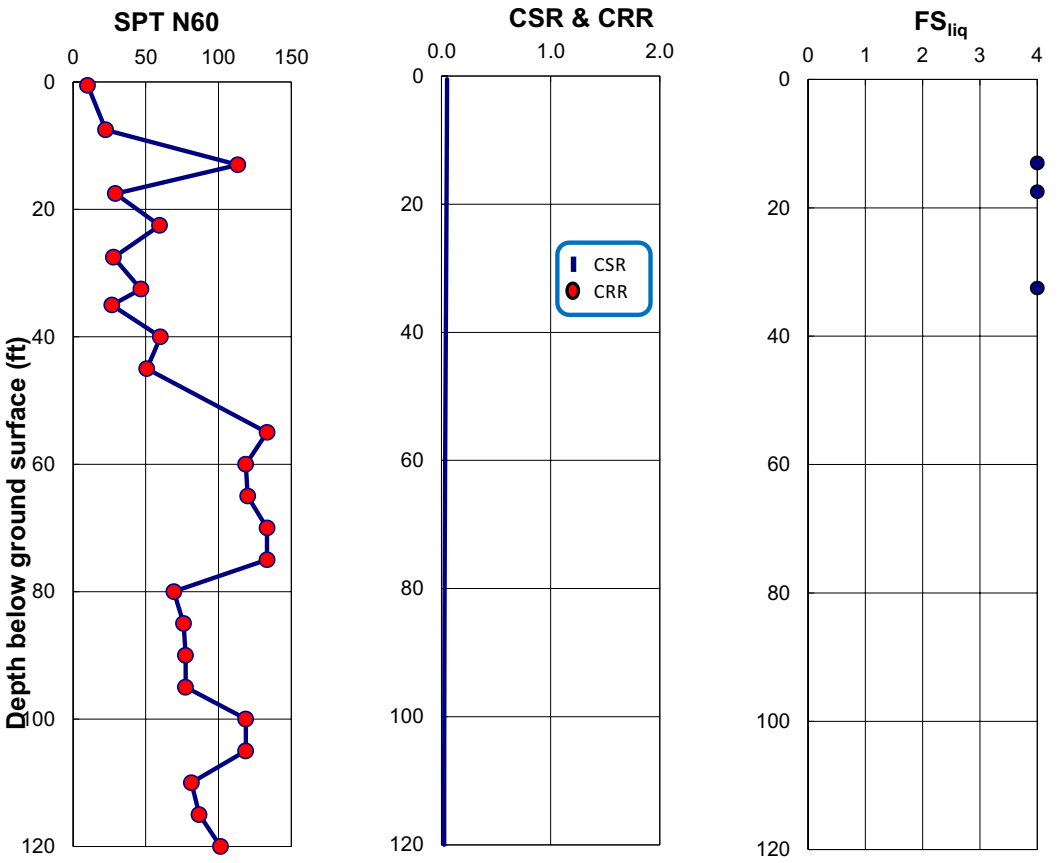


Figure B-1. SPT-Based Liquefaction Triggering Assessment of Boring BH-1 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

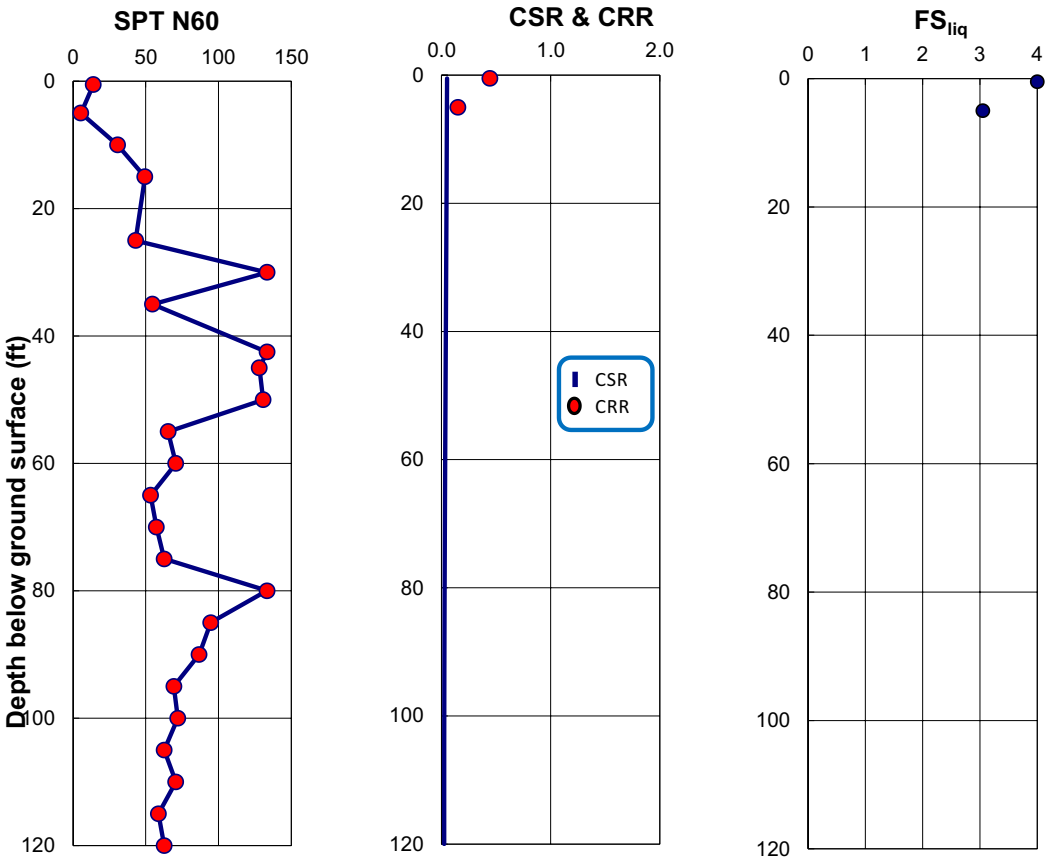


Figure B-2. SPT-Based Liquefaction Triggering Assessment of Boring BH-2 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

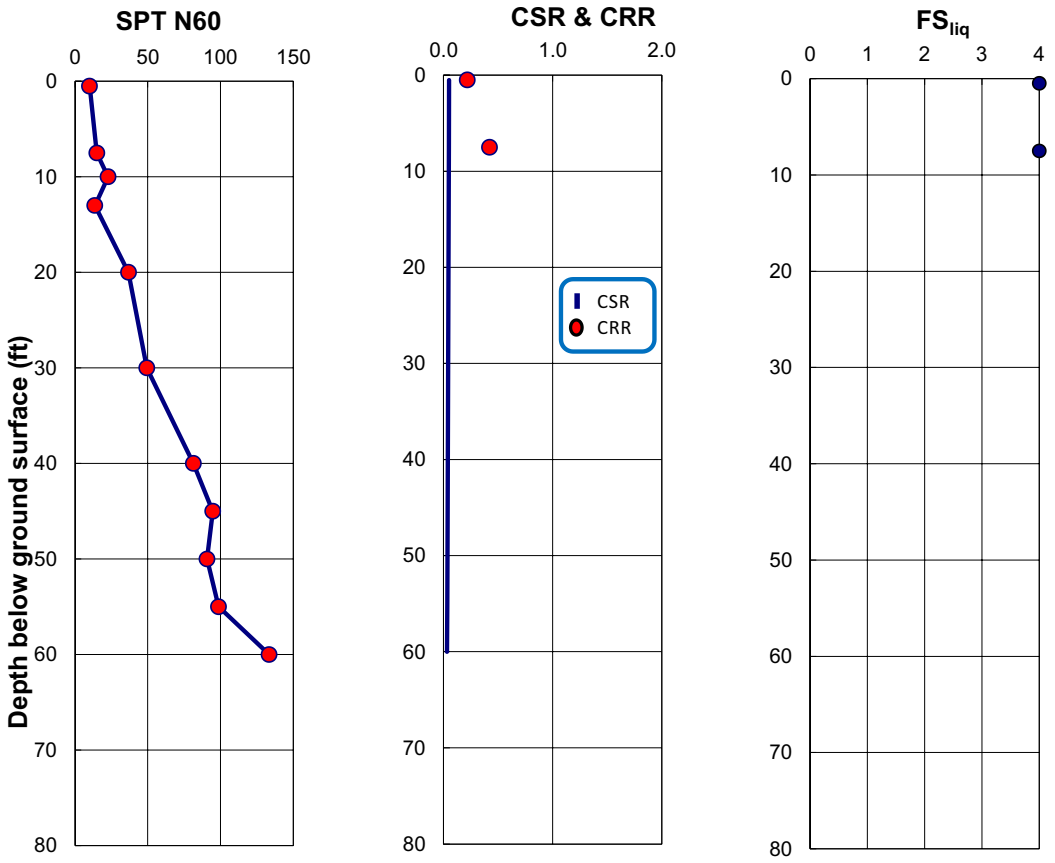


Figure B-3. SPT-Based Liquefaction Triggering Assessment of Boring BH-3 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

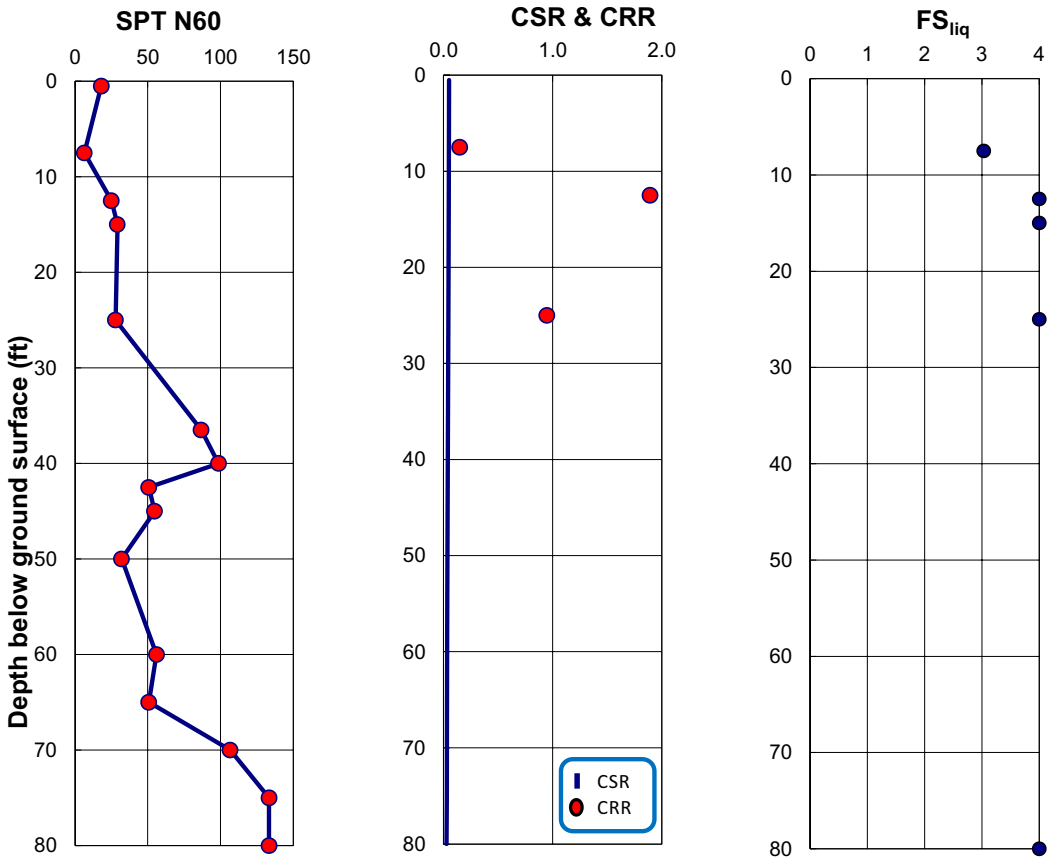


Figure B-4. SPT-Based Liquefaction Triggering Assessment of Boring BH-4 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

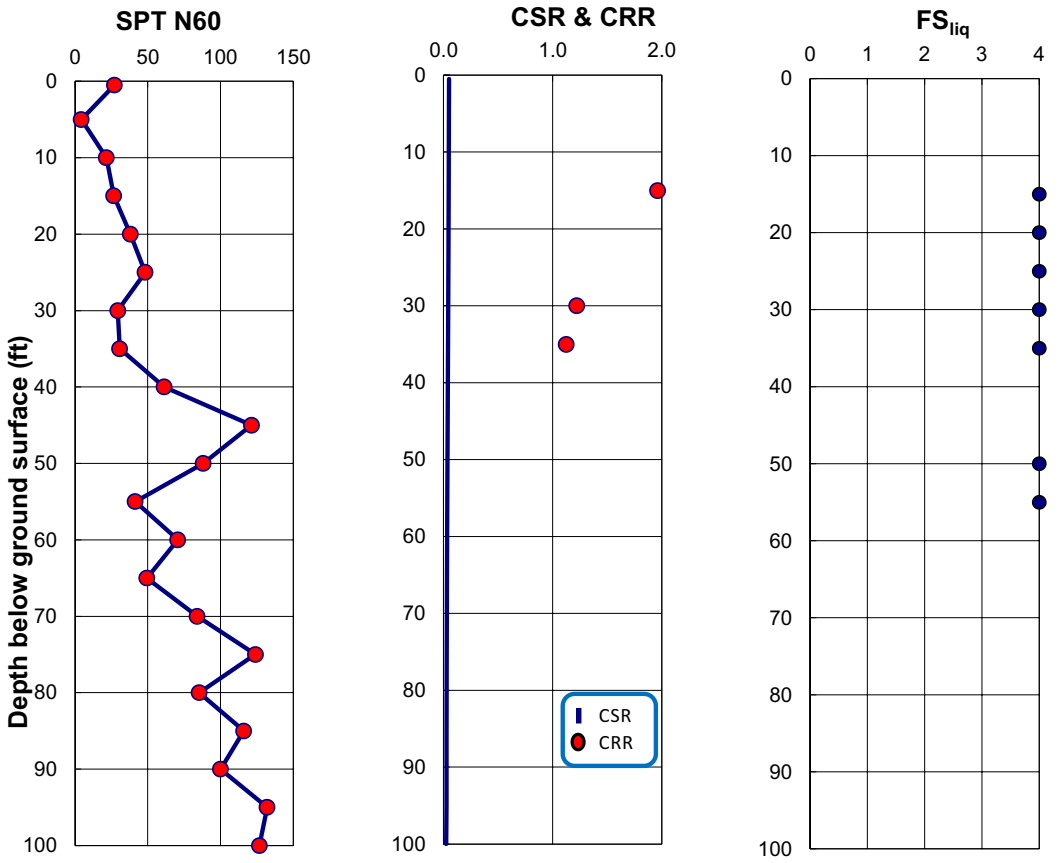
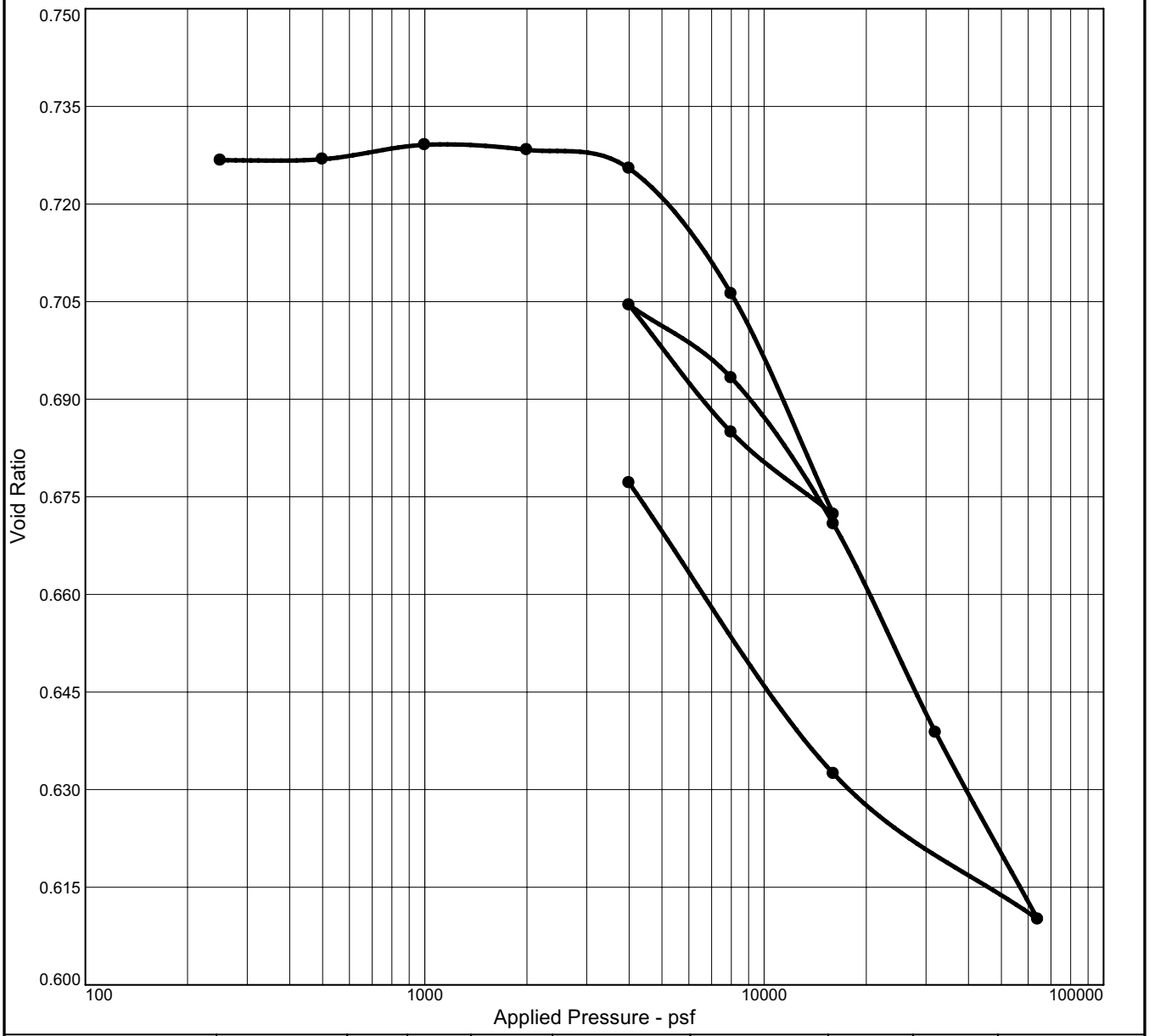


Figure B-5. SPT-Based Liquefaction Triggering Assessment of Boring DH-1 for MCE_G Shaking Level per IBC 2018/ASCE 7-16 (M_w=6.5, PGA=0.037g) – Boulanger and Idriss (2014), Existing Elevation

APPENDIX J
CONSOLIDATION TEST RESULTS

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_r	Initial Void Ratio
Saturation	Moisture									
98.5 %	26.2 %	98.7			2.73		5374	0.11	0.06	0.726

MATERIAL DESCRIPTION	USCS	AASHTO
Dark gray Fat Clay		

Project No. M2205062 **Client:** Fluor Enterprises Inc Greenville, SC

Project: Project Tundra

Location: B-1 **Depth:** 19-21 ft.

Terracon Consultants, Inc.

Houston, TX

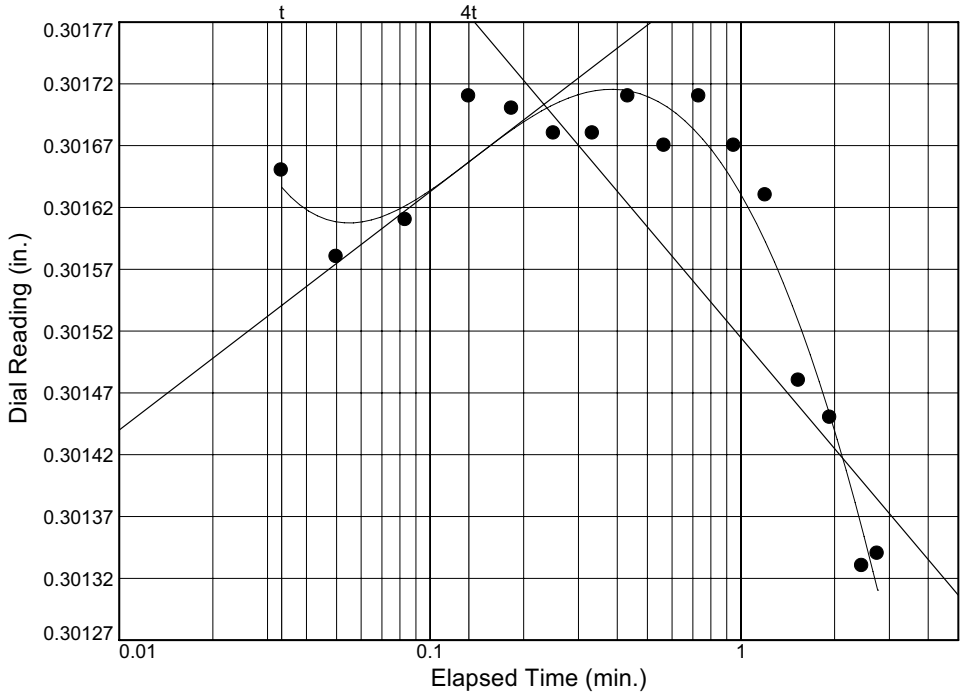
Remarks:

ASTM D2435
Specific gravity assumed

Dial Reading vs. Time

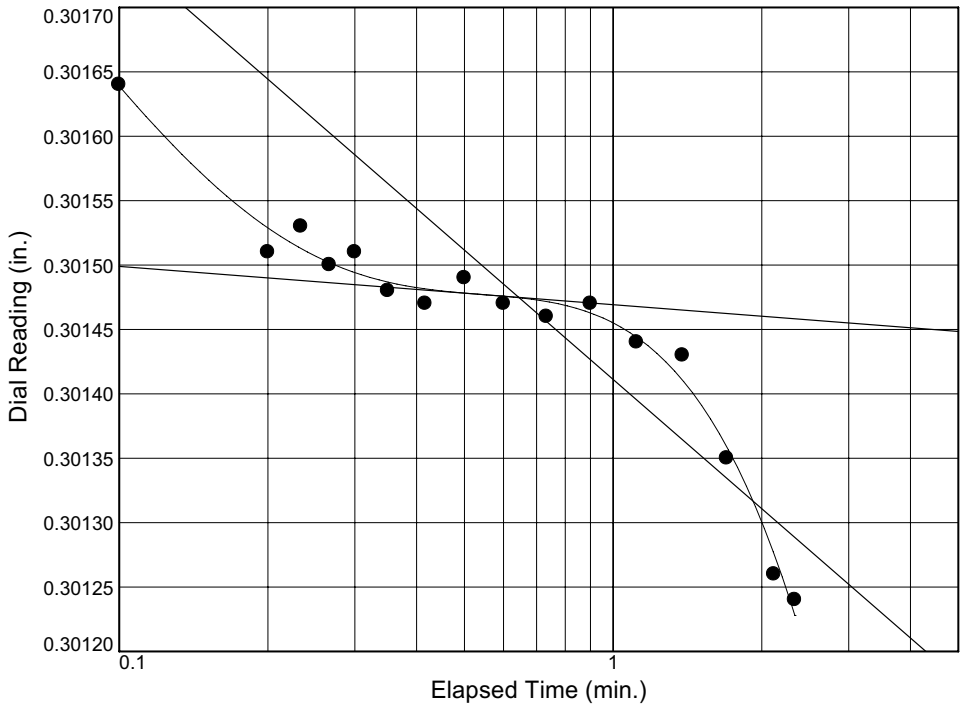
Project No.: M2205062
Project: Project Tundra

Location: B-1 Depth: 19-21 ft.



Load No.= 1
Load= 250 psf
D_0 = 0.3016
D_{50} = 0.3017
D_{100} = 0.3017
T_{50} = 0.14 min.

C_v @ T_{50}
3.573 ft.^{2}/day



Load No.= 2
Load= 500 psf
D_0 = 0.3010
D_{50} = 0.3013
D_{100} = 0.3015
T_{50} = 2.20 min.

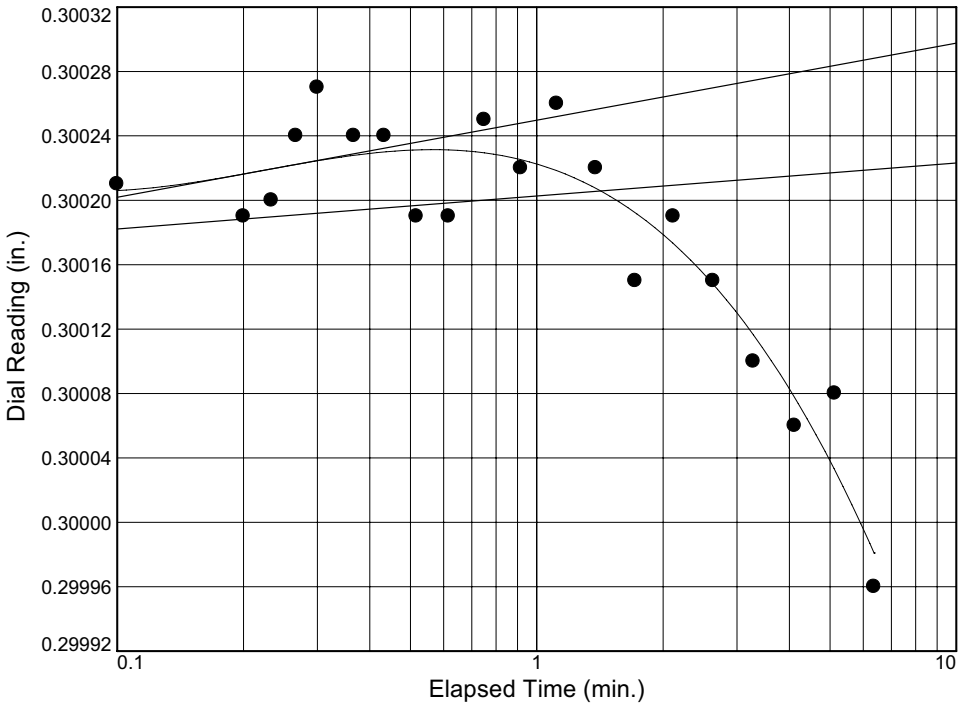
C_v @ T_{50}
0.224 ft.^{2}/day

Terracon Consultants, Inc.

Dial Reading vs. Time

Project No.: M2205062
Project: Project Tundra

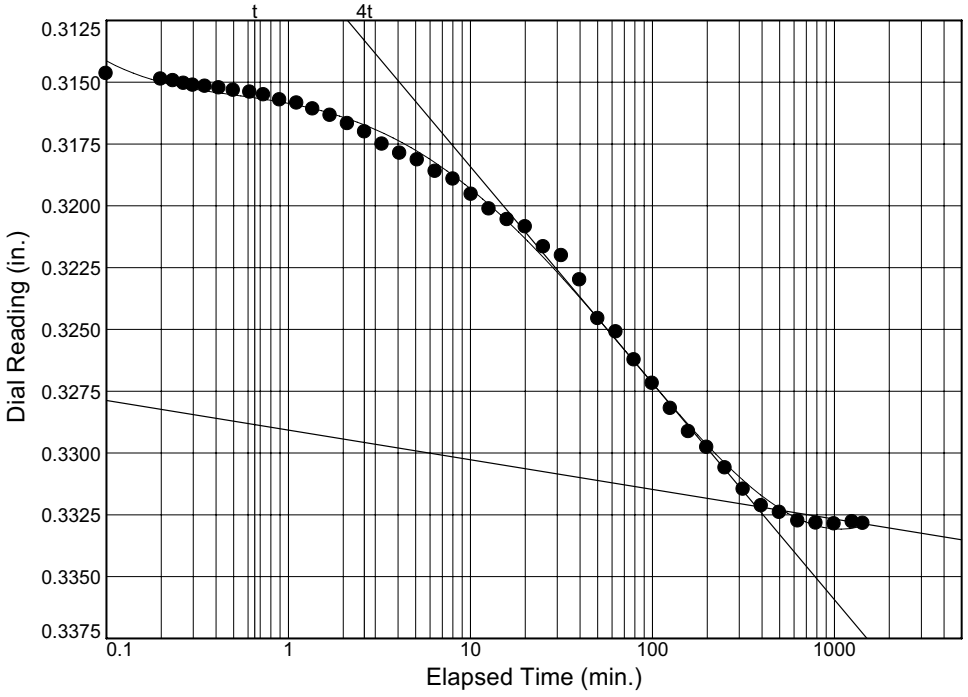
Location: B-1 Depth: 19-21 ft.



Load No.= 3
Load= 1000 psf
D_0 = 0.2999
D_{50} = 0.3001
D_{100} = 0.3002
T_{50} = 4.65 min.

C_v @ T_{50}
0.106 ft.^{2}/day

C_α = 0.000



Load No.= 7
Load= 16000 psf
D_0 = 0.3145
D_{50} = 0.3233
D_{100} = 0.3322
T_{50} = 36.04 min.

C_v @ T_{50}
0.013 ft.^{2}/day

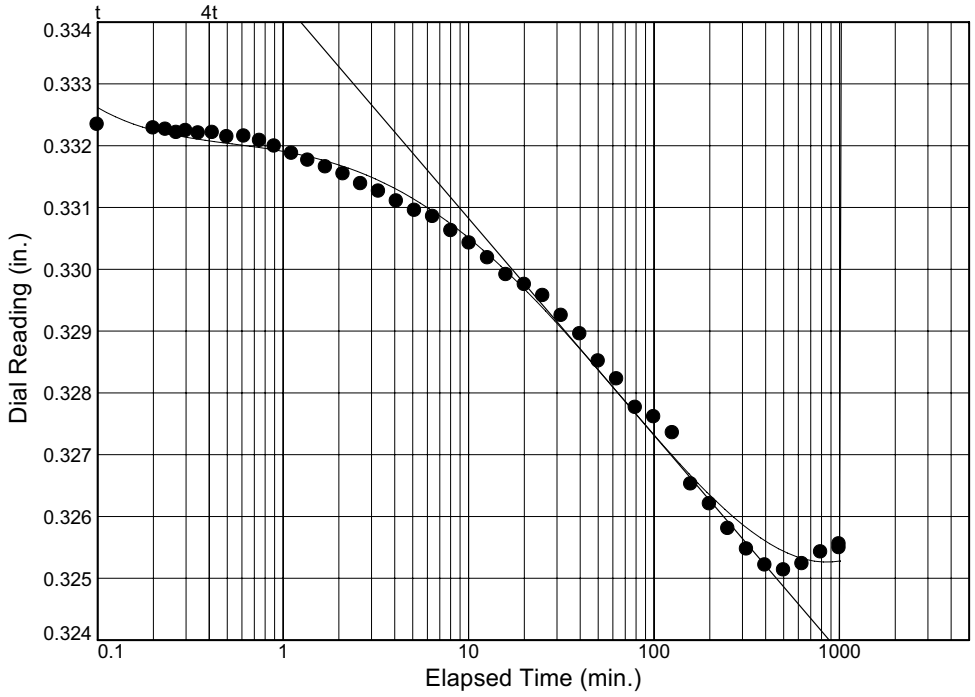
C_α = 0.001

Terracon Consultants, Inc.

Dial Reading vs. Time

Project No.: M2205062
Project: Project Tundra

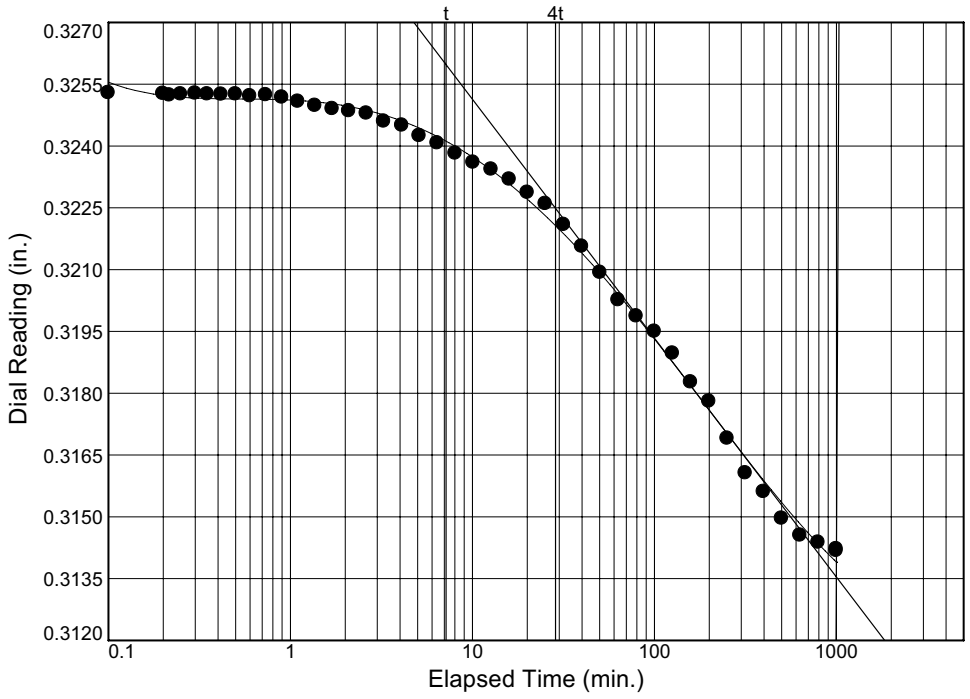
Location: B-1 Depth: 19-21 ft.



Load No.= 8
Load= 8000 psf
D_0 = 0.3332
D_{50} = 0.3285
D_{100} = 0.3238
T_{50} = 46.38 min.

C_v @ T_{50}
0.010 ft.^{2}/day

C_α = 0.921



Load No.= 9
Load= 4000 psf
D_0 = 0.3262
D_{50} = 0.3199
D_{100} = 0.3135
T_{50} = 79.86 min.

C_v @ T_{50}
0.006 ft.^{2}/day

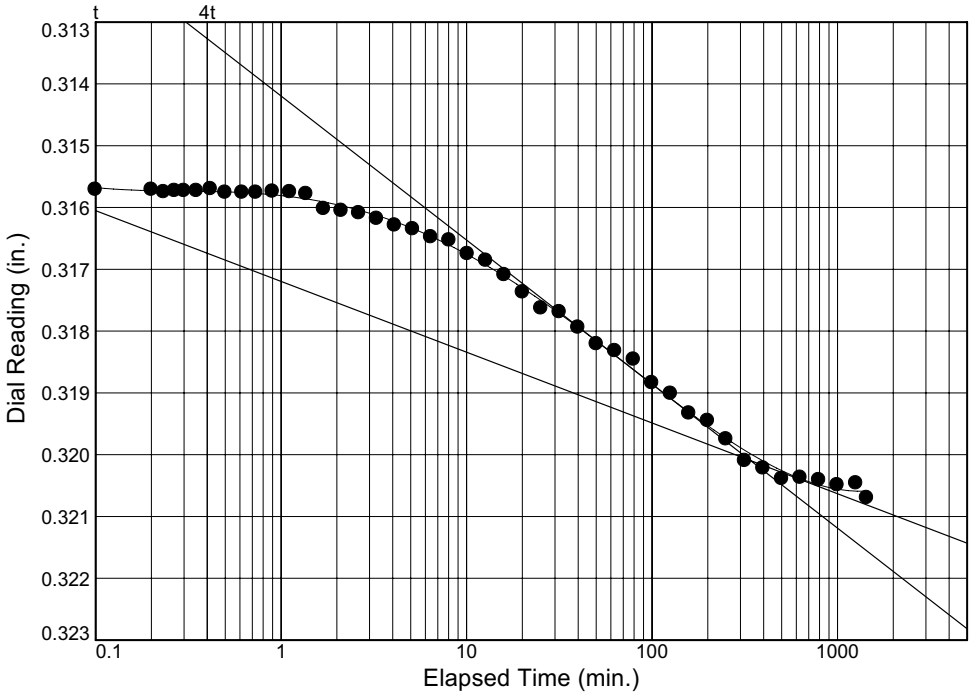
C_α = 0.921

Terracon Consultants, Inc.

Dial Reading vs. Time

Project No.: M2205062
Project: Project Tundra

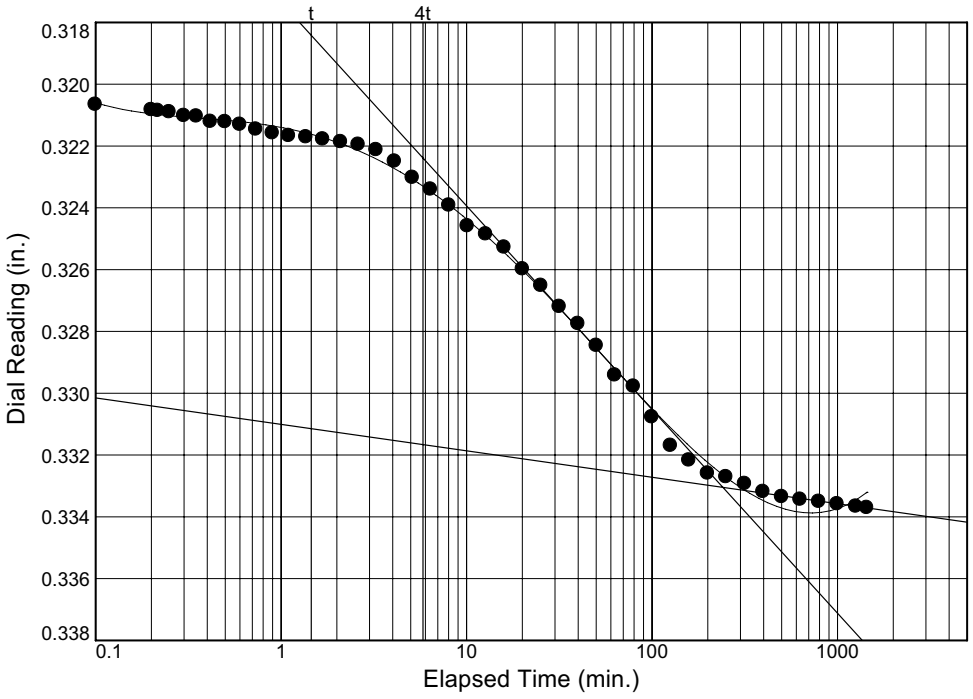
Location: B-1 Depth: 19-21 ft.



Load No.= 10
Load= 8000 psf
D_0 = 0.3156
D_{50} = 0.3179
D_{100} = 0.3201
T_{50} = 36.66 min.

C_v @ T_{50}
0.013 $ft.^2$/day

C_α = 0.001



Load No.= 11
Load= 16000 psf
D_0 = 0.3199
D_{50} = 0.3265
D_{100} = 0.3330
T_{50} = 23.98 min.

C_v @ T_{50}
0.020 $ft.^2$/day

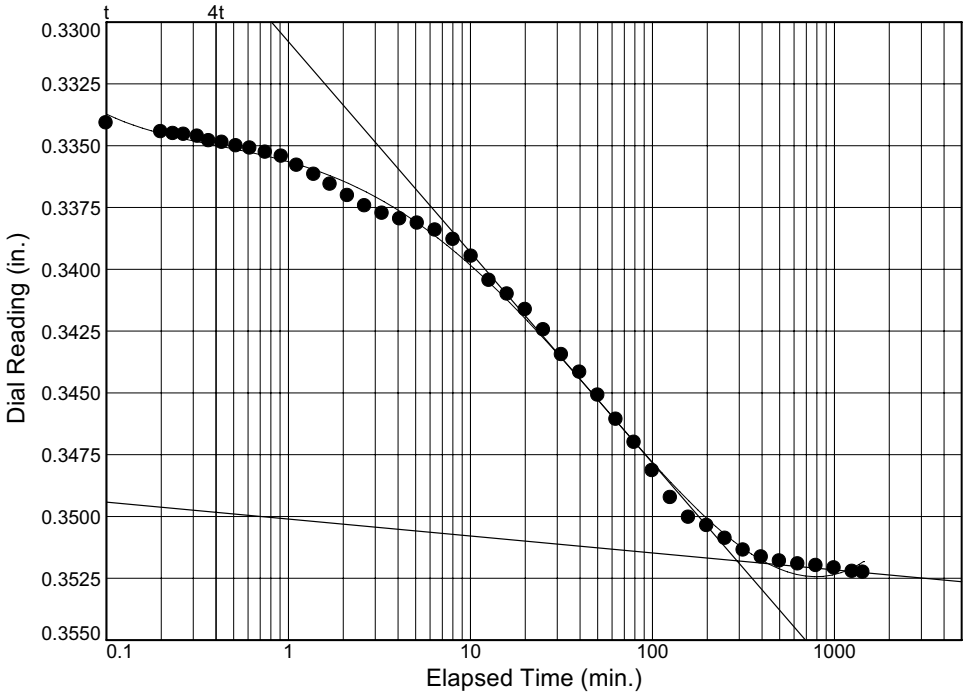
C_α = 0.001

Terracon Consultants, Inc.

Dial Reading vs. Time

Project No.: M2205062
Project: Project Tundra

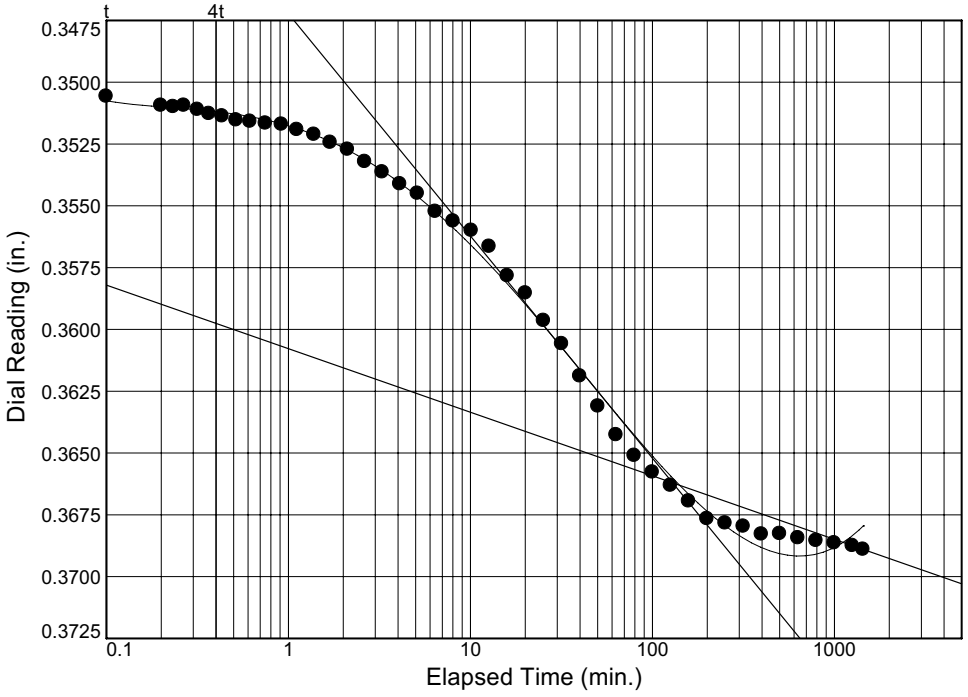
Location: B-1 Depth: 19-21 ft.



Load No.= 12
Load= 32000 psf
D_0 = 0.3325
D_{50} = 0.3421
D_{100} = 0.3518
T_{50} = 20.78 min.

C_v @ T_{50}
0.022 ft.^{2}/day

C_α = 0.001



Load No.= 13
Load= 64000 psf
D_0 = 0.3503
D_{50} = 0.3583
D_{100} = 0.3662
T_{50} = 16.43 min.

C_v @ T_{50}
0.027 ft.^{2}/day

C_α = 0.003

CONSOLIDATION TEST DATA

10/12/2020

Client: Fluor Enterprises Inc Greenville, SC
Project: Project Tundra
Project Number: M2205062
Location: B-1
Depth: 19-21 ft.
Material Description: Dark gray Fat Clay
Testing Remarks: ASTM D2435
Specific gravity assumed

Test Specimen Data

NATURAL MOISTURE		VOID RATIO		AFTER TEST	
Wet w+t =	288.70 g.	Spec. Gr. =	2.73	Wet w+t =	218.65 g.
Dry w+t =	238.88 g.	Est. Ht. Solids =	0.579 in.	Dry w+t =	185.45 g.
Tare Wt. =	48.71 g.	Init. V.R. =	0.726	Tare Wt. =	58.91 g.
Moisture =	26.2 %	Init. Sat. =	98.5 %	Moisture =	26.2 %
UNIT WEIGHT		**TEST START**		Dry Wt. =	126.54 g.
Height =	1.000 in.	Height =	1.000 in.		
Diameter =	2.500 in.	Diameter =	2.500 in.		
Weight =	160.53 g.				
Dry Dens. =	98.7 pcf				

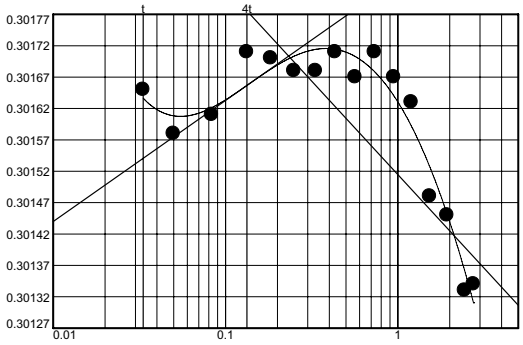
End-Of-Load Summary

Pressure (psf)	Final Dial (in.)	Deformation (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Strain
start	0.30155	0.00000			0.726	
250	0.30134	-0.00021	3.573		0.727	0.0 Swell
500	0.30124	-0.00031	0.224		0.727	0.0 Swell
1000	0.29996	-0.00159	0.106	0.000	0.729	0.2 Swell
2000	0.30040	-0.00115			0.728	0.1 Swell
4000	0.30206	0.00051		0.000	0.725	0.1 Comprs.
8000	0.31322	0.01167		0.001	0.706	1.2 Comprs.
16000	0.33286	0.03131	0.013	0.001	0.672	3.1 Comprs.
8000	0.32555	0.02400	0.010	0.921	0.685	2.4 Comprs.
4000	0.31422	0.01267	0.006	0.921	0.704	1.3 Comprs.
8000	0.32070	0.01915	0.013	0.001	0.693	1.9 Comprs.
16000	0.33371	0.03216	0.020	0.001	0.671	3.2 Comprs.
32000	0.35227	0.05072	0.022	0.001	0.639	5.1 Comprs.
64000	0.36890	0.06735	0.027	0.003	0.610	6.7 Comprs.
16000	0.35594	0.05439			0.632	5.4 Comprs.
4000	0.33006	0.02851		0.020	0.677	2.9 Comprs.

Compression index (C_c), psf = 0.11 **Preconsolidation pressure (P_p), psf =** 5374 **Void ratio at P_p (e_m) =** 0.720
Recompression index (C_r) = 0.06

Pressure: 250 psf	TEST READINGS	Load No. 1

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.30155	11	0.7333	0.30171
2	0.0333	0.30165	12	0.9500	0.30167
3	0.0500	0.30158	13	1.2000	0.30163
4	0.0833	0.30161	14	1.5333	0.30148
5	0.1333	0.30171	15	1.9333	0.30145
6	0.1833	0.30170	16	2.4500	0.30133
7	0.2500	0.30168	17	2.7500	0.30134
8	0.3333	0.30168			
9	0.4333	0.30171			
10	0.5667	0.30167			

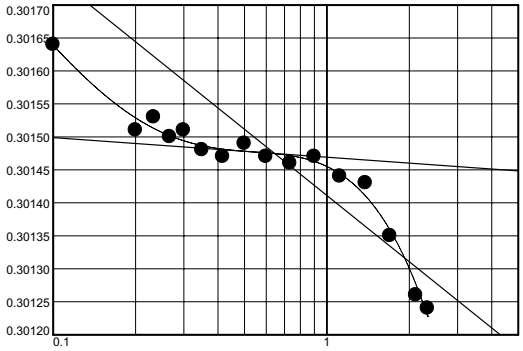


Void Ratio = 0.727 **Swell =** 0.0%

D_0 = 0.3016 **D_{50} =** 0.3017 **D_{100} =** 0.3017 **C_v at 0.14 min. =** 3.573 ft.^{2}/day

Pressure: 500 psf	TEST READINGS	Load No. 2

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.30104	11	0.7333	0.30146
2	0.1000	0.30164	12	0.9000	0.30147
3	0.2000	0.30151	13	1.1167	0.30144
4	0.2333	0.30153	14	1.3833	0.30143
5	0.2667	0.30150	15	1.7000	0.30135
6	0.3000	0.30151	16	2.1167	0.30126
7	0.3500	0.30148	17	2.3333	0.30124
8	0.4167	0.30147			
9	0.5000	0.30149			
10	0.6000	0.30147			

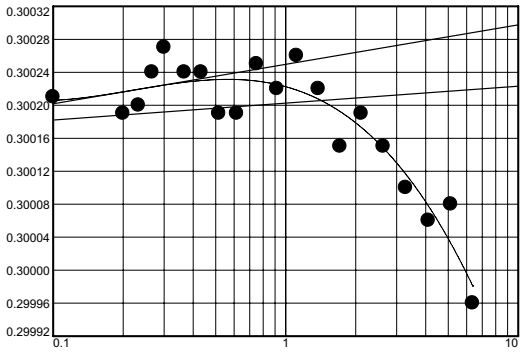


Void Ratio = 0.727 **Swell =** 0.0%

D_0 = 0.3010 **D_{50} =** 0.3013 **D_{100} =** 0.3015 **C_v at 2.20 min. =** 0.224 ft.^{2}/day

Pressure: 1000 psf — **TEST READINGS** — **Load No. 3**

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.29994	12	0.9167	0.30022
2	0.1000	0.30021	13	1.1167	0.30026
3	0.2000	0.30019	14	1.3833	0.30022
4	0.2333	0.30020	15	1.7167	0.30015
5	0.2667	0.30024	16	2.1167	0.30019
6	0.3000	0.30027	17	2.6333	0.30015
7	0.3667	0.30024	18	3.2833	0.30010
8	0.4333	0.30024	19	4.1167	0.30006
9	0.5167	0.30019	20	5.1333	0.30008
10	0.6167	0.30019	21	6.3667	0.29996
11	0.7500	0.30025			



Void Ratio = 0.729 **Swell =** 0.2%

D_0 = 0.2999 **D_{50} =** 0.3001 **D_{100} =** 0.3002 **C_v at 4.65 min. =** 0.106 ft.^{2}/day **C_α =** 0.000

Pressure: 2000 psf — **TEST READINGS** — **Load No. 4**

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.29933	11	0.7500	0.30076	21	6.4333	0.30055
2	0.1000	0.30078	12	0.9167	0.30074	22	8.0667	0.30046
3	0.2000	0.30074	13	1.1167	0.30075	23	8.9833	0.30040
4	0.2333	0.30076	14	1.3833	0.30076			
5	0.2667	0.30076	15	1.7000	0.30071			
6	0.3000	0.30075	16	2.1167	0.30071			
7	0.3667	0.30074	17	2.6333	0.30074			
8	0.4333	0.30076	18	3.2833	0.30070			
9	0.5167	0.30076	19	4.1000	0.30057			
10	0.6167	0.30072	20	5.1333	0.30059			

Void Ratio = 0.728 **Swell =** 0.1%

Pressure: 4000 psf	TEST READINGS	Load No. 5

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.29906	11	0.7333	0.30093	21	6.4333	0.30133
2	0.1000	0.30076	12	0.9000	0.30097	22	8.0667	0.30143
3	0.2000	0.30085	13	1.1167	0.30101	23	10.1333	0.30158
4	0.2333	0.30085	14	1.3667	0.30103	24	12.7167	0.30162
5	0.2667	0.30088	15	1.7000	0.30106	25	15.9833	0.30173
6	0.3000	0.30092	16	2.1167	0.30105	26	20.0833	0.30174
7	0.3500	0.30094	17	2.6333	0.30120	27	25.2500	0.30176
8	0.4167	0.30093	18	3.2833	0.30129	28	31.7500	0.30186
9	0.5000	0.30096	19	4.1000	0.30127	29	36.4667	0.30206
10	0.6167	0.30096	20	5.1333	0.30130			

Void Ratio = 0.725 **Compression =** 0.1%

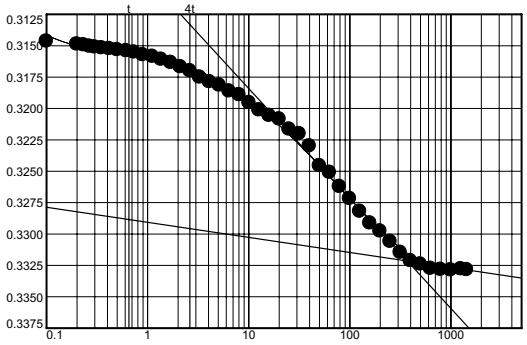
Pressure: 8000 psf	TEST READINGS	Load No. 6

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.29949	15	1.7000	0.30346	29	39.9500	0.30770
2	0.1167	0.30212	16	2.1167	0.30358	30	50.2500	0.30865
3	0.2167	0.30246	17	2.6333	0.30374	31	63.2333	0.30949
4	0.2333	0.30258	18	3.2833	0.30398	32	79.5667	0.31001
5	0.2667	0.30266	19	4.1000	0.30430	33	100.1333	0.31059
6	0.3167	0.30266	20	5.1333	0.30469	34	126.0333	0.31088
7	0.3667	0.30274	21	6.4333	0.30479	35	158.6333	0.31132
8	0.4333	0.30279	22	8.0667	0.30500	36	199.6667	0.31212
9	0.5167	0.30283	23	10.1167	0.30570	37	251.3333	0.31259
10	0.6167	0.30292	24	12.7167	0.30605	38	316.3667	0.31283
11	0.7500	0.30298	25	15.9667	0.30639	39	398.2500	0.31292
12	0.9167	0.30314	26	20.0833	0.30655	40	501.3333	0.31311
13	1.1167	0.30321	27	25.2500	0.30677	41	600.3833	0.31322
14	1.3833	0.30337	28	31.7500	0.30711			

Void Ratio = 0.706 **Compression =** 1.2%

Pressure: 16000 psf | **TEST READINGS** | **Load No. 7**

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.30989	24	12.7167	0.32014
2	0.1000	0.31466	25	15.9833	0.32057
3	0.2000	0.31489	26	20.0833	0.32086
4	0.2333	0.31495	27	25.2500	0.32167
5	0.2667	0.31506	28	31.7500	0.32203
6	0.3000	0.31513	29	39.9500	0.32301
7	0.3500	0.31518	30	50.2500	0.32457
8	0.4167	0.31524	31	63.2333	0.32511
9	0.5000	0.31534	32	79.5667	0.32624
10	0.6167	0.31541	33	100.1333	0.32719
11	0.7333	0.31552	34	126.0333	0.32821
12	0.9000	0.31573	35	158.6333	0.32915
13	1.1167	0.31586	36	199.6667	0.32978
14	1.3667	0.31609	37	251.3333	0.33061
15	1.7000	0.31635	38	316.3667	0.33148
16	2.1167	0.31669	39	398.2500	0.33214
17	2.6333	0.31702	40	501.3333	0.33241
18	3.2833	0.31752	41	631.1000	0.33276
19	4.1000	0.31788	42	794.4833	0.33285
20	5.1333	0.31815	43	1000.1500	0.33288
21	6.4333	0.31862	44	1259.0833	0.33279
22	8.0667	0.31893	45	1440.2333	0.33286
23	10.1333	0.31955			

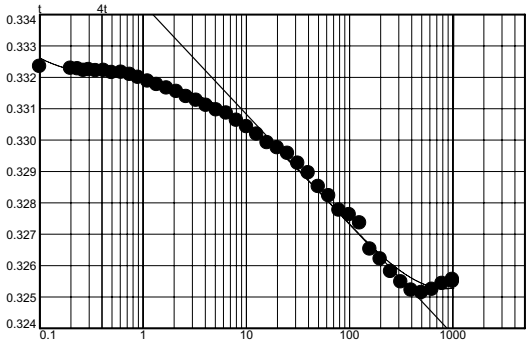


Void Ratio = 0.672 **Compression =** 3.1%

D_0 = 0.3145 **D_{50} =** 0.3233 **D_{100} =** 0.3322 **C_v at 36.04 min. =** 0.013 ft.^{2}/day **C_α =** 0.001

Pressure: 8000 psf | **TEST READINGS** | **Load No. 8**

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.33552	13	1.1167	0.33187
2	0.1000	0.33234	14	1.3667	0.33176
3	0.2000	0.33228	15	1.7000	0.33165
4	0.2333	0.33226	16	2.1167	0.33154
5	0.2667	0.33221	17	2.6333	0.33138
6	0.3000	0.33224	18	3.2833	0.33126
7	0.3500	0.33220	19	4.1000	0.33110
8	0.4167	0.33221	20	5.1333	0.33095
9	0.5000	0.33214	21	6.4333	0.33085
10	0.6167	0.33215	22	8.0667	0.33062
11	0.7500	0.33208	23	10.1333	0.33042
12	0.9000	0.33199	24	12.7167	0.33018



Pressure: 8000 psf	TEST READINGS (continued)	Load No. 8

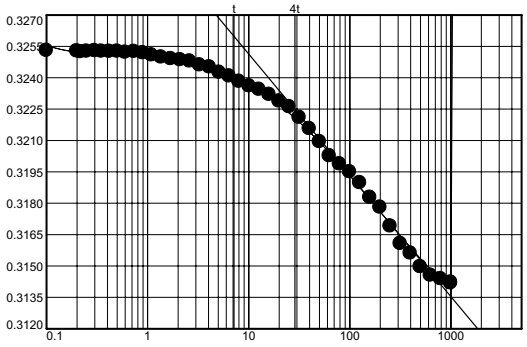
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
25	15.9833	0.32991	35	158.6333	0.32652
26	20.0833	0.32975	36	199.6667	0.32620
27	25.2500	0.32957	37	251.3333	0.32580
28	31.7500	0.32925	38	316.3833	0.32547
29	39.9500	0.32895	39	398.2500	0.32521
30	50.2500	0.32851	40	501.3333	0.32513
31	63.2333	0.32822	41	631.1167	0.32523
32	79.5667	0.32776	42	794.4833	0.32542
33	100.1500	0.32761	43	1000.1500	0.32549
34	126.0333	0.32735	44	1000.3000	0.32555

Void Ratio = 0.685 **Compression =** 2.4%

D_0 = 0.3332 D_{50} = 0.3285 D_{100} = 0.3238 C_v **at 46.38 min. =** 0.010 ft.^{2}/day C_α = 0.921

Pressure: 4000 psf	TEST READINGS	Load No. 9

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.32742	23	10.1167	0.32360
2	0.1000	0.32529	24	12.7000	0.32343
3	0.2000	0.32527	25	15.9667	0.32319
4	0.2167	0.32523	26	20.0667	0.32287
5	0.2500	0.32526	27	25.2333	0.32260
6	0.3000	0.32528	28	31.7500	0.32209
7	0.3500	0.32526	29	39.9333	0.32156
8	0.4167	0.32525	30	50.2500	0.32093
9	0.5000	0.32526	31	63.2167	0.32026
10	0.6000	0.32521	32	79.5667	0.31987
11	0.7333	0.32524	33	100.1333	0.31950
12	0.9000	0.32518	34	126.0167	0.31897
13	1.1000	0.32508	35	158.6167	0.31827
14	1.3667	0.32498	36	199.6667	0.31780
15	1.7000	0.32490	37	251.3167	0.31690
16	2.1000	0.32485	38	316.3667	0.31606
17	2.6167	0.32479	39	398.2500	0.31561
18	3.2667	0.32460	40	501.3333	0.31496
19	4.1000	0.32450	41	631.1000	0.31455
20	5.1167	0.32425	42	794.4667	0.31438
21	6.4167	0.32407	43	1000.1500	0.31418
22	8.0500	0.32382	44	1000.2500	0.31422

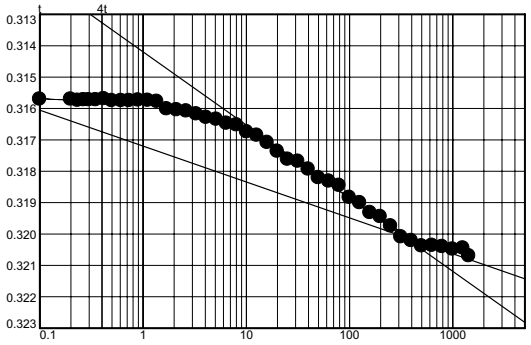


Void Ratio = 0.704 **Compression =** 1.3%

D_0 = 0.3262 D_{50} = 0.3199 D_{100} = 0.3135 C_v **at 79.86 min. =** 0.006 ft.^{2}/day C_α = 0.921

Pressure: 8000 psf	TEST READINGS	Load No. 10

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.31256	24	12.7167	0.31686
2	0.1000	0.31571	25	15.9833	0.31709
3	0.2000	0.31571	26	20.0833	0.31737
4	0.2333	0.31575	27	25.2500	0.31763
5	0.2667	0.31573	28	31.7500	0.31769
6	0.3000	0.31573	29	39.9500	0.31794
7	0.3500	0.31573	30	50.2500	0.31821
8	0.4167	0.31570	31	63.2333	0.31832
9	0.5000	0.31576	32	79.5667	0.31846
10	0.6167	0.31576	33	100.1333	0.31884
11	0.7333	0.31576	34	126.0333	0.31901
12	0.9000	0.31574	35	158.6333	0.31933
13	1.1167	0.31575	36	199.6667	0.31945
14	1.3667	0.31578	37	251.3333	0.31975
15	1.7000	0.31602	38	316.3667	0.32010
16	2.1167	0.31605	39	398.2500	0.32022
17	2.6333	0.31609	40	501.3333	0.32039
18	3.2833	0.31618	41	631.1000	0.32037
19	4.1000	0.31629	42	794.4833	0.32041
20	5.1333	0.31635	43	1000.1500	0.32049
21	6.4333	0.31648	44	1259.0833	0.32046
22	8.0667	0.31653	45	1440.3333	0.32070
23	10.1333	0.31675			

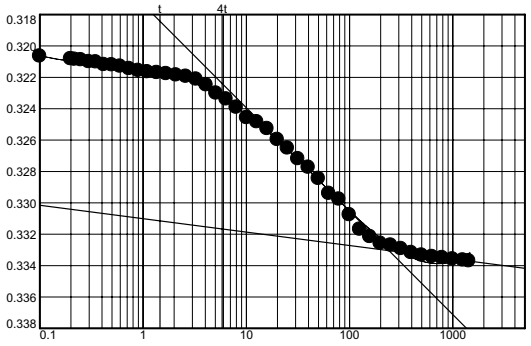


Void Ratio = 0.693 **Compression =** 1.9%

D_0 = 0.3156 **D_{50} =** 0.3179 **D_{100} =** 0.3201 **C_v at 36.66 min. =** 0.013 ft.^{2}/day **C_α =** 0.001

Pressure: 16000 psf	TEST READINGS	Load No. 11

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.31759	13	1.1000	0.32167
2	0.1000	0.32066	14	1.3667	0.32171
3	0.2000	0.32083	15	1.6833	0.32178
4	0.2167	0.32086	16	2.1000	0.32187
5	0.2500	0.32090	17	2.6167	0.32195
6	0.3000	0.32102	18	3.2667	0.32213
7	0.3500	0.32104	19	4.1000	0.32250
8	0.4167	0.32121	20	5.1167	0.32302
9	0.5000	0.32122	21	6.4167	0.32340
10	0.6000	0.32131	22	8.0500	0.32392
11	0.7333	0.32146	23	10.1167	0.32459
12	0.9000	0.32158	24	12.7000	0.32485



Pressure: 16000 psf	TEST READINGS (continued)	Load No. 11

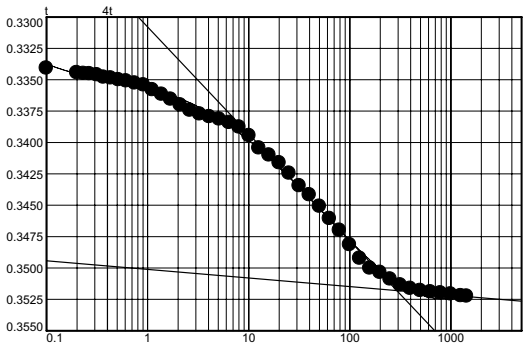
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
25	15.9667	0.32528	35	158.6167	0.33217	45	1440.3500	0.33371
26	20.0667	0.32598	36	199.6500	0.33259			
27	25.2333	0.32652	37	251.3167	0.33271			
28	31.7500	0.32720	38	316.3500	0.33293			
29	39.9333	0.32775	39	398.2333	0.33319			
30	50.2333	0.32846	40	501.3167	0.33335			
31	63.2167	0.32942	41	631.0833	0.33344			
32	79.5500	0.32978	42	794.4667	0.33351			
33	100.1167	0.33077	43	1000.1333	0.33359			
34	126.0167	0.33170	44	1259.0667	0.33366			

Void Ratio = 0.671 **Compression =** 3.2%

D_0 = 0.3199 **D_{50} =** 0.3265 **D_{100} =** 0.3330 **C_v at 23.98 min. =** 0.020 ft.^{2}/day **C_α =** 0.001

Pressure: 32000 psf	TEST READINGS	Load No. 12

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.32747	24	12.7167	0.34046
2	0.1000	0.33409	25	15.9833	0.34102
3	0.2000	0.33445	26	20.0833	0.34164
4	0.2333	0.33452	27	25.2500	0.34246
5	0.2667	0.33455	28	31.7500	0.34346
6	0.3167	0.33463	29	39.9500	0.34418
7	0.3667	0.33481	30	50.2500	0.34510
8	0.4333	0.33488	31	63.2333	0.34608
9	0.5167	0.33502	32	79.5667	0.34701
10	0.6167	0.33511	33	100.1333	0.34816
11	0.7500	0.33528	34	126.0333	0.34925
12	0.9167	0.33544	35	158.6333	0.35004
13	1.1167	0.33581	36	199.6667	0.35038
14	1.3833	0.33617	37	251.3333	0.35090
15	1.7000	0.33657	38	316.3667	0.35137
16	2.1167	0.33703	39	398.2500	0.35165
17	2.6333	0.33745	40	501.3333	0.35181
18	3.2833	0.33775	41	631.1000	0.35193
19	4.1000	0.33797	42	794.4833	0.35200
20	5.1333	0.33815	43	1000.1500	0.35209
21	6.4333	0.33843	44	1259.0833	0.35223
22	8.0667	0.33880	45	1440.2333	0.35227
23	10.1333	0.33948			

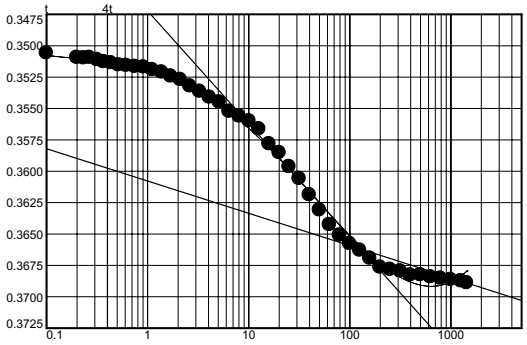


Void Ratio = 0.639 **Compression =** 5.1%

D_0 = 0.3325 **D_{50} =** 0.3421 **D_{100} =** 0.3518 **C_v at 20.78 min. =** 0.022 ft.^{2}/day **C_α =** 0.001

Pressure: 64000 psf	TEST READINGS	Load No. 13

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.34048	24	12.7167	0.35665
2	0.1000	0.35058	25	15.9833	0.35784
3	0.2000	0.35094	26	20.0833	0.35854
4	0.2333	0.35100	27	25.2500	0.35965
5	0.2667	0.35094	28	31.7667	0.36059
6	0.3167	0.35111	29	39.9500	0.36189
7	0.3667	0.35128	30	50.2667	0.36311
8	0.4333	0.35137	31	63.2500	0.36427
9	0.5167	0.35154	32	79.5833	0.36511
10	0.6167	0.35159	33	100.1500	0.36578
11	0.7500	0.35167	34	126.0500	0.36631
12	0.9167	0.35171	35	158.6500	0.36695
13	1.1167	0.35192	36	199.6833	0.36766
14	1.3833	0.35212	37	251.3500	0.36784
15	1.7000	0.35244	38	316.3833	0.36797
16	2.1167	0.35272	39	398.2667	0.36829
17	2.6333	0.35322	40	501.3500	0.36827
18	3.2833	0.35364	41	631.1167	0.36844
19	4.1000	0.35412	42	794.5000	0.36855
20	5.1333	0.35450	43	1000.1667	0.36864
21	6.4333	0.35524	44	1259.1000	0.36875
22	8.0667	0.35562	45	1440.0667	0.36890
23	10.1333	0.35600			



Void Ratio = 0.610 **Compression =** 6.7%

D_0 = 0.3503 **D_{50} =** 0.3583 **D_{100} =** 0.3662 **C_v at 16.43 min. =** 0.027 ft.^{2}/day **C_α =** 0.003

Pressure: 16000 psf	TEST READINGS	Load No. 14

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.38549	13	1.1000	0.36859	25	15.9667	0.36488
2	0.1000	0.37100	14	1.3667	0.36836	26	20.0833	0.36439
3	0.2000	0.37035	15	1.7000	0.36821	27	25.2500	0.36371
4	0.2167	0.37030	16	2.1000	0.36812	28	31.7500	0.36263
5	0.2500	0.37018	17	2.6167	0.36797	29	39.9333	0.36224
6	0.3000	0.36993	18	3.2833	0.36771	30	50.2500	0.36138
7	0.3500	0.36984	19	4.1000	0.36742	31	63.2167	0.36063
8	0.4167	0.36960	20	5.1333	0.36717	32	79.5667	0.35979
9	0.5000	0.36948	21	6.4333	0.36670	33	100.1333	0.35917
10	0.6000	0.36931	22	8.0667	0.36598	34	126.0167	0.35836
11	0.7333	0.36899	23	10.1167	0.36554	35	158.6167	0.35786
12	0.9000	0.36892	24	12.7167	0.36519	36	199.6667	0.35740

Pressure: 16000 psf	TEST READINGS (continued)	Load No. 14

No.	Elapsed Time	Dial Reading
37	251.3167	0.35695
38	316.3667	0.35687
39	398.2500	0.35675
40	501.3167	0.35661
41	631.1000	0.35642
42	794.4667	0.35632
43	1000.1500	0.35627
44	1259.0667	0.35609
45	1406.3500	0.35594

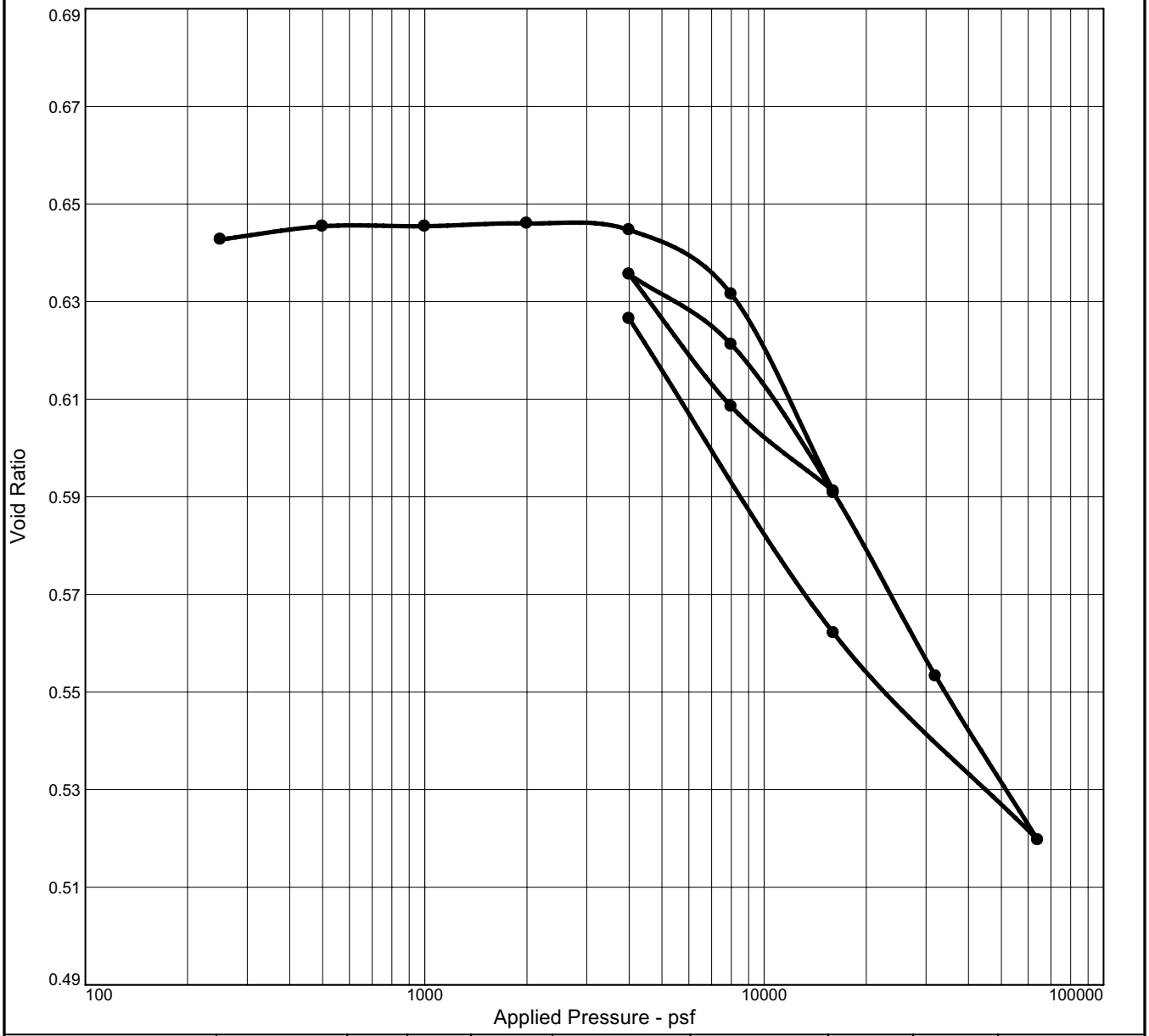
Void Ratio = 0.632 **Compression =** 5.4%

Pressure: 4000 psf	TEST READINGS	Load No. 15

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.36134	17	2.6333	0.35388	33	100.1500	0.34251
2	0.1000	0.35612	18	3.2833	0.35370	34	126.0500	0.34101
3	0.2000	0.35587	19	4.1167	0.35353	35	158.6333	0.33998
4	0.2333	0.35585	20	5.1500	0.35311	36	199.6833	0.33782
5	0.2667	0.35577	21	6.4333	0.35249	37	251.3500	0.33679
6	0.3167	0.35572	22	8.0667	0.35198	38	316.3833	0.33600
7	0.3667	0.35565	23	10.1333	0.35148	39	398.2667	0.33406
8	0.4333	0.35549	24	12.7167	0.35113	40	501.3500	0.33316
9	0.5167	0.35535	25	15.9833	0.35057	41	631.1167	0.33197
10	0.6167	0.35527	26	20.0833	0.34930	42	794.5000	0.33125
11	0.7500	0.35517	27	25.2500	0.34871	43	1000.1667	0.33069
12	0.9167	0.35504	28	31.7667	0.34817	44	1259.1000	0.33028
13	1.1167	0.35472	29	39.9500	0.34732	45	1585.0667	0.33009
14	1.3833	0.35457	30	50.2667	0.34586	46	1995.4333	0.33004
15	1.7000	0.35436	31	63.2500	0.34481	47	2000.0667	0.33006
16	2.1167	0.35404	32	79.5833	0.34354			

Void Ratio = 0.677 **Compression =** 2.9%

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_r	Initial Void Ratio
Saturation	Moisture									
98.8 %	23.2 %	103.8			2.73		6436	0.13	0.09	0.642

MATERIAL DESCRIPTION	USCS	AASHTO
Dark gray Fat Clay		

Project No. M2205062 **Client:** Fluor Enterprises Inc Greenville, SC

Project: Project Tundra

Location: B-2 **Depth:** 12-13 ft.

Terracon Consultants, Inc.

Houston, TX

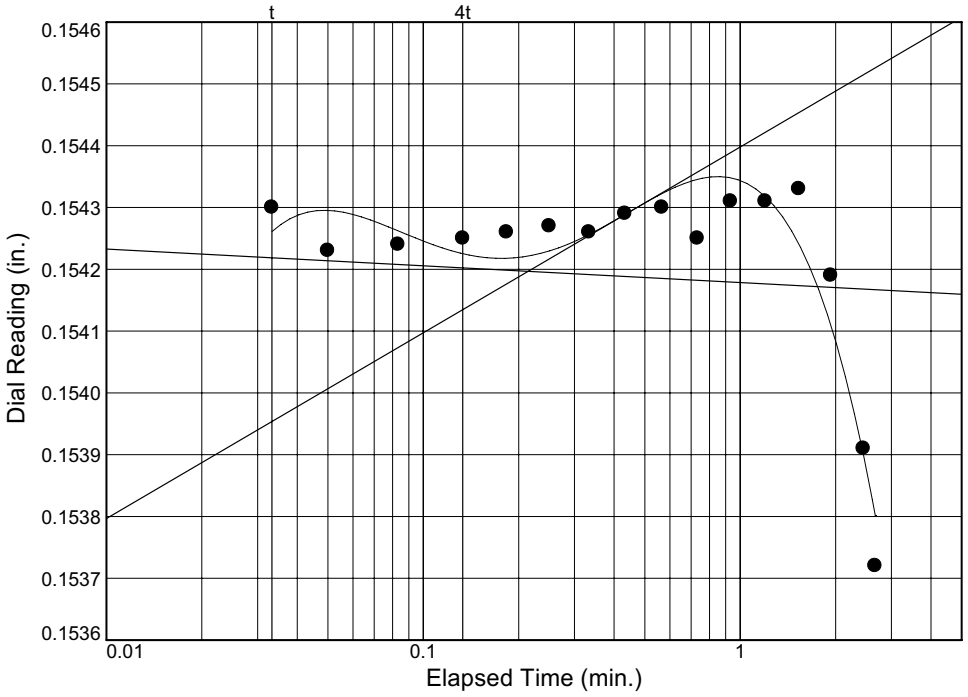
Remarks:

ASTM D2435
Specific gravity assumed

Dial Reading vs. Time

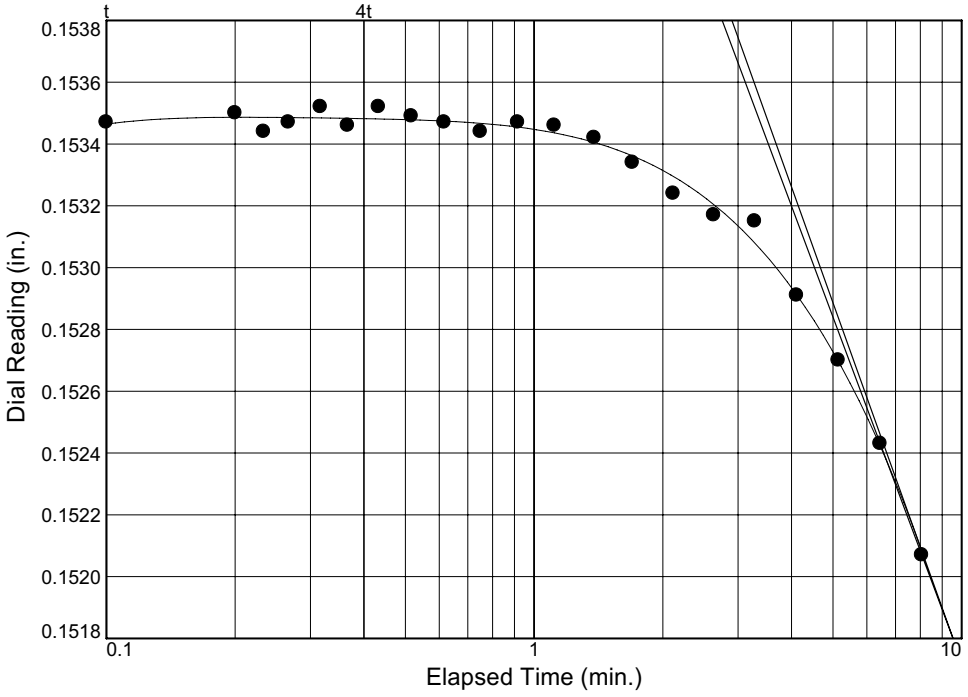
Project No.: M2205062
Project: Project Tundra

Location: B-2 Depth: 12-13 ft.



Load No.= 1
Load= 250 psf
D_0 = 0.1543
D_{50} = 0.1542
D_{100} = 0.1542
T_{50} = 0.10 min.

C_v @ T_{50}
4.980 ft.^{2}/day



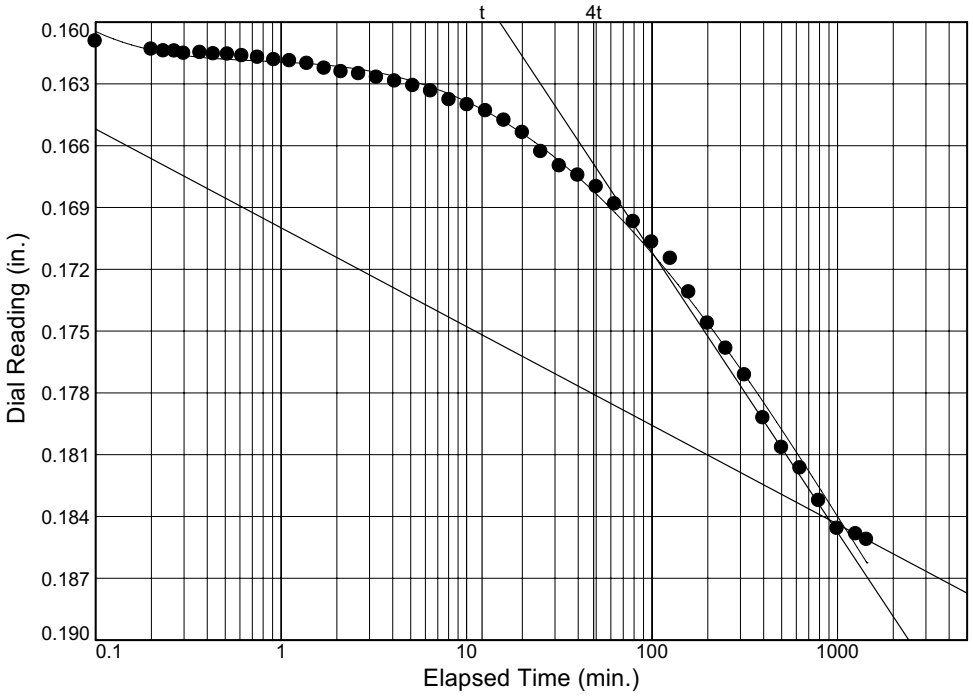
Load No.= 2
Load= 500 psf
D_0 = 0.1534
D_{50} = 0.1526
D_{100} = 0.1518
T_{50} = 5.60 min.

C_v @ T_{50}
0.088 ft.^{2}/day

Dial Reading vs. Time

Project No.: M2205062
Project: Project Tundra

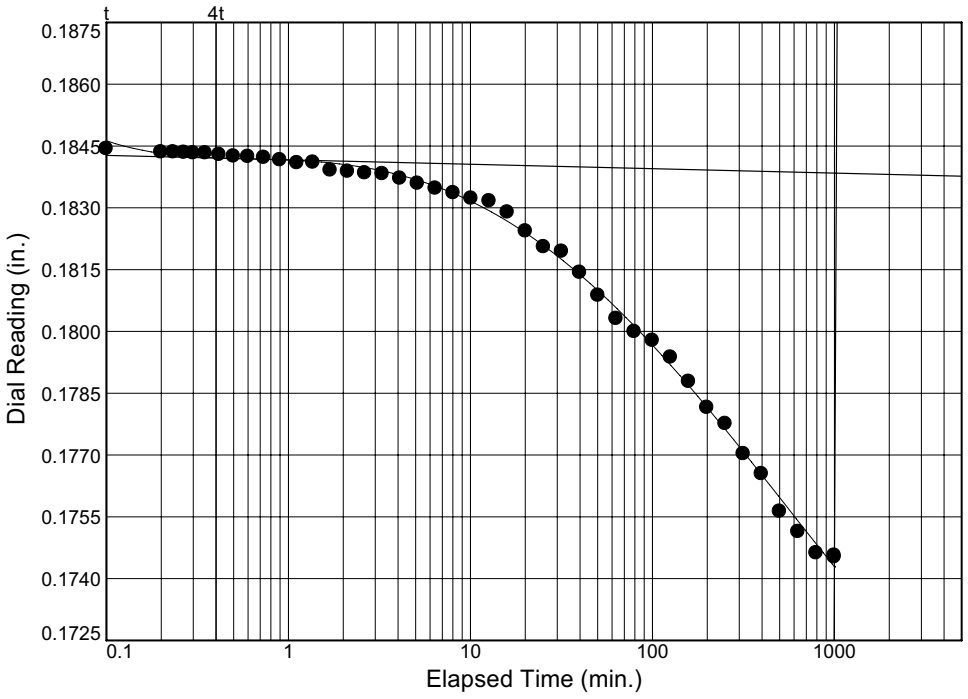
Location: B-2 Depth: 12-13 ft.



Load No.= 7
Load= 16000 psf
D_0 = 0.1602
D_{50} = 0.1722
D_{100} = 0.1842
T_{50} = 123.31 min.

C_v @ T_{50}
0.004 ft.^{2}/day

C_α = 0.005



Load No.= 8
Load= 8000 psf
D_0 = 0.1850
D_{50} = 0.1844
D_{100} = 0.1838
T_{50} = 0.14 min.

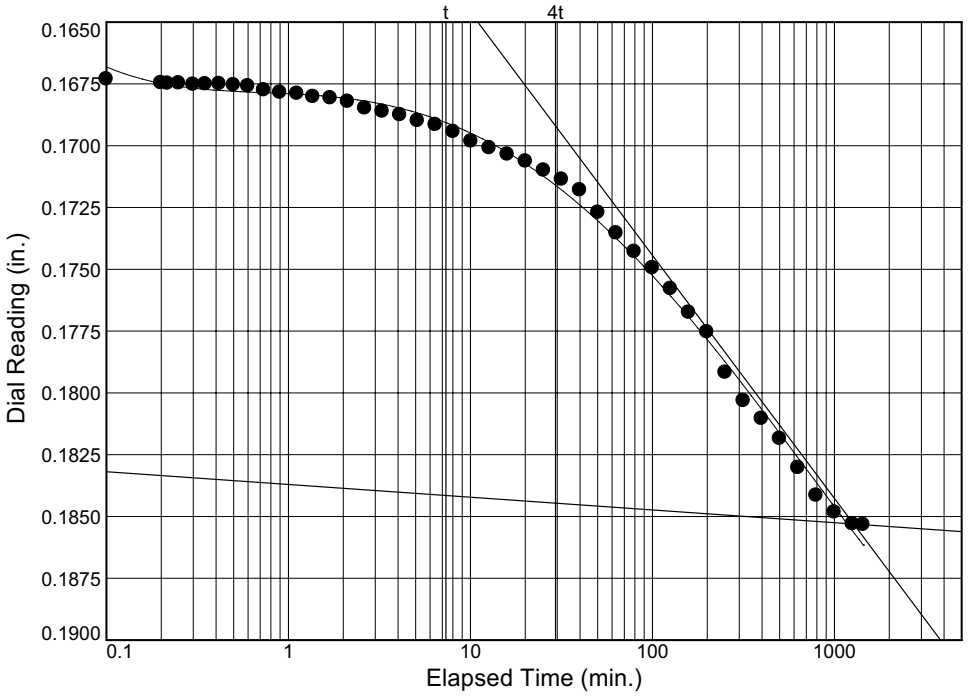
C_v @ T_{50}
3.308 ft.^{2}/day

C_α = 0.921

Dial Reading vs. Time

Project No.: M2205062
Project: Project Tundra

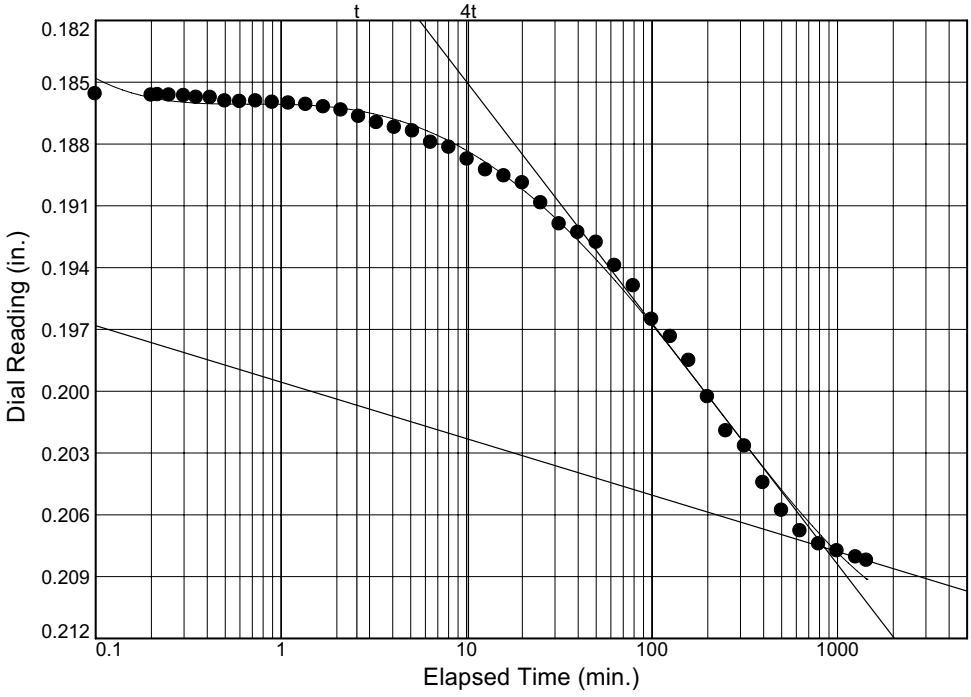
Location: B-2 Depth: 12-13 ft.



Load No.= 11
Load= 16000 psf
D_0 = 0.1665
D_{50} = 0.1759
D_{100} = 0.1853
T_{50} = 120.19 min.

C_v @ T_{50}
0.004 ft.^{2}/day

C_α = 0.001



Load No.= 12
Load= 32000 psf
D_0 = 0.1844
D_{50} = 0.1960
D_{100} = 0.2076
T_{50} = 84.96 min.

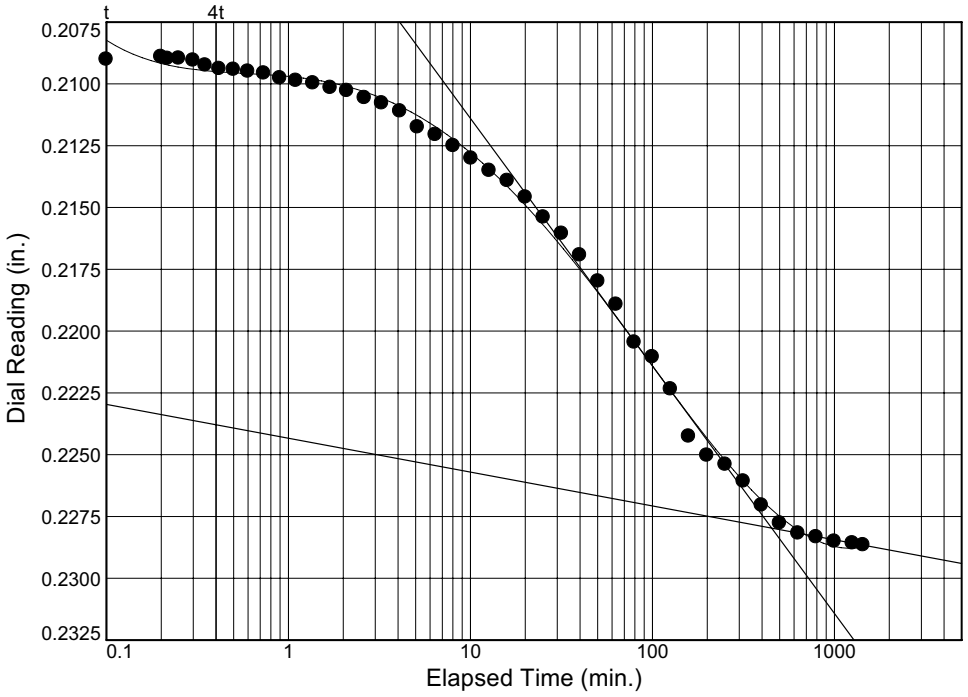
C_v @ T_{50}
0.005 ft.^{2}/day

C_α = 0.003

Dial Reading vs. Time

Project No.: M2205062
Project: Project Tundra

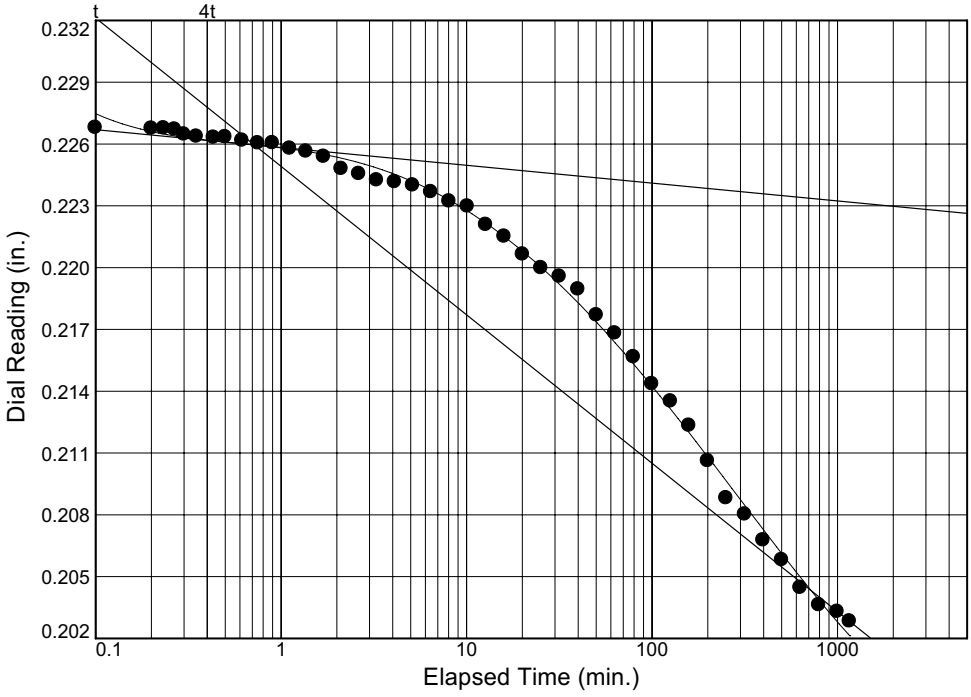
Location: B-2 Depth: 12-13 ft.



Load No.= 13
Load= 64000 psf
D_0 = 0.2070
D_{50} = 0.2175
D_{100} = 0.2280
T_{50} = 39.58 min.

C_v @ T_{50}
0.011 ft.^{2}/day

C_α = 0.001



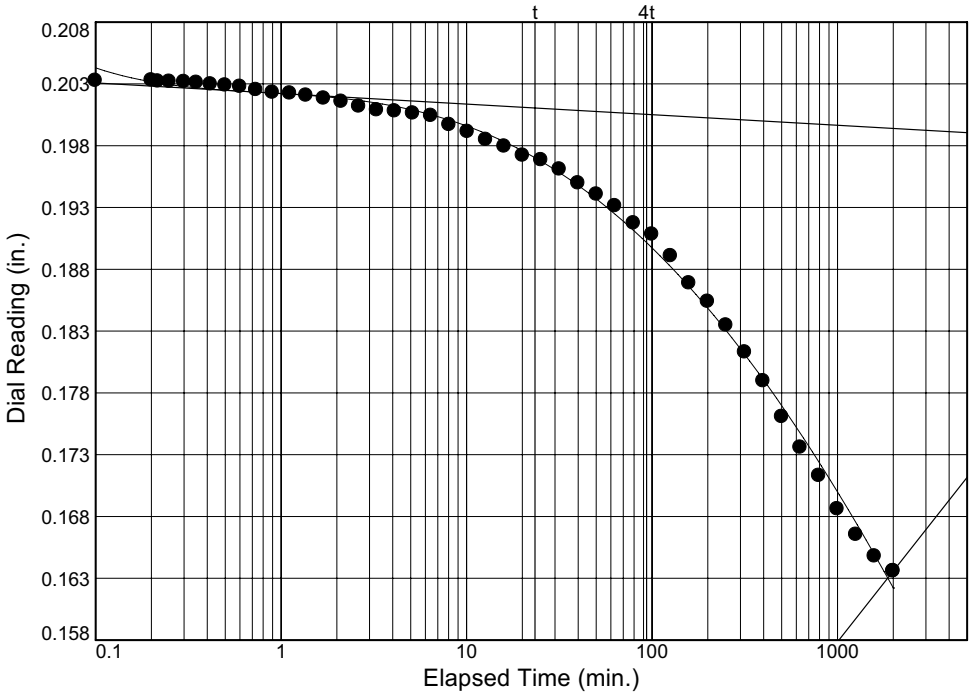
Load No.= 14
Load= 16000 psf
D_0 = 0.2288
D_{50} = 0.2274
D_{100} = 0.2260
T_{50} = 0.11 min.

C_v @ T_{50}
3.989 ft.^{2}/day

Dial Reading vs. Time

Project No.: M2205062
Project: Project Tundra

Location: B-2 Depth: 12-13 ft.



Load No.= 15
Load= 4000 psf
D_0 = 0.2039
D_{50} = 0.2009
D_{100} = 0.1979
T_{50} = 5.15 min.

C_v @ T_{50}
0.090 ft.^{2}/day

C_α = 0.019

CONSOLIDATION TEST DATA

10/12/2020

Client: Fluor Enterprises Inc Greenville, SC
Project: Project Tundra
Project Number: M2205062
Location: B-2
Depth: 12-13 ft.
Material Description: Dark gray Fat Clay
Testing Remarks: ASTM D2435
Specific gravity assumed

Test Specimen Data

NATURAL MOISTURE		VOID RATIO		AFTER TEST	
Wet w+t =	208.00 g.	Spec. Gr. =	2.73	Wet w+t =	227.92 g.
Dry w+t =	178.02 g.	Est. Ht. Solids =	0.609 in.	Dry w+t =	195.35 g.
Tare Wt. =	48.90 g.	Init. V.R. =	0.642	Tare Wt. =	63.09 g.
Moisture =	23.2 %	Init. Sat. =	98.8 %	Moisture =	24.6 %

UNIT WEIGHT		TEST START			
Height =	1.000 in.	Height =	1.000 in.	Dry Wt. =	132.26 g.
Diameter =	2.500 in.	Diameter =	2.500 in.		
Weight =	164.82 g.				
Dry Dens. =	103.8 pcf				

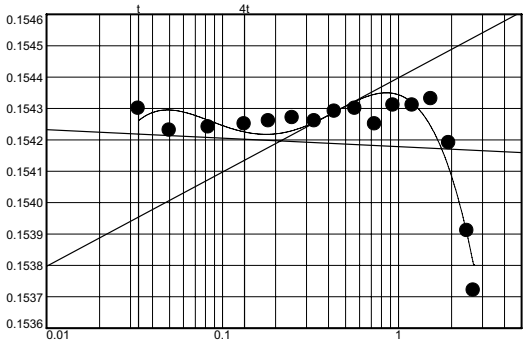
End-Of-Load Summary

Pressure (psf)	Final Dial (in.)	Deformation (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Strain
start	0.15433	0.00000			0.642	
250	0.15372	-0.00061	4.980		0.643	0.1 Swell
500	0.15207	-0.00226	0.088		0.645	0.2 Swell
1000	0.15206	-0.00227			0.645	0.2 Swell
2000	0.15171	-0.00262		0.000	0.646	0.3 Swell
4000	0.15253	-0.00180		0.001	0.645	0.2 Swell
8000	0.16053	0.00620		0.002	0.632	0.6 Comprs.
16000	0.18513	0.03080	0.004	0.005	0.591	3.1 Comprs.
8000	0.17456	0.02023	3.308	0.921	0.609	2.0 Comprs.
4000	0.15807	0.00374			0.636	0.4 Comprs.
8000	0.16681	0.01248		0.003	0.621	1.2 Comprs.
16000	0.18533	0.03100	0.004	0.001	0.591	3.1 Comprs.
32000	0.20822	0.05389	0.005	0.003	0.553	5.4 Comprs.
64000	0.22866	0.07433	0.011	0.001	0.520	7.4 Comprs.
16000	0.20283	0.04850	3.989		0.562	4.9 Comprs.
4000	0.16359	0.00926	0.090	0.019	0.627	0.9 Comprs.

Compression index (C_c), psf = 0.13 **Preconsolidation pressure (P_p), psf =** 6436 **Void ratio at P_p (e_m) =** 0.639
Recompression index (C_r) = 0.09

Pressure: 250 psf	TEST READINGS	Load No. 1

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.15433	11	0.7333	0.15425
2	0.0333	0.15430	12	0.9333	0.15431
3	0.0500	0.15423	13	1.2000	0.15431
4	0.0833	0.15424	14	1.5333	0.15433
5	0.1333	0.15425	15	1.9333	0.15419
6	0.1833	0.15426	16	2.4500	0.15391
7	0.2500	0.15427	17	2.6667	0.15372
8	0.3333	0.15426			
9	0.4333	0.15429			
10	0.5667	0.15430			

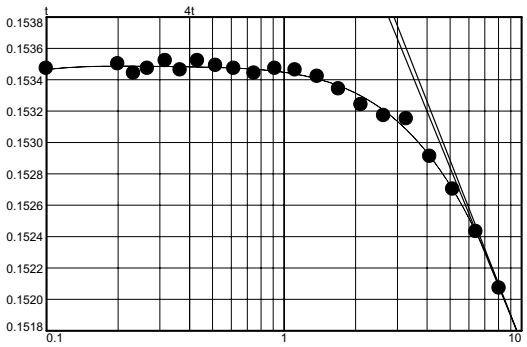


Void Ratio = 0.643 **Swell =** 0.1%

D_0 = 0.1543 **D_{50} =** 0.1542 **D_{100} =** 0.1542 **C_V at 0.10 min. =** 4.980 ft.^{2}/day

Pressure: 500 psf	TEST READINGS	Load No. 2

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.15334	12	0.9167	0.15347
2	0.1000	0.15347	13	1.1167	0.15346
3	0.2000	0.15350	14	1.3833	0.15342
4	0.2333	0.15344	15	1.7000	0.15334
5	0.2667	0.15347	16	2.1167	0.15324
6	0.3167	0.15352	17	2.6333	0.15317
7	0.3667	0.15346	18	3.2833	0.15315
8	0.4333	0.15352	19	4.1167	0.15291
9	0.5167	0.15349	20	5.1500	0.15270
10	0.6167	0.15347	21	6.4500	0.15243
11	0.7500	0.15344	22	8.0667	0.15207



Void Ratio = 0.645 **Swell =** 0.2%

D_0 = 0.1534 **D_{50} =** 0.1526 **D_{100} =** 0.1518 **C_V at 5.60 min. =** 0.088 ft.^{2}/day

Pressure: 1000 psf	TEST READINGS	Load No. 3

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.15161	11	0.7500	0.15235
2	0.1167	0.15202	12	0.9167	0.15234
3	0.2167	0.15209	13	1.1167	0.15233
4	0.2333	0.15211	14	1.3833	0.15233
5	0.2667	0.15202	15	1.7167	0.15234
6	0.3167	0.15210	16	2.1167	0.15229
7	0.3667	0.15219	17	2.6333	0.15227
8	0.4333	0.15211	18	3.0833	0.15206
9	0.5167	0.15211			
10	0.6167	0.15236			

Void Ratio = 0.645 **Swell =** 0.2%

Pressure: 2000 psf	TEST READINGS	Load No. 4

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.15100	11	0.7333	0.15236	21	6.4333	0.15252
2	0.1000	0.15227	12	0.9000	0.15239	22	8.0667	0.15249
3	0.2000	0.15230	13	1.1000	0.15244	23	10.1167	0.15240
4	0.2167	0.15232	14	1.3667	0.15242	24	12.7167	0.15229
5	0.2500	0.15230	15	1.7000	0.15263	25	15.9667	0.15212
6	0.3000	0.15232	16	2.1000	0.15258	26	20.0833	0.15180
7	0.3500	0.15231	17	2.6167	0.15254	27	22.0000	0.15171
8	0.4167	0.15231	18	3.2667	0.15259			
9	0.5000	0.15232	19	4.1000	0.15257			
10	0.6000	0.15238	20	5.1333	0.15249			

Void Ratio = 0.646 **Swell =** 0.3%

Pressure: 4000 psf	TEST READINGS	Load No. 5

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.15018	11	0.7500	0.15183	21	6.4333	0.15234
2	0.1000	0.15171	12	0.9167	0.15186	22	8.0667	0.15230
3	0.2000	0.15172	13	1.1167	0.15191	23	10.1333	0.15240
4	0.2333	0.15172	14	1.3833	0.15199	24	12.7167	0.15244
5	0.2667	0.15176	15	1.7000	0.15200	25	15.9833	0.15246
6	0.3167	0.15173	16	2.1167	0.15201	26	20.0833	0.15248
7	0.3667	0.15171	17	2.6333	0.15216	27	23.2667	0.15253
8	0.4333	0.15178	18	3.2833	0.15216			
9	0.5167	0.15179	19	4.1000	0.15221			
10	0.6167	0.15182	20	5.1333	0.15224			

Void Ratio = 0.645 **Swell =** 0.2%

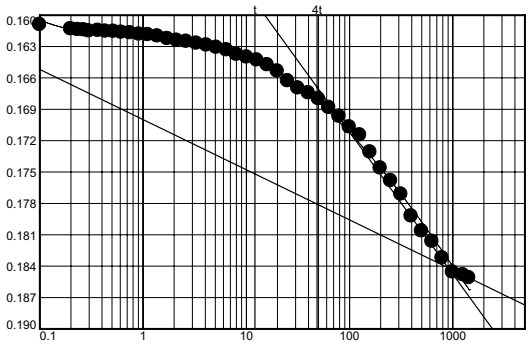
Pressure: 8000 psf	TEST READINGS	Load No. 6

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.15018	15	1.7000	0.15399	29	39.9333	0.15675
2	0.1000	0.15288	16	2.1167	0.15413	30	50.2500	0.15718
3	0.2000	0.15311	17	2.6333	0.15431	31	63.2333	0.15743
4	0.2333	0.15314	18	3.2833	0.15446	32	79.5667	0.15794
5	0.2667	0.15321	19	4.1000	0.15456	33	100.1333	0.15846
6	0.3000	0.15324	20	5.1333	0.15472	34	126.0333	0.15876
7	0.3500	0.15329	21	6.4333	0.15490	35	158.6167	0.15951
8	0.4167	0.15336	22	8.0667	0.15512	36	199.6667	0.15990
9	0.5000	0.15345	23	10.1167	0.15529	37	251.3333	0.16016
10	0.6167	0.15349	24	12.7167	0.15564	38	316.3667	0.16034
11	0.7500	0.15352	25	15.9667	0.15594	39	398.2500	0.16055
12	0.9000	0.15365	26	20.0833	0.15611	40	420.4667	0.16053
13	1.1167	0.15374	27	25.2500	0.15625			
14	1.3667	0.15383	28	31.7500	0.15640			

Void Ratio = 0.632 **Compression =** 0.6%

Pressure: 16000 psf	TEST READINGS	Load No. 7

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.15727	23	10.1333	0.16403
2	0.1000	0.16093	24	12.7167	0.16432
3	0.2000	0.16133	25	15.9833	0.16478
4	0.2333	0.16141	26	20.1000	0.16537
5	0.2667	0.16142	27	25.2500	0.16630
6	0.3000	0.16153	28	31.7667	0.16699
7	0.3667	0.16149	29	39.9500	0.16745
8	0.4333	0.16156	30	50.2667	0.16800
9	0.5167	0.16157	31	63.2333	0.16884
10	0.6167	0.16165	32	79.5833	0.16970
11	0.7500	0.16172	33	100.1500	0.17070
12	0.9167	0.16184	34	126.0333	0.17148
13	1.1167	0.16189	35	158.6333	0.17311
14	1.3833	0.16202	36	199.6667	0.17463
15	1.7167	0.16226	37	251.3333	0.17585
16	2.1167	0.16242	38	316.3833	0.17714
17	2.6333	0.16252	39	398.2500	0.17923
18	3.2833	0.16270	40	501.3333	0.18066
19	4.1167	0.16288	41	631.1000	0.18166
20	5.1500	0.16310	42	794.4833	0.18324
21	6.4333	0.16335	43	1000.1500	0.18459
22	8.0833	0.16378	44	1259.0833	0.18485



Pressure: 16000 psf	TEST READINGS (continued)	Load No. 7

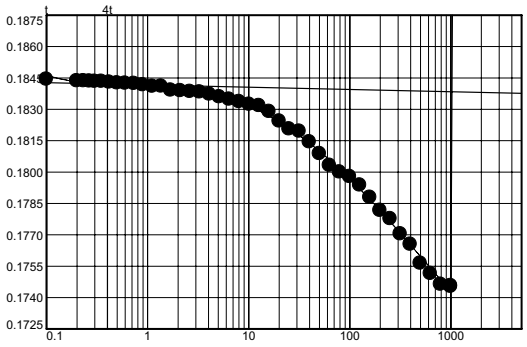
No.	Elapsed Time	Dial Reading
45	1440.3333	0.18513

Void Ratio = 0.591 **Compression =** 3.1%

D_0 = 0.1602 **D_{50} =** 0.1722 **D_{100} =** 0.1842 **C_v at 123.31 min. =** 0.004 ft.^{2}/day **C_α =** 0.005

Pressure: 8000 psf	TEST READINGS	Load No. 8

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.18826	23	10.1167	0.18323
2	0.1000	0.18443	24	12.7167	0.18316
3	0.2000	0.18435	25	15.9667	0.18289
4	0.2333	0.18435	26	20.0833	0.18243
5	0.2667	0.18434	27	25.2500	0.18205
6	0.3000	0.18433	28	31.7500	0.18194
7	0.3500	0.18433	29	39.9333	0.18143
8	0.4167	0.18429	30	50.2500	0.18087
9	0.5000	0.18425	31	63.2333	0.18031
10	0.6000	0.18424	32	79.5667	0.17999
11	0.7333	0.18422	33	100.1333	0.17978
12	0.9000	0.18416	34	126.0333	0.17937
13	1.1167	0.18409	35	158.6333	0.17878
14	1.3667	0.18410	36	199.6667	0.17815
15	1.7000	0.18391	37	251.3333	0.17776
16	2.1167	0.18388	38	316.3667	0.17703
17	2.6333	0.18384	39	398.2500	0.17654
18	3.2833	0.18382	40	501.3333	0.17563
19	4.1000	0.18371	41	631.1000	0.17514
20	5.1333	0.18359	42	794.4833	0.17462
21	6.4333	0.18347	43	1000.1500	0.17452
22	8.0667	0.18336	44	1000.2500	0.17456



Void Ratio = 0.609 **Compression =** 2.0%

D_0 = 0.1850 **D_{50} =** 0.1844 **D_{100} =** 0.1838 **C_v at 0.14 min. =** 3.308 ft.^{2}/day **C_α =** 0.921

Pressure: 4000 psf	TEST READINGS	Load No. 9

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.17661	16	2.1167	0.17418	31	63.2333	0.17030
2	0.1000	0.17464	17	2.6333	0.17414	32	79.5667	0.16980
3	0.2000	0.17468	18	3.2833	0.17408	33	100.1333	0.16932
4	0.2333	0.17472	19	4.1000	0.17392	34	126.0333	0.16855
5	0.2667	0.17470	20	5.1333	0.17380	35	158.6333	0.16782
6	0.3000	0.17469	21	6.4333	0.17365	36	199.6667	0.16721
7	0.3500	0.17464	22	8.0667	0.17348	37	251.3333	0.16612
8	0.4167	0.17465	23	10.1167	0.17327	38	316.3667	0.16518
9	0.5000	0.17459	24	12.7167	0.17315	39	398.2500	0.16412
10	0.6167	0.17453	25	15.9667	0.17285	40	501.3333	0.16285
11	0.7500	0.17454	26	20.0833	0.17267	41	631.1000	0.16227
12	0.9000	0.17447	27	25.2500	0.17240	42	794.4667	0.16122
13	1.1167	0.17443	28	31.7500	0.17206	43	1000.1500	0.15987
14	1.3667	0.17432	29	39.9500	0.17182	44	1259.0667	0.15820
15	1.7000	0.17435	30	50.2500	0.17084	45	1440.3167	0.15807

Void Ratio = 0.636 **Compression =** 0.4%

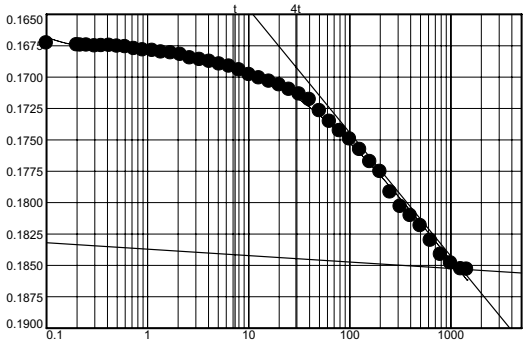
Pressure: 8000 psf	TEST READINGS	Load No. 10

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.15601	16	2.1000	0.15887	31	63.2167	0.16163
2	0.1000	0.15824	17	2.6167	0.15893	32	79.5667	0.16187
3	0.2000	0.15819	18	3.2833	0.15923	33	100.1333	0.16221
4	0.2167	0.15830	19	4.1000	0.15947	34	126.0333	0.16263
5	0.2667	0.15826	20	5.1333	0.15961	35	158.6333	0.16325
6	0.3000	0.15828	21	6.4333	0.15970	36	199.6667	0.16369
7	0.3500	0.15839	22	8.0667	0.15984	37	251.3333	0.16436
8	0.4167	0.15831	23	10.1167	0.16001	38	316.3667	0.16490
9	0.5000	0.15850	24	12.7167	0.16025	39	398.2500	0.16522
10	0.6000	0.15849	25	15.9667	0.16039	40	501.3333	0.16563
11	0.7333	0.15849	26	20.0833	0.16047	41	631.1000	0.16580
12	0.9000	0.15854	27	25.2500	0.16065	42	794.4833	0.16618
13	1.1000	0.15856	28	31.7500	0.16074	43	1000.1500	0.16630
14	1.3667	0.15864	29	39.9333	0.16100	44	1259.0833	0.16667
15	1.7000	0.15878	30	50.2500	0.16116	45	1440.3667	0.16681

Void Ratio = 0.621 **Compression =** 1.2%

Pressure: 16000 psf | **TEST READINGS** | **Load No. 11**

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.16364	24	12.7167	0.17009
2	0.1000	0.16731	25	15.9667	0.17035
3	0.2000	0.16746	26	20.0833	0.17063
4	0.2167	0.16748	27	25.2500	0.17100
5	0.2500	0.16747	28	31.7500	0.17137
6	0.3000	0.16753	29	39.9333	0.17180
7	0.3500	0.16751	30	50.2500	0.17270
8	0.4167	0.16750	31	63.2333	0.17354
9	0.5000	0.16755	32	79.5667	0.17429
10	0.6000	0.16759	33	100.1333	0.17495
11	0.7333	0.16775	34	126.0333	0.17579
12	0.9000	0.16785	35	158.6333	0.17675
13	1.1167	0.16789	36	199.6667	0.17754
14	1.3667	0.16802	37	251.3333	0.17918
15	1.7000	0.16808	38	316.3667	0.18032
16	2.1167	0.16822	39	398.2500	0.18104
17	2.6333	0.16849	40	501.3333	0.18185
18	3.2833	0.16862	41	631.1167	0.18303
19	4.1000	0.16876	42	794.4833	0.18415
20	5.1333	0.16899	43	1000.1500	0.18483
21	6.4333	0.16916	44	1259.0833	0.18530
22	8.0667	0.16944	45	1440.0000	0.18533
23	10.1167	0.16982			

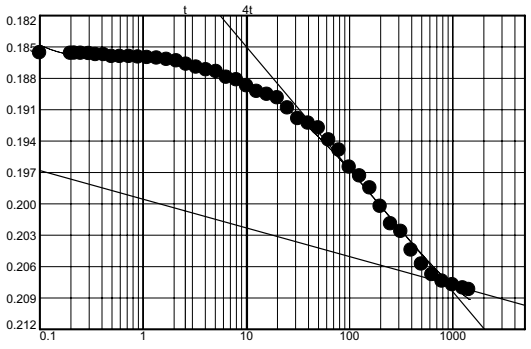


Void Ratio = 0.591 **Compression =** 3.1%

D_0 = 0.1665 **D_{50} =** 0.1759 **D_{100} =** 0.1853 **C_v at 120.19 min. =** 0.004 ft.^{2}/day **C_α =** 0.001

Pressure: 32000 psf | **TEST READINGS** | **Load No. 12**

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.17909	13	1.1000	0.18603
2	0.1000	0.18558	14	1.3667	0.18609
3	0.2000	0.18564	15	1.7000	0.18621
4	0.2167	0.18562	16	2.1167	0.18636
5	0.2500	0.18564	17	2.6333	0.18668
6	0.3000	0.18567	18	3.2833	0.18697
7	0.3500	0.18575	19	4.1000	0.18721
8	0.4167	0.18576	20	5.1333	0.18738
9	0.5000	0.18593	21	6.4333	0.18793
10	0.6000	0.18595	22	8.0667	0.18817
11	0.7333	0.18593	23	10.1167	0.18875
12	0.9000	0.18599	24	12.7167	0.18927



Pressure: 32000 psf	TEST READINGS (continued)	Load No. 12

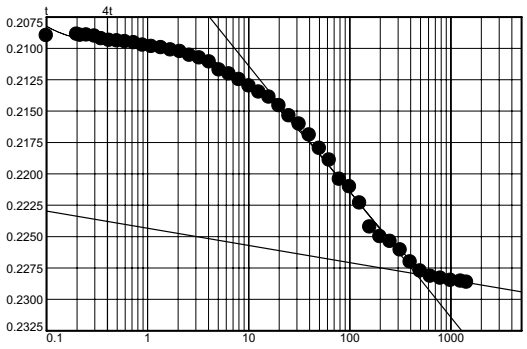
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
25	15.9667	0.18956	35	158.6333	0.19852	45	1440.1500	0.20822
26	20.0833	0.18990	36	199.6667	0.20028			
27	25.2500	0.19087	37	251.3333	0.20194			
28	31.7500	0.19189	38	316.3667	0.20267			
29	39.9333	0.19231	39	398.2500	0.20445			
30	50.2500	0.19278	40	501.3333	0.20579			
31	63.2333	0.19391	41	631.1000	0.20679			
32	79.5667	0.19490	42	794.4667	0.20742			
33	100.1333	0.19652	43	1000.1500	0.20776			
34	126.0333	0.19736	44	1259.0667	0.20806			

Void Ratio = 0.553 **Compression =** 5.4%

D_0 = 0.1844 **D_{50} =** 0.1960 **D_{100} =** 0.2076 **C_v at 84.96 min. =** 0.005 ft.^{2}/day **C_α =** 0.003

Pressure: 64000 psf	TEST READINGS	Load No. 13

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.19771	24	12.7167	0.21351
2	0.1000	0.20901	25	15.9667	0.21392
3	0.2000	0.20890	26	20.0667	0.21459
4	0.2167	0.20898	27	25.2333	0.21540
5	0.2500	0.20897	28	31.7500	0.21606
6	0.3000	0.20905	29	39.9333	0.21693
7	0.3500	0.20925	30	50.2500	0.21799
8	0.4167	0.20939	31	63.2167	0.21893
9	0.5000	0.20942	32	79.5667	0.22046
10	0.6000	0.20950	33	100.1333	0.22105
11	0.7333	0.20957	34	126.0167	0.22235
12	0.9000	0.20977	35	158.6167	0.22426
13	1.1000	0.20987	36	199.6667	0.22503
14	1.3667	0.20997	37	251.3333	0.22540
15	1.7000	0.21016	38	316.3667	0.22608
16	2.1000	0.21028	39	398.2500	0.22705
17	2.6167	0.21057	40	501.3333	0.22777
18	3.2667	0.21078	41	631.1000	0.22818
19	4.1000	0.21111	42	794.4667	0.22833
20	5.1333	0.21175	43	1000.1500	0.22851
21	6.4333	0.21206	44	1259.0667	0.22858
22	8.0667	0.21251	45	1440.2667	0.22866
23	10.1167	0.21301			

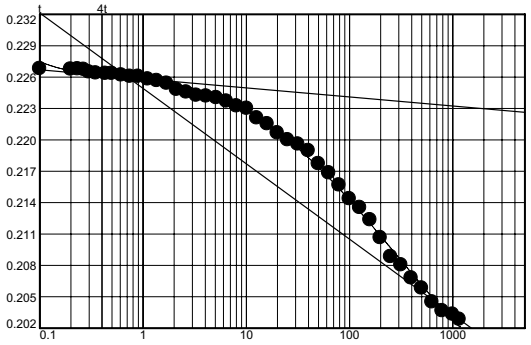


Void Ratio = 0.520 **Compression =** 7.4%

D_0 = 0.2070 **D_{50} =** 0.2175 **D_{100} =** 0.2280 **C_v at 39.58 min. =** 0.011 ft.^{2}/day **C_α =** 0.001

Pressure: 16000 psf	TEST READINGS	Load No. 14

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.24491	23	10.1333	0.22298
2	0.1000	0.22679	24	12.7167	0.22208
3	0.2000	0.22675	25	15.9833	0.22151
4	0.2333	0.22677	26	20.0833	0.22065
5	0.2667	0.22671	27	25.2500	0.21998
6	0.3000	0.22647	28	31.7500	0.21957
7	0.3500	0.22637	29	39.9500	0.21895
8	0.4333	0.22632	30	50.2500	0.21770
9	0.5000	0.22634	31	63.2333	0.21681
10	0.6167	0.22617	32	79.5667	0.21566
11	0.7500	0.22604	33	100.1333	0.21435
12	0.9000	0.22605	34	126.0333	0.21351
13	1.1167	0.22579	35	158.6333	0.21233
14	1.3667	0.22564	36	199.6667	0.21062
15	1.7000	0.22539	37	251.3333	0.20882
16	2.1167	0.22480	38	316.3667	0.20802
17	2.6333	0.22455	39	398.2500	0.20677
18	3.2833	0.22425	40	501.3333	0.20581
19	4.1000	0.22416	41	631.1000	0.20447
20	5.1333	0.22400	42	794.4833	0.20363
21	6.4333	0.22368	43	1000.1500	0.20330
22	8.0667	0.22322	44	1162.2500	0.20283

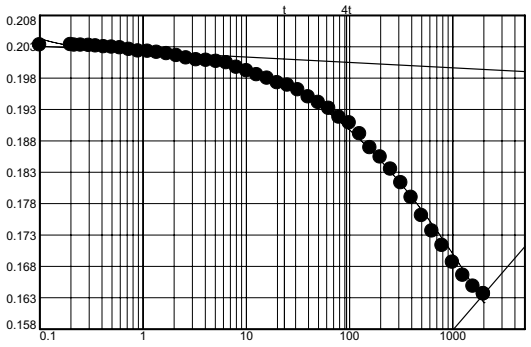


Void Ratio = 0.562 **Compression =** 4.9%

D_0 = 0.2288 **D_{50} =** 0.2274 **D_{100} =** 0.2260 **C_v at 0.11 min. =** 3.989 ft.^{2}/day

Pressure: 4000 psf	TEST READINGS	Load No. 15

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.0000	0.20817	14	1.3667	0.20207
2	0.1000	0.20326	15	1.7000	0.20183
3	0.2000	0.20330	16	2.1167	0.20157
4	0.2167	0.20320	17	2.6333	0.20118
5	0.2500	0.20319	18	3.2833	0.20087
6	0.3000	0.20316	19	4.1000	0.20078
7	0.3500	0.20310	20	5.1333	0.20061
8	0.4167	0.20297	21	6.4333	0.20042
9	0.5000	0.20289	22	8.0667	0.19968
10	0.6000	0.20277	23	10.1167	0.19913
11	0.7333	0.20252	24	12.7167	0.19848
12	0.9000	0.20229	25	15.9833	0.19794
13	1.1167	0.20224	26	20.0833	0.19720



Pressure: 4000 psf	TEST READINGS (continued)	Load No. 15

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
27	25.2500	0.19685	37	251.3333	0.18346	47	2000.2500	0.16359
28	31.7500	0.19609	38	316.3667	0.18128			
29	39.9500	0.19497	39	398.2500	0.17895			
30	50.2500	0.19406	40	501.3333	0.17607			
31	63.2333	0.19312	41	631.1167	0.17359			
32	79.5667	0.19172	42	794.4833	0.17130			
33	100.1333	0.19082	43	1000.1500	0.16860			
34	126.0333	0.18908	44	1259.0833	0.16653			
35	158.6333	0.18687	45	1585.0500	0.16479			
36	199.6667	0.18538	46	1995.4167	0.16357			

Void Ratio = 0.627 **Compression =** 0.9%

D_0 = 0.2039 **D_{50} =** 0.2009 **D_{100} =** 0.1979 **C_v at 5.15 min. =** 0.090 ft.^{2}/day **C_α =** 0.019

ATTACHMENT 6 – PLANT SITE DATA SHEET

Minnkota Power Cooperative

Project Tundra Carbon Capture and Sequestration Project

PLANT SITE DATA SHEET

DOCUMENT NUMBER:
M1NN-CCS-SPC-210-00002

Fluor Project No: M1NN

				CTL kri8786G 2020.12.10 07:55:18 -06'00'	NS	Jayesh Patel Digitally signed by Jayesh Patel Date: 2020.12.10 10:50:31 -06'00'	
0	09Dec2020	14	Issued for Design	KPC/CTK	NS	JP	
B	28Jul2020	14	Issued for Client Review	KPC/CTK	NS	JP	
A	22Jul2020	4	Issued for Internal Review	KP	NS		
REV	**DATE**	**PAGES**	**DESCRIPTION**	**ORIG.**	**CHKD**	**Fluor**	**CLIENT**
						APPROVED BY	

PLANT SITE DATA SHEET

RECORD OF REVISIONS

Revision No.	Date	Description
A	22Jul2020	Issued for Internal Review
B	28Jul2020	Issued for Client Review
0	09Dec2020	Issued for Design



FLUOR®

PLANT SITE DATA SHEET

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1 SCOPE 4
2 MODIFICATIONS TO PIP CVC01017 4

PLANT SITE DATA SHEET

1 SCOPE

PIP CVC01017, Plant Site Data Sheet, dated January 2019 is adopted for Minnkota Power Cooperative, Inc Project Tundra use with the following modifications noted in this addendum.

2 MODIFICATIONS TO PIP CVC01017

The following requirements are defined as additions, deletions, and revisions to PIP CVC01017. Section numbers below refer to PIP CVC01017 section numbers

Section	***Description***
Table of Contents 2. References	*Change:* 2.1 Process Industry Practices……2 *To:* 2.1 Project Specification……2
All	*Change:* All references to PIP CVC01015 to M1NN-CCS-SPC-210-00001 PIP CVC01018 to M1NN-CCS-SPC-210-00003 PIP CVI02350 to M1NN-CCS-SPC-210-00007 PIP CVS02100 to M1NN-CCS-SPC-210-00008 PIP CVS02350 to M1NN-CCS-SPC-210-00006 PIP CVS02700 to M1NN-CCS-SPC-210-00009 PIP STS03001 to M1NN-CCS-SPC-215-00011 PIP STC01015 to M1NN-CCS-SPC-215-00001 PIP STE05501 to M1NN-CCS-SPC-215-00006 PIP STE05511 to M1NN-CCS-SPC-215-00012 PIP ARC01015 to M1NN-CCS-SPC-220-00001
Section 2.2	*Add:* - 2017 ASHRAE Handbook – Fundamentals, Chapter 14 – Climatic Design Information - North Dakota State Building Code of 2020

[redacted]

DATA SHEET

PLANT SITE DATA SHEET (US CUSTOMARY UNITS)

FACILITY NAME/LOCATION: Milton R Young (MRY) Generating Station / Center, MD

BUILDING CODE:

DESIGN AT THIS PLANT SITE SHALL BE IN ACCORDANCE WITH THE FOLLOWING BUILDING CODE(S):

		YEAR OF LOCALLY ADOPTED EDITION
[ ]	INTERNATIONAL BUILDING CODE (IBC)	
[ ]	INTERNATIONAL FIRE CODE (IFC)	
[ ]	NFPA 101, LIFE SAFETY CODE (LSC)	
[X]	OTHER: ND State Building Code of Jan 2020	Reference to IBC 2018 and state amendments
[ ]	NONE	

OWNER'S LIAISON WITH BUILDING AUTHORITY:

NAME: TBD PHONE: TBD

LOCAL BUILDING AUTHORITY:

NAME: Oliver County Planning & Zoning Department
ADDRESS: P.O. Box 188. Center. ND 58530
PHONE/FAX.: PH (701) 794 3649 / FAX (701) 794 3476
CONTACT: John Wicklund
EXEMPTIONS: [X] YES [ ] NO SPECIFY: TBD
BUILDING PERMITS: [ ] YES [X] NO SPECIFY:

STATE OR OTHER FIRE AUTHORITY:

NAME: North Dakota Fire Marshal's Office
ADDRESS: P.O. Box 1054, Bismarck, ND 58502 1054
PHONE/FAX.: PH (701) 328 5555 / FAX (701) 328 5510
CONTACT: Doug Nelson

STORM WATER GOVERNING AUTHORITY:

NAME: Director, Division of Water Quality
ADDRESS: 918 E Divide Ave, Bismarck, ND 58501 1947
PHONE/FAX.: 701 328 5225
CONTACT: Karl Rockeman, P.E.;

FACILITY STANDARD INDUSTRIAL CLASSIFICATION CODE (OSHA) OR NORTH AMERICAN INDUSTRIAL CLASSIFICATION CODE: OSHA

EPA MULTI-SECTOR GENERAL PERMIT APPLICABLE TO FACILITY?	[ ] YES	[X] NO
INDIVIDUAL PERMIT REQUIRED?	[X] YES	[ ] NO

CONSTRUCTION DISTURBED AREA: PHASE I: GREATER THAN 5 ACRES PHASE II: BETWEEN 1 TO 5 ACRES

NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM (NPDES) EQUIVALENT:

NPDES PERMIT REQUIRED FOR GREATER THAN: _____ ACRES DISTURBED?	[X] YES	[ ] NO
NOTICE OF INTENT REQUIRED?	[X] YES	[ ] NO
STORM WATER DISCHARGE PERMIT (SWDP) REQUIRED?	[X] YES	[ ] NO
STORM WATER POLLUTION PREVENTION PLAN (SWPPP) REQUIRED?	[X] YES	[ ] NO
SPILL PREVENTION, CONTAINMENT, AND COUNTERMEASURE (SPCC) PLAN REQUIRED?	[X] YES	[ ] NO
EROSION CONTROL PLAN REQUIRED (EVEN WITHOUT PERMIT)? (US LIMIT IS 1 ACRE)	[X] YES	[ ] NO

NO.	DATE	REVISION DESCRIPTION	BY	APVD.

[redacted]

DATA SHEET

PLANT SITE DATA SHEET
(US CUSTOMARY UNITS)

TOPOGRAPHICAL AND SURVEY DATA:

NORTH AMERICAN DATUM: [X] [ ] NAD 83 OR [X] OTHER: NAD 27

NORTH AMERICAN VERTICAL DATUM: [X] [ ] NAVD 88 OR [X] OTHER: NAVD 1929

PLANT DATUM ELEVATION: 100 FT = 1988 FT MEAN SEA LEVEL (MSL)

ANGULAR RELATION BETWEEN TRUE NORTH AND PLANT DESCRIPTIVE NORTH: 0 DEG. [ ] R [ ] L

PLANT COORDINATE 0,0 = N/A (LATITUDE), N/A (LONGITUDE) BASED ON THE N/A COORDINATE SYSTEM

ZIP CODE: 58530

PLANT BENCHMARK (SURVEY BENCHMARK) LOCATION: see M1NN-00-K001-0003-01 Minnkota Tundra Project - Topographic Survey

RIGHTS OF WAY SURVEY DOCUMENT LOCATION(S): see M1NN-00-K001-0003-01 Minnkota Tundra Project - Topographic Survey

WIND DIRECTION:

PREVAILING WIND DIRECTION: [ ] N [ ] NE [ ] E [X] SE [ ] S [ ] SW [ ] W [ ] NW

PERCENT ANNUALLY IN EACH DIRECTION: ____% ____% ____% ____% ____% ____% ____% ____%

IN TERMS OF: [ ] TRUE NORTH OR [X] PLANT NORTH

DATA SOURCE AND LOCATION:

TEMPERATURE:

HIGHEST MAX. TEMPERATURE:	113 °F		LOWEST MIN. TEMPERATURE:	-45 °F	
AVERAGE TEMPERATURE:	SUMMER:	°F	WINTER:	°F	
HVAC DESIGN DRY BULB:	SUMMER:	93.1 °F	WINTER:	-17.5 °F	
HVAC DESIGN WET BULB:	SUMMER:	69.9 °F	WINTER:	N/A °F	
RELATIVE HUMIDITY:	SUMMER:	%	WINTER:	%	

SOURCE: [X] ASHRAE 169 [X] OWNER [X] OTHER: M1NN-CCS-SPC-235-00001, ASHRAE 2017 Station WMO #727640

AIR HEATING INDEX (SUM OF HEATING DEGREE DAYS): N/A

AIR COOLING INDEX (SUM OF COOLING DEGREE DAYS): N/A

AIR FREEZING INDEX (SUM OF FREEZING DEGREE DAYS):

AIR THAWING INDEX (SUM OF THAWING DEGREE DAYS):

RAINFALL:

DESIGN RAINFALL INTENSITY: 3.86 INCH/HR. BASED ON A 15 MIN. RAINFALL DURATION PERIOD ASSOCIATED WITH THE 10 - YEAR STORM

DESIGN ACCUMULATED 24-HOUR RAINFALL: 2.98 INCH, BASED ON THE 10 - YEAR STORM

RAINFALL INTENSITY FOR EVALUATION OF POTENTIAL FLOODING: 4.87 IN/HR, BASED ON A 15 MIN. RAINFALL DURATION ASSOCIATED WITH THE 25 - YEAR STORM

PEAK RAINY SEASON FOR THIS PLANT SITE IS FROM (MONTHS) ____ TO ____

AVERAGE ANNUAL RAINFALL: ____ INCHES

FLOODS:

100-YEAR FLOOD ELEVATION: ____ FT ABOVE [ ] PLANT DATUM OR [ ] MSL OR [ ] ____

PROBABLE MAX. FLOOD ELEV.: ____ FT ABOVE [ ] PLANT DATUM OR [ ] MSL OR [ ] ____

FLOOD CONTROL DISTRICT OR WATERSHED CONTACT:

OTHER FLOOD ELEVATIONS CONSIDERED AT THIS PLANT FOR ROADS, PARKING, AREAS, AND OTHER LESS CRITICAL AREAS:

Flood elevation for the overflow condition of the Nelson Lake Dam was determined to be much lower than the plant grade elevation.

WETLANDS:

LOCATION/LIMITS: North and South Retention Ponds per US Fish and Wildlife Service

RAILROADS: Not applicable to this project

RAILROAD DESIGN AT THIS SITE SHALL BE IN ACCORDANCE WITH THE FOLLOWING RAILROAD CODE OR STANDARD:

[ ] AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION (AREMA) EDITION: ____

[ ] OTHER:

LOCAL OPERATING RAILROAD:

RAILCAR CLEARANCES: VERTICAL: ____ FT HORIZONTAL: ____ FT FROM CENTERLINE OF TRACK

MINIMUM WEIGHT AND TYPE RAIL: NO. 1 RELAY RAIL PERMITTED: [ ] YES [ ] NO

MAXIMUM TRACK CURVATURE FROM MAIN LINE RAILROAD:

MAXIMUM TRACK CURVATURE WITHIN PLANT LIMITS:

RAILROAD HP: RAILROAD LP:

	DATA SHEET	
	PLANT SITE DATA SHEET (US CUSTOMARY UNITS)	PAGE 3 OF 5

PLANT ROADS AND STREETS:

ROAD AND STREET DESIGN AT THIS SITE SHALL BE IN ACCORDANCE WITH THE FOLLOWING CODE OR STANDARD:

- [ ] AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)
- [ ] STATE D.O.T. SPECIFICATION: _____
- [X] OTHER: M1NN-CCS-SPC-210-00001
- [ ] CRANE LOADING: _____

PRIMARY ROADS – MAIN TRAFFIC ROUTES, TANKER AND SEMI-TRAILER TRUCK TRAFFIC OCCURS

ROAD WIDTH: 20 FT
HP: _____ LP: _____
SHOULDER WIDTH: 3 FT
HORIZONTAL CLEARANCE: 5 FT FROM: [ ] CENTERLINE [X] EDGE OF ROAD
VERTICAL CLEARANCE: 21'-0" FT
ROADWAY SURFACE MATERIAL: Asphalt
CORNER RADIUS: _____ FT

SECONDARY ROADS – REGULAR OPERATIONAL & MAINTENANCE TRAFFIC, NOT SUBJECT TO HIGH TRAFFIC

ROAD WIDTH: 20 FT
HP: _____ LP: _____
SHOULDER WIDTH: 3 FT
HORIZONTAL CLEARANCE: 5 FT FROM: [ ] CENTERLINE [X] EDGE OF ROAD
VERTICAL CLEARANCE: 12'-0" FT
ROADWAY SURFACE MATERIAL: Asphalt
CORNER RADIUS: _____ FT

ACCESSWAYS - TRAVEL WAYS THAT PROVIDE ACCESS TO EQUIPMENT OR CONGESTED AREAS

MIN. SINGLE LANE WIDTH: 8 FT
SHOULDER WIDTH: 2 FT
HORIZONTAL CLEARANCE: 3 FT FROM: [ ] CENTERLINE [X] EDGE OF ROAD
VERTICAL CLEARANCE: 12'-0" FT
ROADWAY SURFACE MATERIAL: Gravel

ROUTES WITH SPECIAL VEHICLES OR REQUIREMENTS SUCH AS OVER WEIGHT, OVER HEIGHT, HEAVY WHEEL LOADINGS, AND ETC.

HEAVY FORKLIFTS: MAKE AND MODEL: _____ WEIGHT: _____ HEIGHT: _____ WIDTH: _____
CONTAINER LIFTS: MAKE AND MODEL: _____ WEIGHT: _____ HEIGHT: _____ WIDTH: _____
HEAVY CRANES: MAKE AND MODEL: _____ WEIGHT: _____ HEIGHT: _____ WIDTH: _____
WASTE HAULERS: MAKE AND MODEL: _____ WEIGHT: _____ HEIGHT: _____ WIDTH: _____

HEAVY HAUL OR OVER SIZE HAUL ROUTE TO PLANT: _____ WIDTH OF ROAD: _____ CORNER RADIUS: _____

EMERGENCY/EVACUATION ROUTE FROM PLANT: _____

BRIDGES/CULVERT RESTRICTIONS DUE TO LOAD CAPACITY OR OVER WIDTH: (PROVIDE LOCATION AND RESTRICTION BELOW):

_____

_____

	DATA SHEET	
	PLANT SITE DATA SHEET (US CUSTOMARY UNITS)	PAGE 4 OF 5

WIND LOADS:

MINIMUM DESIGN WIND LOADS AT THIS SITE SHALL BE COMPUTED IN ACCORDANCE WITH THE FOLLOWING CODE OR STANDARD, USING THE SITE SPECIFIC PARAMETERS INDICATED BELOW:

- [X] ASCE/SEI 7- 16 "MINIMUM DESIGN LOADS FOR BUILDINGS AND OTHER STRUCTURES"
- [ ] BUILDING CODE INDICATED ON PAGE 1
- [ ] PHMSA 49 CFR PART 193 EDITION: ____ [ ] NFPA 59A EDITION: ____
- [ ] OTHER W/ EDITION: ____

RISK CATEGORY: [ ] I [ ] II [X] III [ ] IV [ ] SEE PROJECT DATA SHEET [ ] OTHER: ____

BASIC WIND SPEED: 121 MPH [X] 3-SECOND GUST [ ] FASTEST MILE [ ] OTHER: ____

RECURRENCE INTERVAL: [ ] 50 YEAR [ ] 100 YEAR [ ] OTHER: ____ YEAR

EXPOSURE CATEGORY: [ ] B [X] C [ ] D

TOPOGRAPHIC FACTOR: [ ] K_{zt}: ____ [ ] SEE PROJECT DATA SHEET [ ] N/A [ ] OTHER: ____

HURRICANE PRONE REGION: [ ] YES [X] NO DISTANCE FROM COAST LINE: ____

SPECIAL WIND REGION: [ ] YES [X] NO CONDITIONS: ____

EARTHQUAKE LOADS:

MINIMUM DESIGN EARTHQUAKE LOADS AT THIS SITE SHALL BE COMPUTED IN ACCORDANCE WITH THE FOLLOWING CODE OR STANDARD, USING THE SITE SPECIFIC PARAMETERS INDICATED BELOW:

- [X] ASCE/SEI 7- 16 "MINIMUM DESIGN LOADS FOR BUILDINGS AND OTHER STRUCTURES"
- [ ] SEISMIC CODE NAME AND EDITION: ____
- [ ] BUILDING CODE INDICATED ON PAGE 1
- [ ] PHMSA 49 CFR PART 193 EDITION: ____ [ ] NFPA 59A EDITION: ____
- [ ] OTHER W/ EDITION: ____

FOR ASCE/SEI 7 AND OTHER CODES AND STANDARDS BASED ON NEHRP PROVISIONS:

SITE SPECIFIC SEISMIC HAZARD ASSESSMENT PERFORMED? [ ] YES [X] NO

REFERENCE: ____

RISK CATEGORY: [ ] I [ ] II [X] III [ ] IV [ ] SEE PROJECT DATA SHEET [ ] OTHER: ____

PROPER SELECTION OF IMPORTANCE FACTOR FOR RISK CATEGORY (ASCE/SEI 7 TABLE 1.5-2) SHALL BE MADE.

SITE CLASS: [ ] A [ ] B [ ] C [X] D [ ] E [ ] F

0.2 S SPECTRAL RESPONSE ACCELERATION (S_S) = 0.052g

1.0 S SPECTRAL RESPONSE ACCELERATION (S_1) = 0.022g

FOR OTHER CODES AND STANDARDS: ____

SNOW LOADS:

MINIMUM DESIGN SNOW LOADS AT THIS SITE SHALL BE COMPUTED IN ACCORDANCE WITH THE FOLLOWING CODE OR STANDARD, USING THE SITE SPECIFIC PARAMETERS INDICATED BELOW:

- [X] ASCE/SEI 7- 16 "MINIMUM DESIGN LOADS FOR BUILDINGS AND OTHER STRUCTURES"
- [ ] BUILDING CODE INDICATED ON PAGE 1
- [ ] OTHER W/ EDITION: ____

RISK CATEGORY: [ ] I [ ] II [X] III [ ] IV [ ] SEE PROJECT DATA SHEET [ ] OTHER: ____

PROPER SELECTION OF IMPORTANCE FACTOR FOR RISK CATEGORY (ASCE/SEI 7 TABLE 1.5-2) SHALL BE MADE.

GROUND SNOW LOAD: 35 PSF, 50-YEAR MEAN RECURRENCE INTERVAL

ICE LOADS:

MINIMUM DESIGN ICE LOADS AT THIS SITE SHALL BE COMPUTED IN ACCORDANCE WITH THE FOLLOWING CODE OR STANDARD, USING THE SITE SPECIFIC PARAMETERS INDICATED BELOW:

- [X] ASCE/SEI 7- 16 "MINIMUM DESIGN LOADS FOR BUILDINGS AND OTHER STRUCTURES"
- [ ] BUILDING CODE INDICATED ON PAGE 1
- [ ] OTHER W/ EDITION: ____

RISK CATEGORY: [ ] I [ ] II [X] III [ ] IV [ ] SEE PROJECT DATA SHEET [ ] OTHER: ____

PROPER SELECTION OF IMPORTANCE FACTOR FOR RISK CATEGORY (ASCE/SEI 7 TABLE 1.5-2) SHALL BE MADE.

ICE THICKNESS: TBD INCHES, 50-YEAR MEAN RECURRENCE INTERVAL

CONCURRENT WIND SPEED: ____ MPH, 3-SECOND GUST, 50-YEAR MEAN RECURRENCE INTERVAL

SPECIAL ICING REGION: [ ] YES [X] NO CONDITIONS: ____

SOIL PROPERTIES:

[X] PROJECT DATA SHEET [X] OTHER: Geotechnical Report : Terracon Project No. 2205062

FROST DEPTH:

SITE FROST DEPTH: 7 FT BELOW GRADE

PERMAFROST THICKNESS: N/A FT

ACTIVE LAYER THICKNESS: N/A FT (TUNDRA)

STANDARD STAIRS AND FIXED LADDERS (FOLLOWING CRITERIA SHALL BE USED UNLESS OTHERWISE SPECIFIED)

STANDARD STAIRS FOR INDUSTRIAL OCCUPANCIES:

CONCENTRATED LIVE LOAD	[ ] 300 LBS	[x] OTHER: 1000 LBS				
UNIFORM LIVE LOAD	[x] 100 PSF	[ ] OTHER: PSF				
STAIR WIDTH FOR OCCUPANT LOAD ≤ 20 PEOPLE		[x] 30 INCHES	[ ] OTHER: INCHES			
RISER DIMENSION FOR OCCUPANT LOAD ≤ 20 PEOPLE		MIN: 6.5 INCHES		MAX: 9 INCHES		
TREAD DIMENSION FOR OCCUPANT LOAD ≤ 20 PEOPLE		MIN: 10 INCHES		MAX: 11 INCHES		
STAIR WIDTH FOR OCCUPANT LOAD > 20 AND < 50 PEOPLE		[x] 36 INCHES	[ ] OTHER: INCHES			
RISER DIMENSION FOR OCCUPANT LOAD > 20 AND < 50 PEOPLE		MIN: 6.5 INCHES		MAX: 9 INCHES		
TREAD DIMENSION FOR OCCUPANT LOAD > 20 AMD < 50 PEOPLE		MIN: 10 INCHES		MAX: 11 INCHES		
COATING	[x] GALVANIZED	[ ] PAINTED	[ ] SAFETY YELLOW PAINT	PAINT SPEC:		

FIXED LADDERS:

CONCENTRATED LIVE LOAD	[x] 300 LBS	[ ] OTHER: LBS				
CLEAR WIDTH BETWEEN LADDER RAILS	[x] 18 INCHES	[ ] OTHER: INCHES				
DIAMETER OR SIZE OF RUNGS	[x] 3/4 INCHES	[ ] OTHER: INCHES				
RUNG SPACING	[x] 12 INCHES	[ ] OTHER: INCHES				
SIDE-STEP LADDERS	[x] YES	[ ] NO	[ ] PREFERRED FOR:			
THROUGH LADDERS	[x] YES	[ ] NO	[ ] PREFERRED FOR:			
LADDER PITCH FROM HORIZONTAL	[x] 90 DEGREES	[ ] 75 TO 90 DEGREES				
TYPE OF LADDER RAIL	[x] 2-1/2 IN X 3/8 IN BAR	[x] 3 IN X 3/8 IN BAR	[x] C3x4.1	[ ] OTHER:		
LADDER BASE DETAIL AT VERTICAL VESSELS	[ ] TYPE 1	[ ] TYPE 2				
DEFINE LOWER LEVEL TO BE BASE OF LADDER FOR LADDERS WITH CAGES	[x] YES	[ ] NO				
LIMIT CLIMB LENGTH OF ALL LADDERS TO 24 FEET AND PROVIDE CAGES	[x] YES	[ ] NO				
HEIGHT ABOVE LOWER LEVEL TO PROVIDE LADDER SAFETY/PERSONAL FALL ARREST SYSTEMS	[x] > 24 FT	[ ] OTHER:				
WIDTH OF FLARED LADDER RAILS AT THROUGH LADDERS	[ ] 24 INCHES	[ ] 30 INCHES	[ ] OTHER: INCHES			
MAXIMUM CLIMB LENGTH BETWEEN REST PLATFORMS	24 FEET	APPLICATION:				
MAXIMUM LENGTH OF CONTINUOUS LADDER:	28 FEET	APPLICATION:				
ALLOW INTERMEDIATE LADDER ACCESS	[ ] YES	[ ] NO	APPLICATION:			
SAFETY TRANSITION SUPPORTS AT INTERMEDIATE AND TOP LADDER ACCESS	[x] YES	[ ] NO	TYPE:			
COATING	[x] GALVANIZED	[ ] PAINTED	[ ] SAFETY YELLOW PAINT	PAINT SPEC:		

TYPE OF RUNGS

SMOOTH ROUND BAR	[x] YES	[ ] NO	
TWISTED SQUARE BAR	[ ] YES	[ ] NO	
SQUARE BAR WITH EDGE ON TOP	[ ] YES	[ ] NO	
REBAR	[ ] YES	[ ] NO	MATERIAL:
COATED WITH SKID RESISTANT MATERIAL	[ ] YES	[ ] NO	MATERIAL:

OTHER:

LADDER SAFETY SYSTEM

FLEXIBLE CABLE CARRIER	[x] YES	[ ] NO
RIGID RAIL CARRIER	[ ] YES	[ ] NO
LADDER DAVIT SYSTEM	[ ] YES	[ ] NO

MANUFACTURER / MODEL : /

PERSONAL FALL ARREST SYSTEM

IN ADDITION TO LADDER SAFETY SYSTEM	[ ] YES	[ ] NO
IN LIEU OF LADDER SAFETY SYSTEM	[x] YES	[ ] NO

MANUFACTURER / MODEL : 3M / DBI-SALA

CAGE OR WELL

TO BE PROVIDED FOR LADDERS WITH CLIMB LENGTH [x] ≤ 24 FEET [x] > 24 FEET [ ] OTHER:

MINIMUM CLIMB LENGTH OF LADDER REQUIRING CAGE: 12 FEET

EXTENDED VERTICAL BARS TO TOP RAIL OF GUARD FOR LADDERS ON ELEVATED PLATFORMS [x] YES [ ] NO

INSIDE RADIUS OF INTERMEDIATE AND TOP HOOPS	[x] 1 FT 1-3/4 IN	[ ] OTHER:	
INSIDE RADIUS OF BOTTOM HOOPS	[x] 1 FT 5-3/4 IN	[ ] OTHER:	

SAFETY GATES

MANUFACTURER / MODEL : /

MINIMUM SWING ANGLE [x] 90 DEGREES [ ] OTHER: DEGREES

LOCATION OF HINGES AT SIDE-STEP LADDERS [x] AT BACK OF CLIMBER [ ] AT FRONT OF CLIMBER

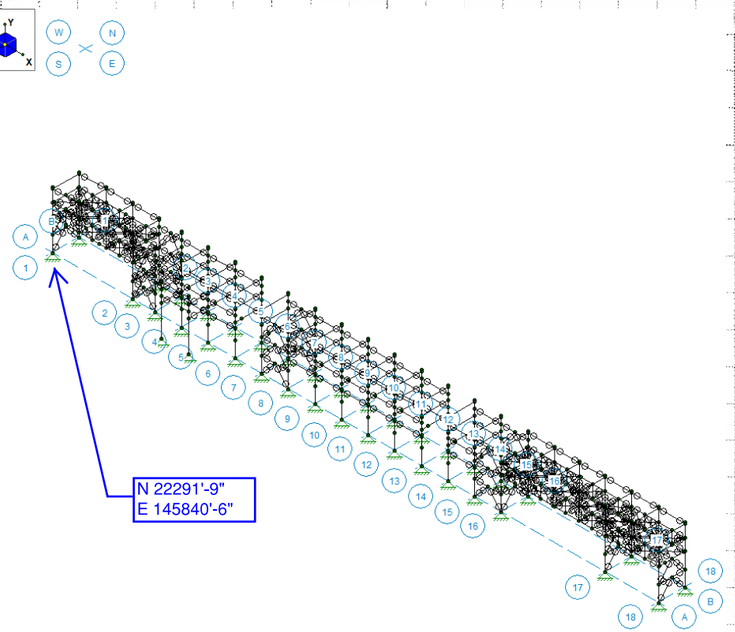
ATTACHMENT 7 – FOUNDATION AND STRUCTURAL SKETCHES

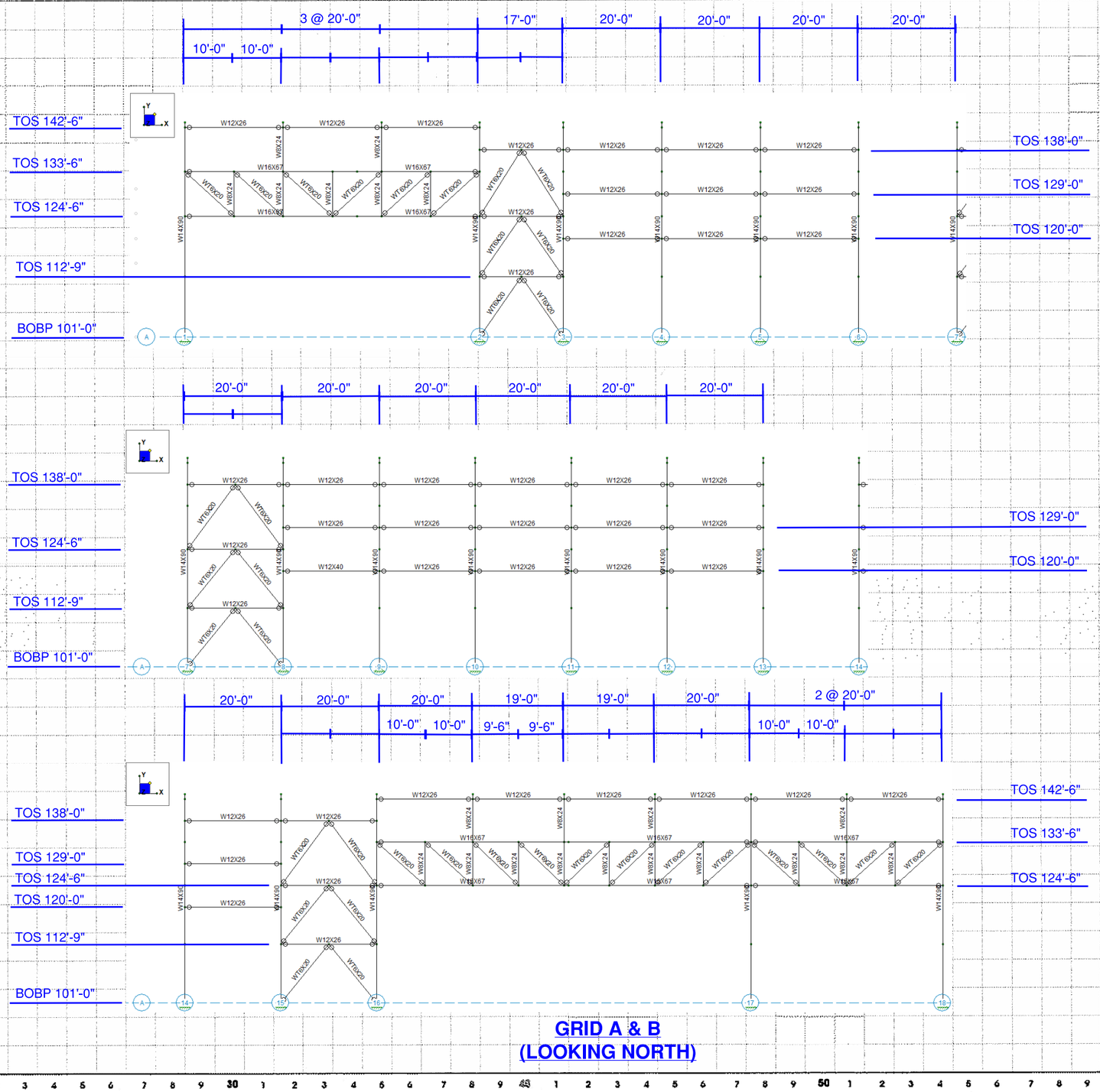
FLUOR®

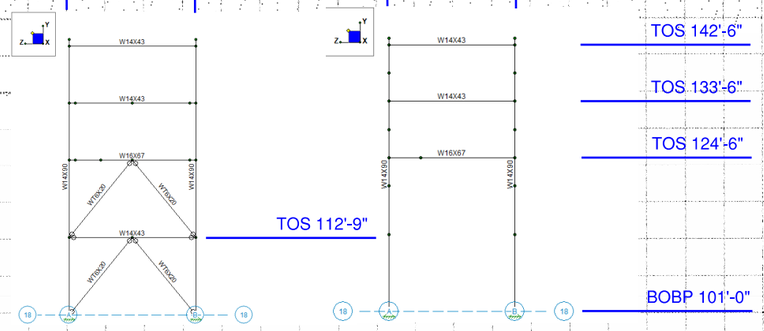
FORM E52 (Rev. 2-05)

CALCULATIONS AND SKETCHES

DATE	2020-09-17
CONT. NO.	PIPERACK 0001-01
BY	JG
CHK'D	CTK
SHEET NO.	1 OF 3







GRID 1, 2, 16, 17, 18 (LOOKING WEST)

GRID 3-15 (LOOKING WEST)

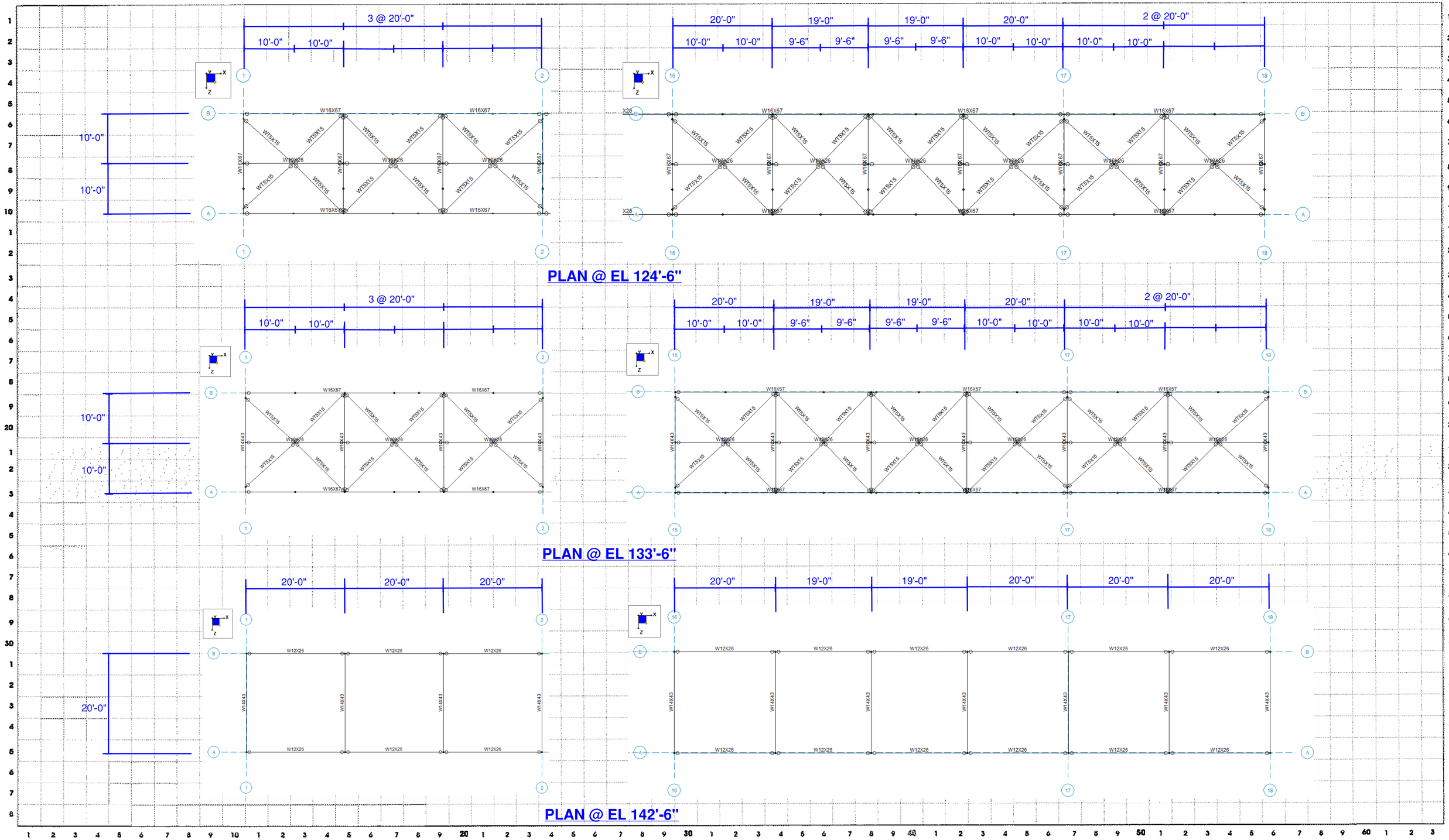
GRID A & B (LOOKING NORTH)

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FORM E52 (Rev. 2-05)

CALCULATIONS AND SKETCHES

DATE	2020-09-17
CONT. NO.	PIPERACK 0001-01
BY	JG CHK'D CTK
SHEET NO.	2 OF 3

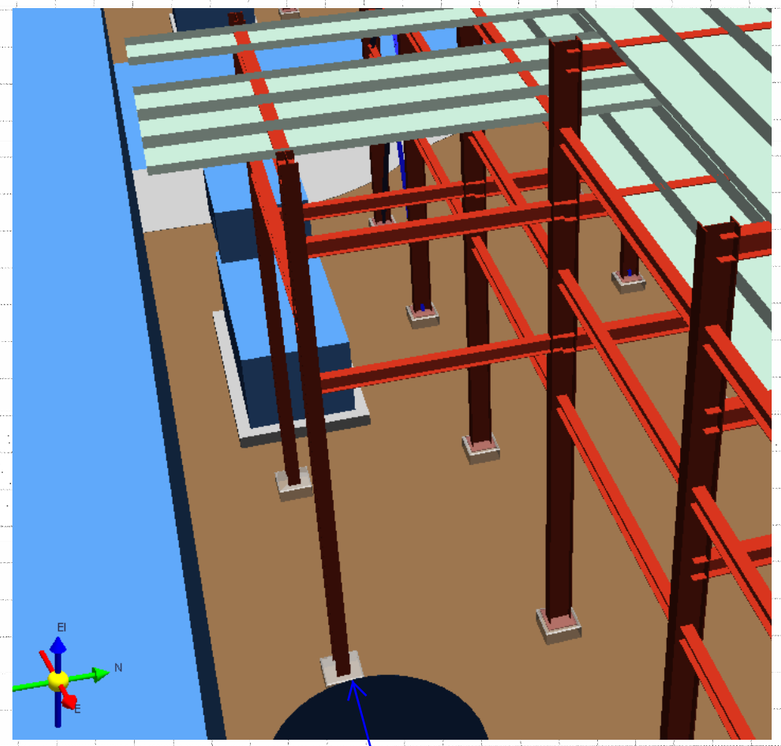


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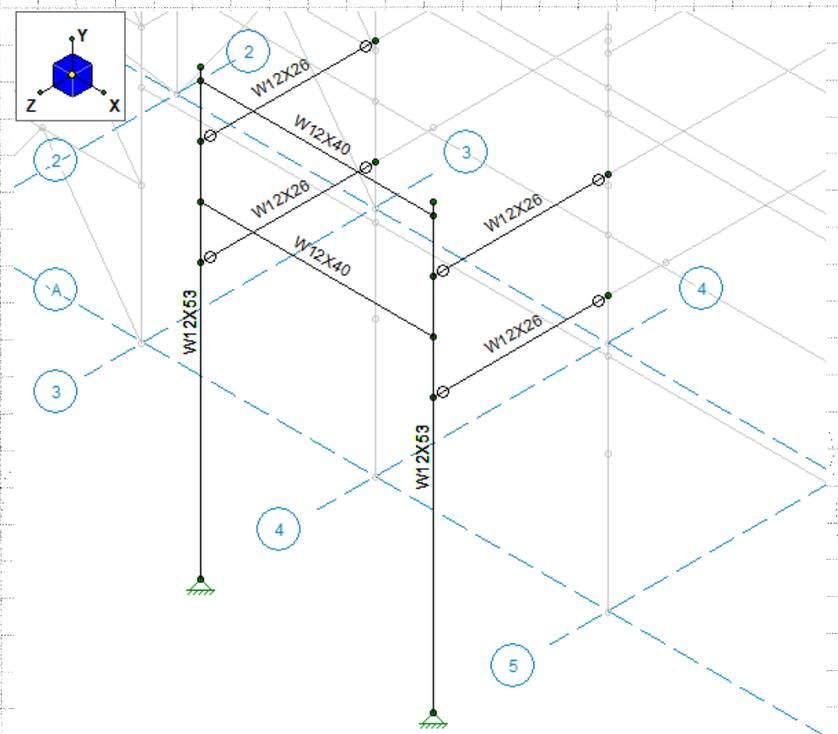
FORM E52 (Rev. 2-05)

CALCULATIONS AND SKETCHES

DATE	2020-09-17		
CONT. NO.	PIPERACK 0001-01		
BY	JG	CHK'D	CTK
SHEET NO.	3 OF 3		



N 22276'-9"
E 145957'-6"

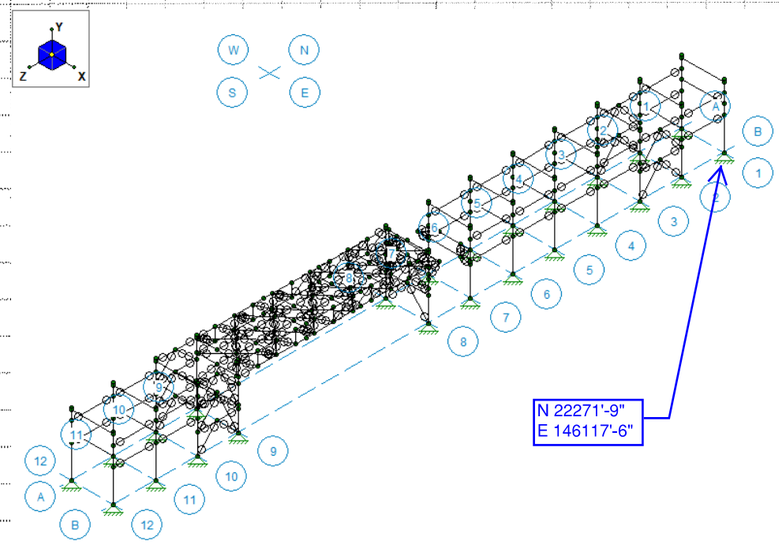


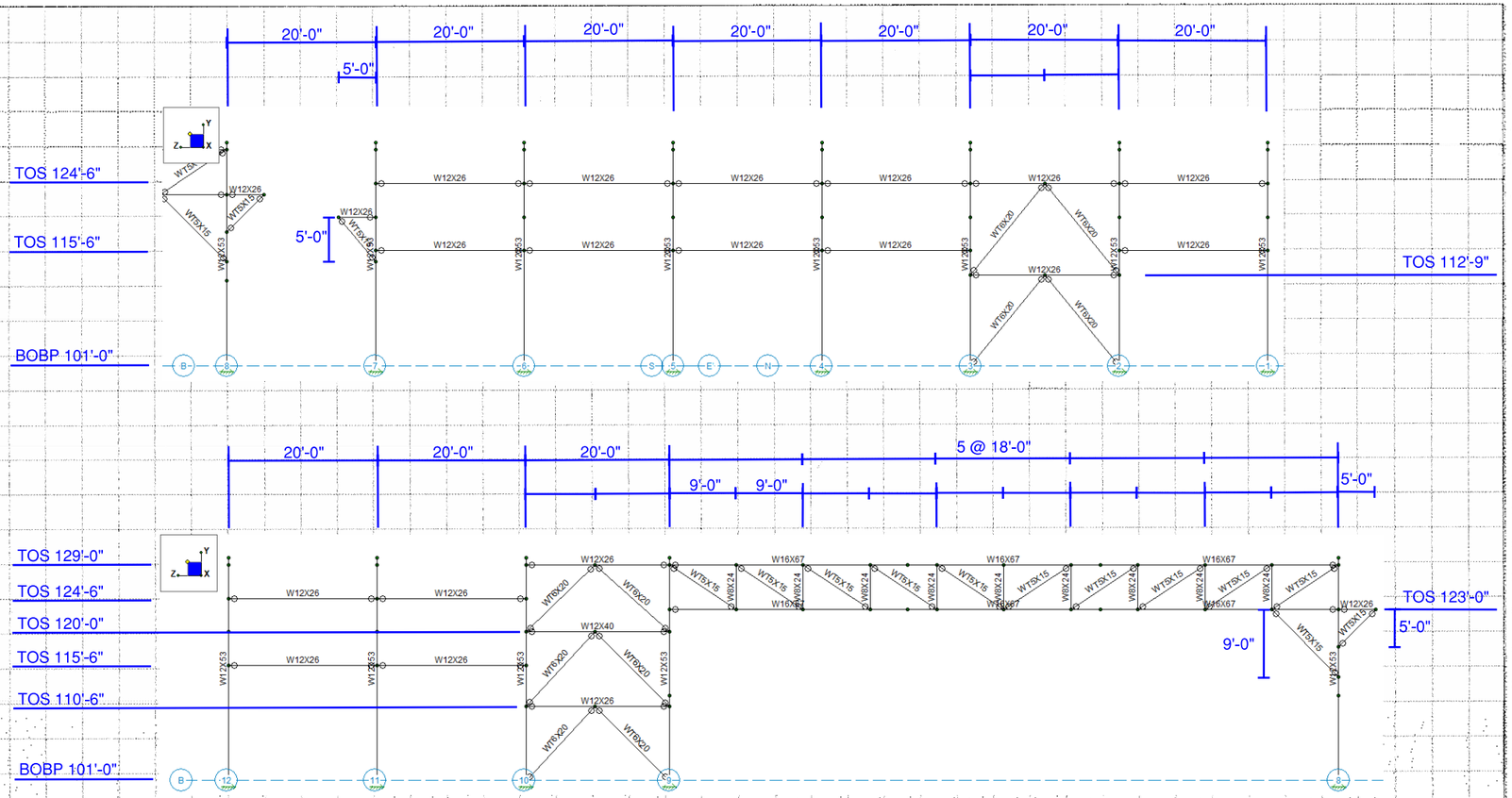
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FORM E52 (Rev. 2-05)

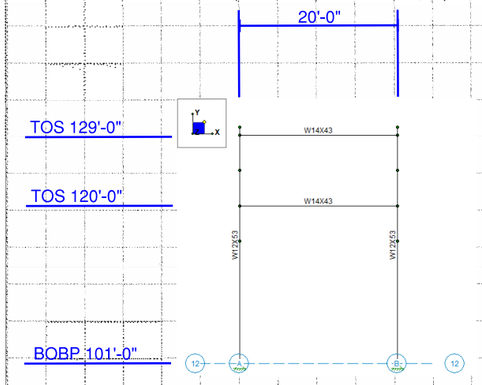
CALCULATIONS AND SKETCHES

DATE 2020-09-17
CONT. NO. PIPERACK 0001-02
BY JG CHK'D
SHEET NO. 1 OF 2

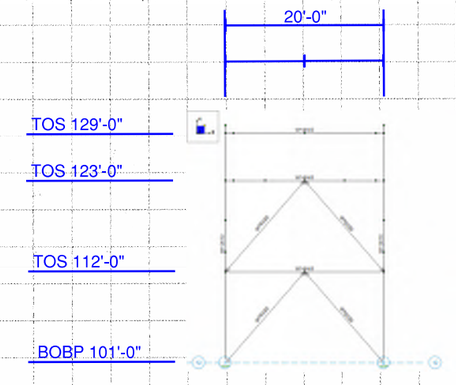




GRID A & B
(LOOKING WEST)



GRID 1-7, 10-12
(LOOKING NORTH)



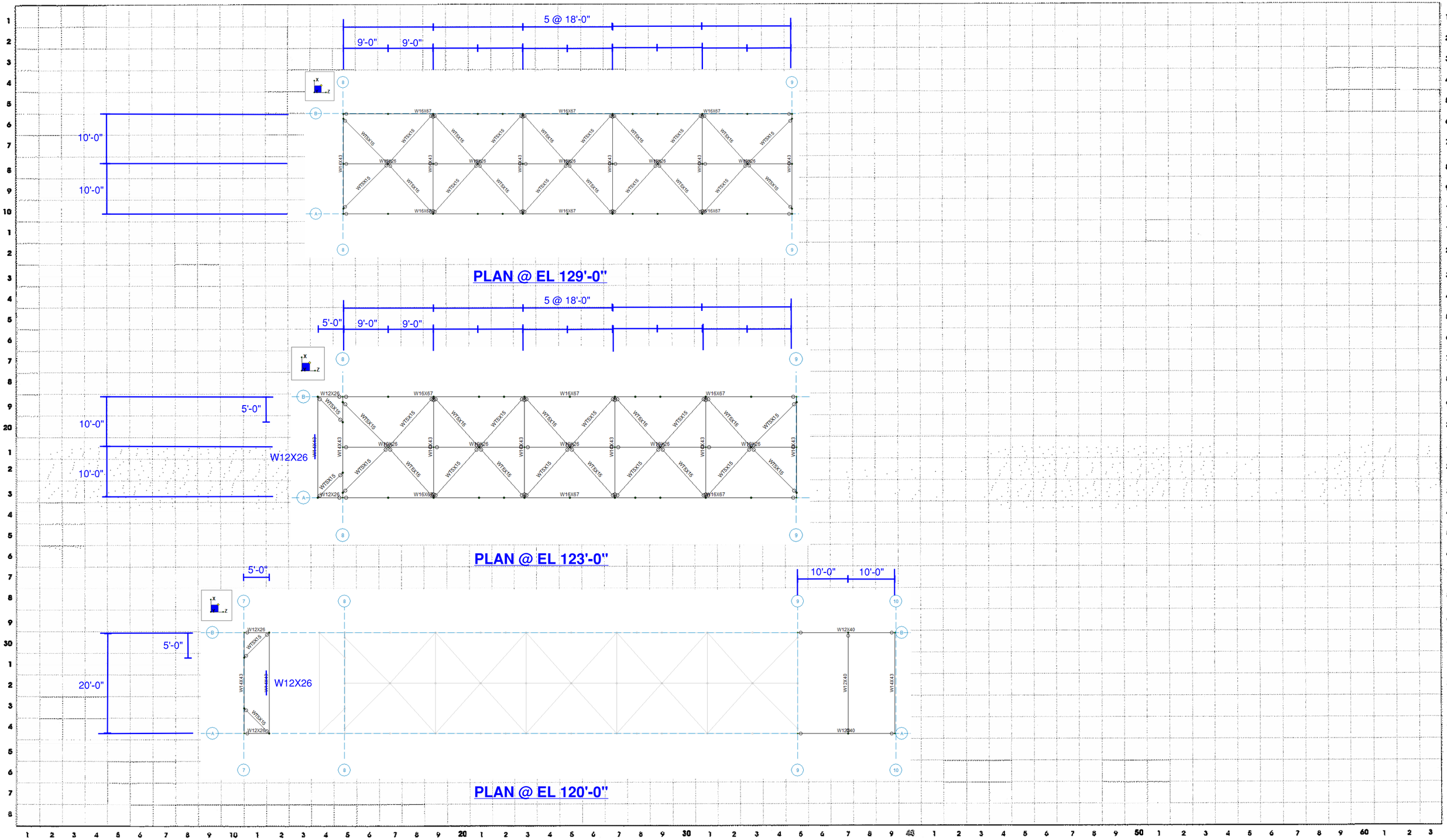
GRID 8, 9
(LOOKING NORTH)

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FORM E52 (Rev. 2-05)

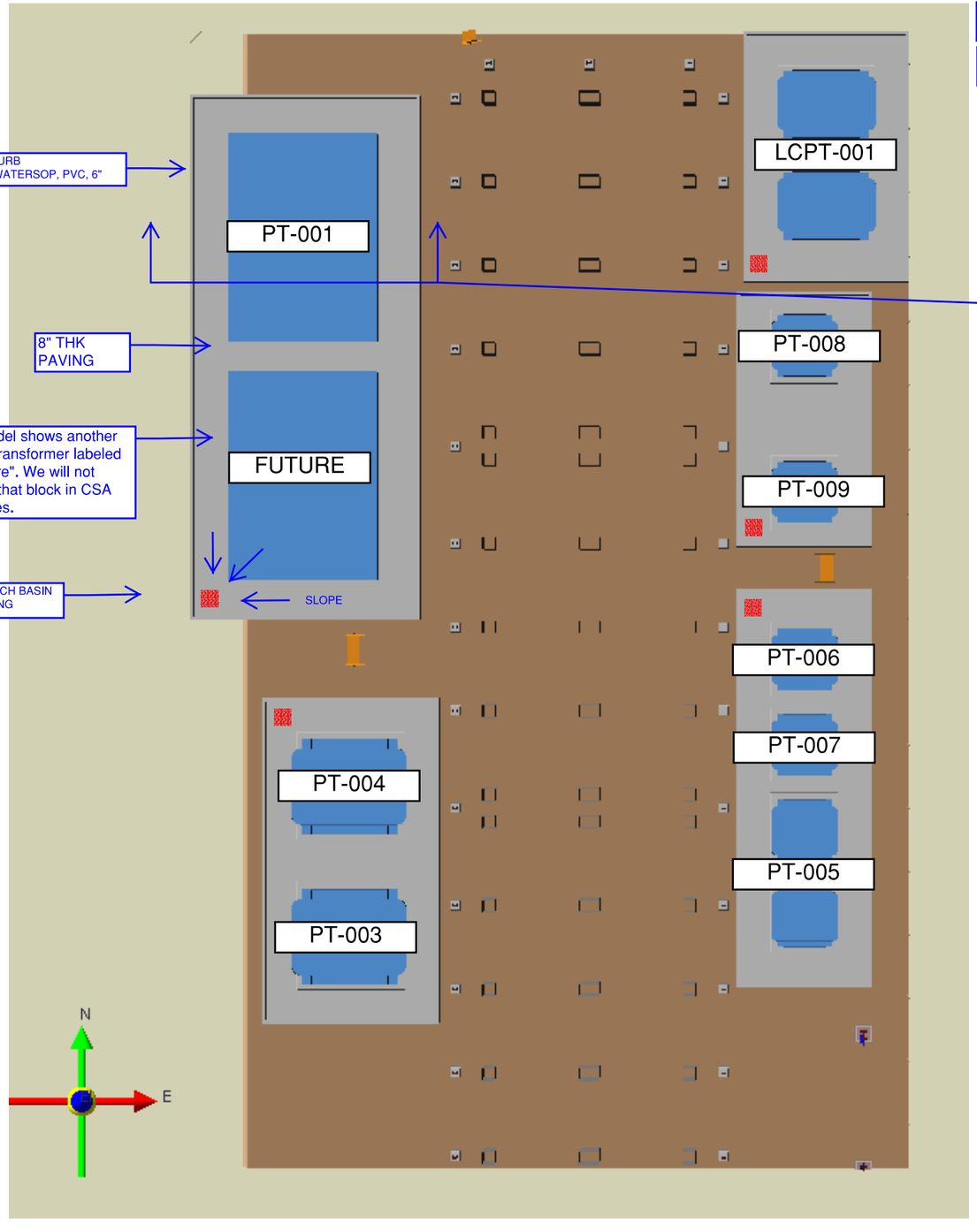
CALCULATIONS AND SKETCHES

DATE	2020-09-17
CONT. NO.	PIPERACK 0001-02
BY	JG CHK'D
SHEET NO.	2 OF 2



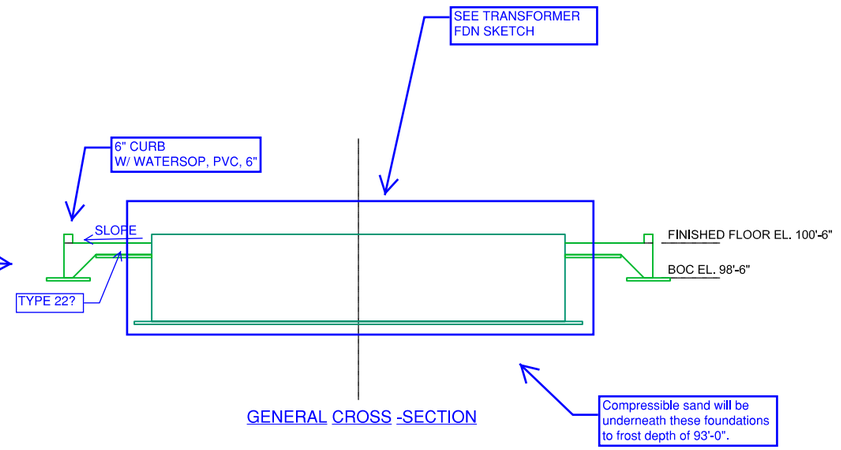
DATE: 10/14/2020
BY: JG
CHKD:
SHEET NO: 1 OF 1

TRANSFORMER CONTAINMENT AREA FDN SKETCH



The current containment area sizes are OK for FEED.

See transformer FDN sketch for block sizes.

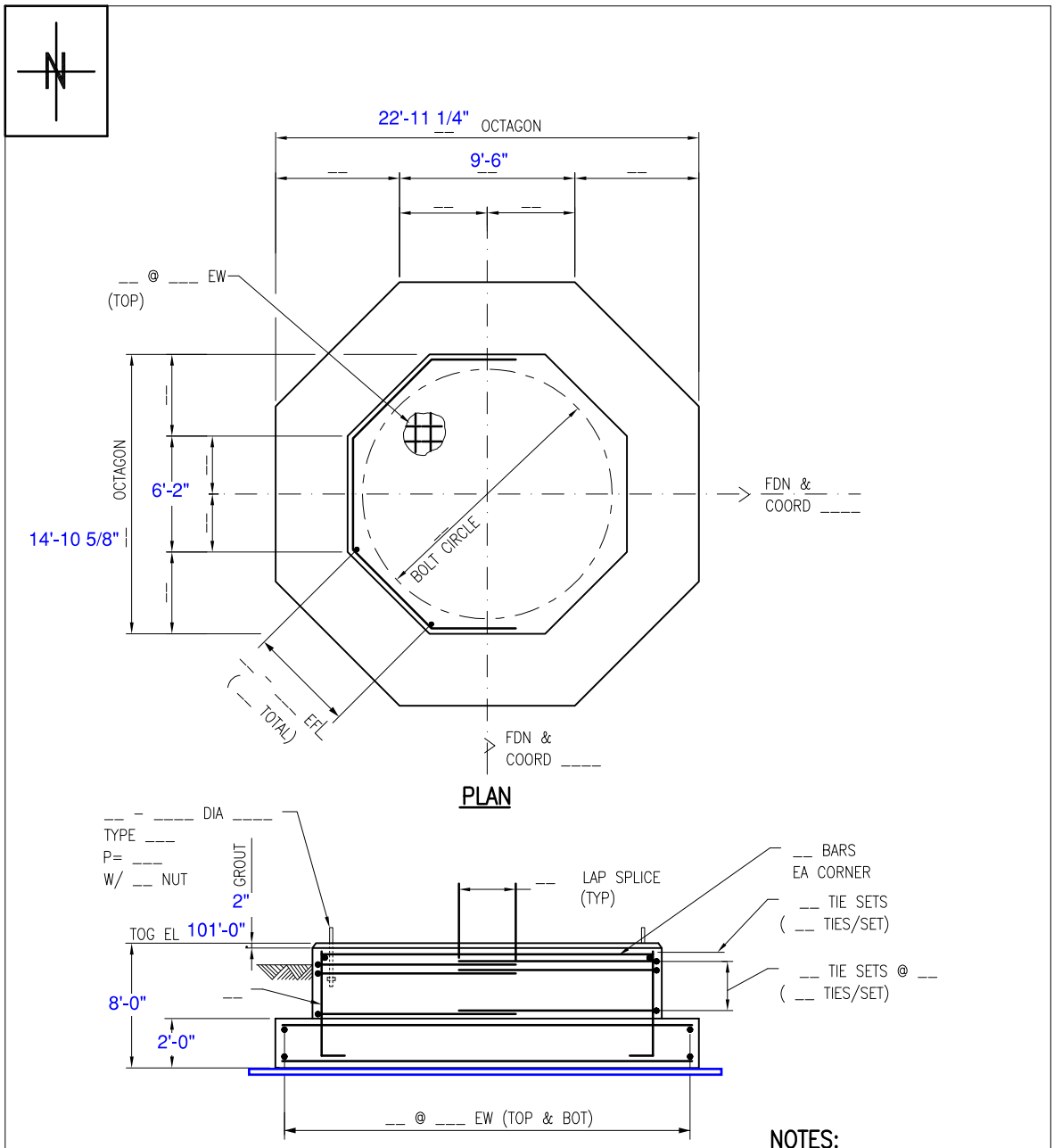


FLUOR

CALCULATIONS and SKETCHES

DATE	2020-10-13
CONT. NO.	
BY	JG CHK'D
SHEET NO.	1 of 1

VERTICAL VESSEL FOUNDATION (ON SOIL) (TYPE III)



ELEVATION

FOUNDATION FOR V-601A/B

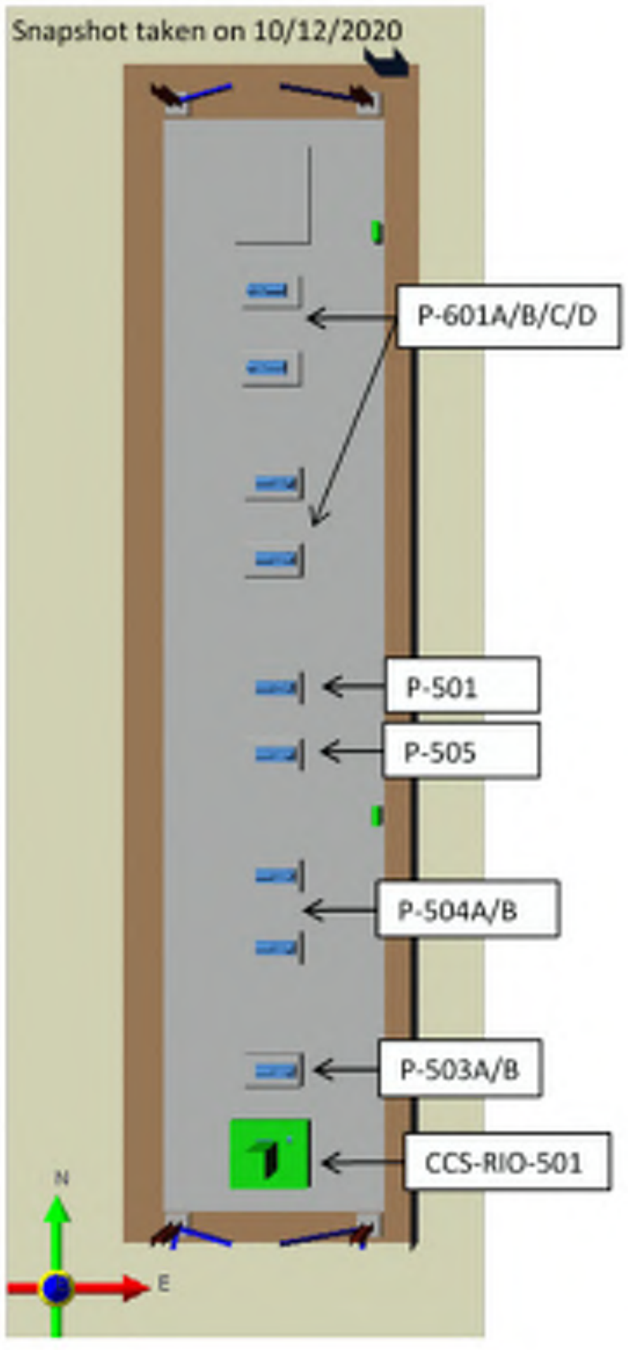
NOTES:

1. ENGINEER TO LOCATE VESSEL DRAIN (TO BE POSITIONED TOWARDS SUMP).
2. ENGINEER TO INDICATE IF BOLT LOCATION IS STRADDLING ON CENTERLINE OR NOT.

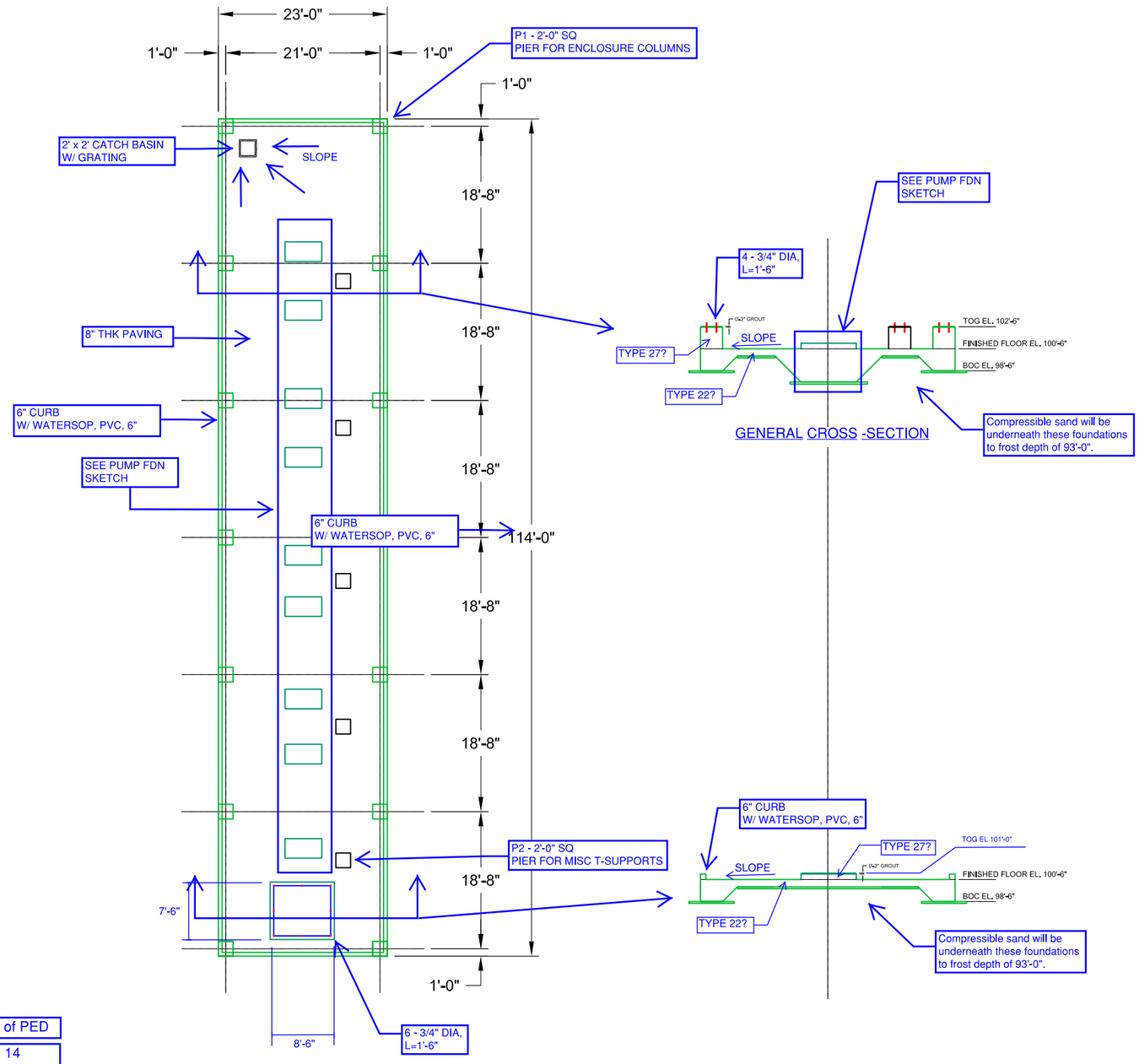
FILENAME: SKETCH_FOUNDATION_ON SOIL_VERTICAL VESSEL III

DATE: 10/14/2020
BY: JG
CHKD:
SHEET NO: 1 OF 1

PUMP ENCLOSURE FDN SKETCH

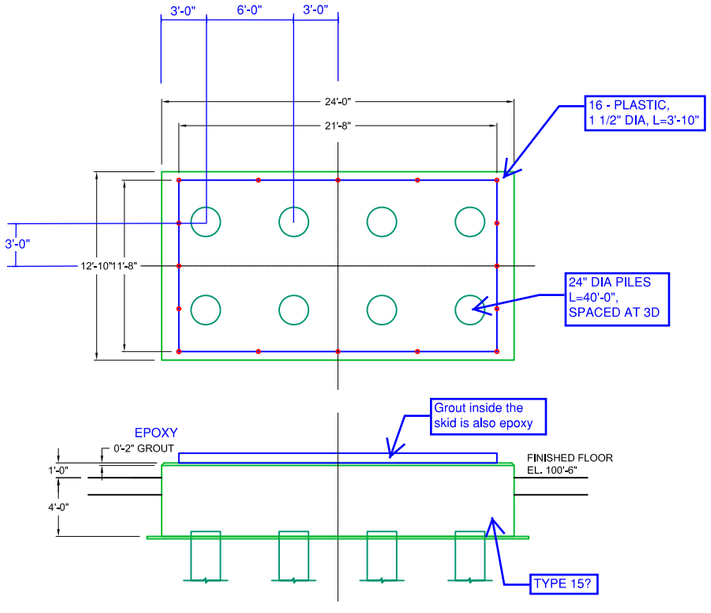


	No. of PED
P1	14
P2	5

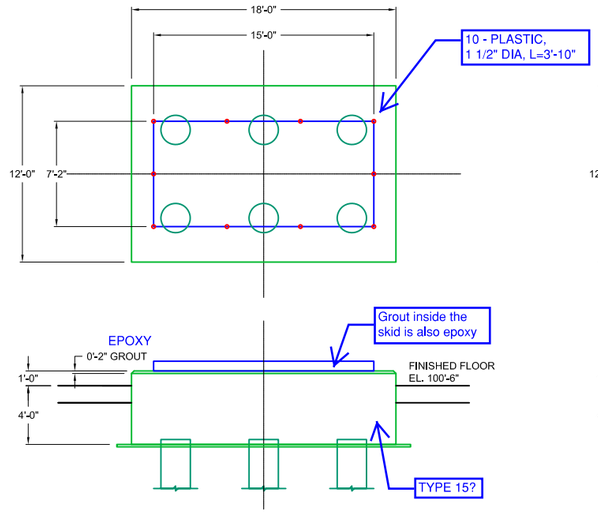


DATE: 10/14/2020
BY: JG
CHKD:
SHEET NO: 1 OF 2

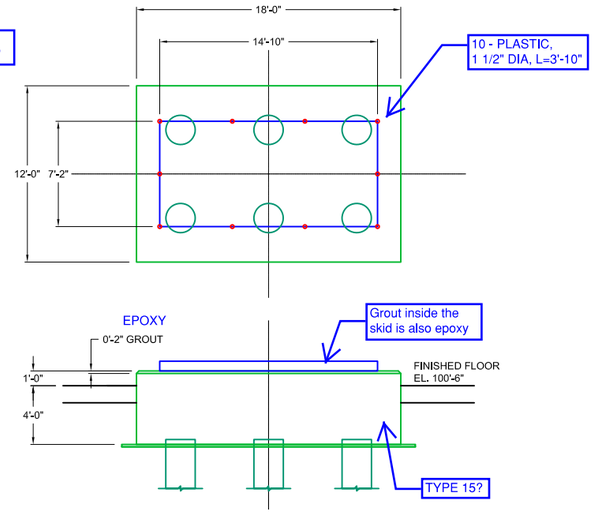
PUMP FDN SKETCH



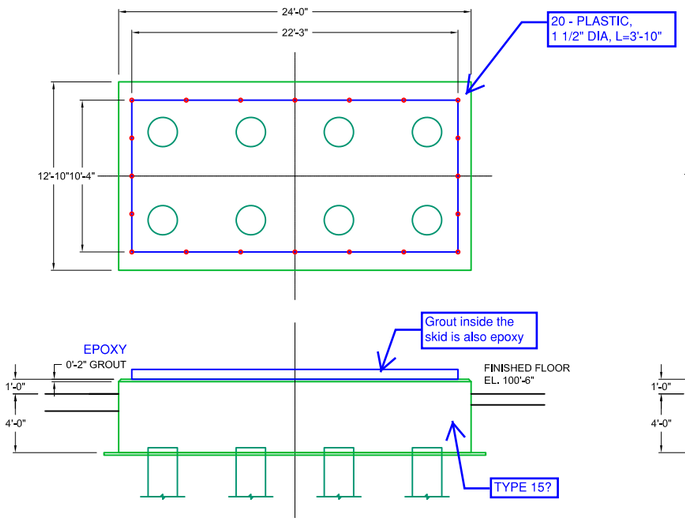
P-101 A/B



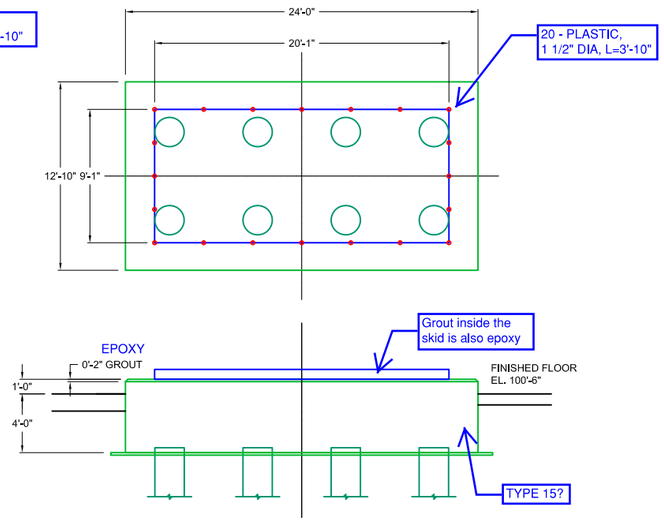
P-202 A/B



P-102 A/B



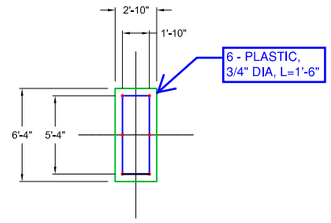
P-203 A/B



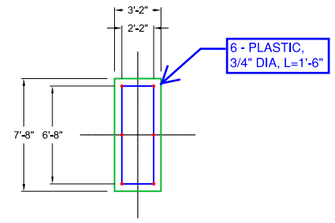
P-301 A/B

DATE: 10/14/2020
BY: JG
CHKD:
SHEET NO: 2 OF 2

PUMP FDN SKETCH

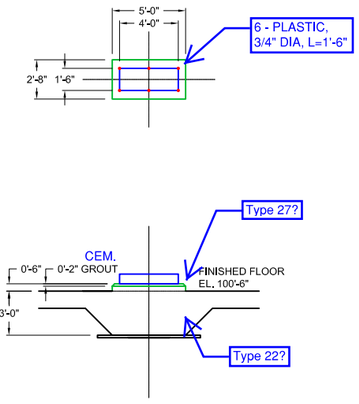


P-302 A/B

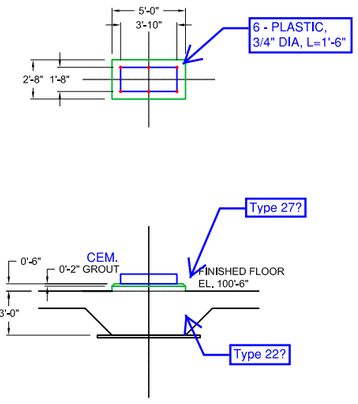


P-303 A/B

PUMPS INSIDE PUMP ENCLOSURE



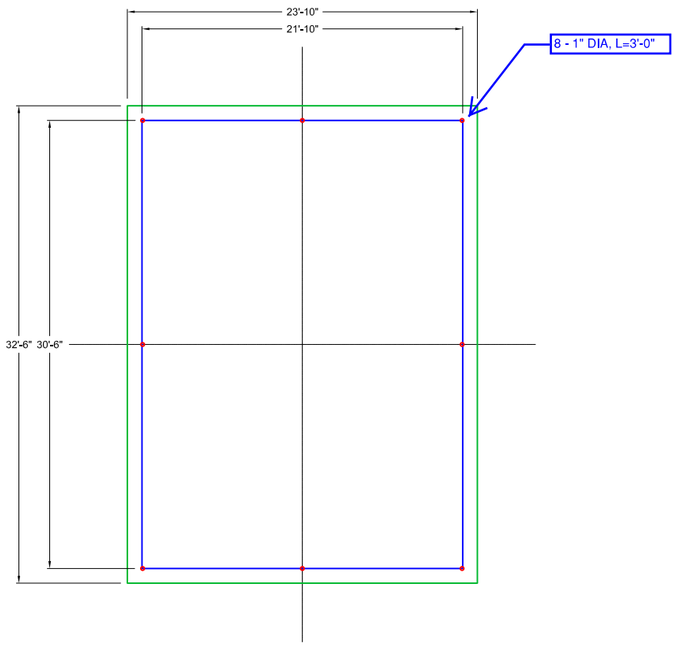
P-501
P-503 A/B
P-601 A/B/C/D

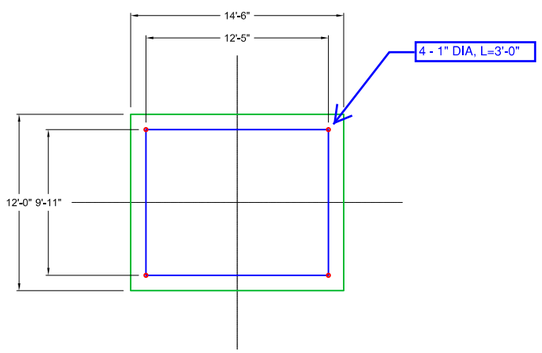


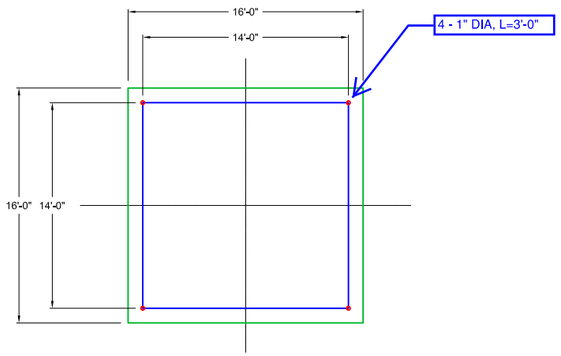
P-504 A/B
P-505

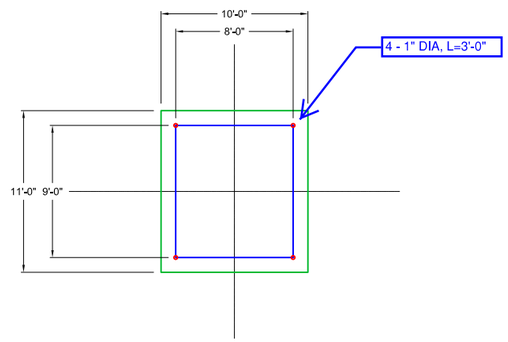
DATE: 10/14/2020
BY: JG
CHKD:
SHEET NO: 1 OF 1

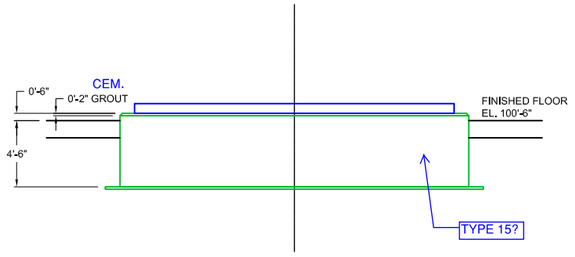
TRANSFORMER FDN SKETCH





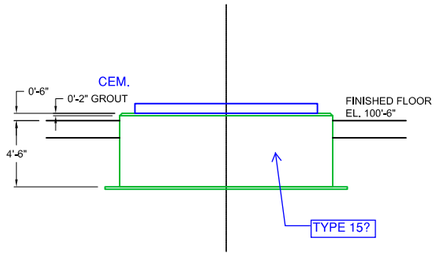




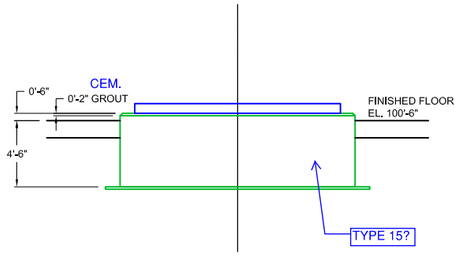


CCS-PT-001

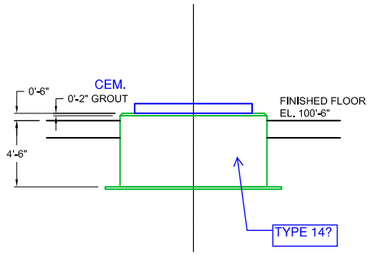
The model shows another similar transformer labeled as "future". We will not include that block in CSA quantities.



CCS-LPT-001 A/B



CCS-PT-003
CCS-PT-004



CCS-PT-005 A/B
CCS-PT-006
CCS-PT-007
CCS-PT-008
CCS-PT-009

DATE: 10/15/2020
BY: JG
CHKD: CTK
SHEET NO: 1 OF 2

CHEMICAL INJECTION FDN SKETCH

CHEMICAL UNLOADING

SULFURIC ACID TANK (PK-701)

8" THK WALL W/ WATERSOP, PVC, 6"

TYP STILE. SHIFT LOCATION AS NEEDED.

2' x 2' CATCH BASIN W/ GRATING (TYP)

29'-0" X 24'-0"
~~24'-0" X 24'-0"~~
CONTAINMENT AREA

SULFURIC ACID TANK
12'-0" ID x 12'-0"H
8400 GALLONS

3'-6" TALL CONTAINMENT WALL

14'-10 5/8"
6'-2"
4'-0"
14'-10

63'-6"
14'-6" 3'-3" 4'-6" 11'-0" 3'-6" 11'-0" 3'-6" 11'-0" 3'-6" 11'-0" 4'-6" 3'-3"

PK-701

SLOPE

1'-5" TALL CONTAINMENT WALL

12'-0 7/8"
5'-0"

9'-0" ID x 9'-9"H
4000 GALLONS (EACH)

4'-0"W x 6'-0"L (EACH SKID)

PUMP SKID SULFURIC ACID
PUMP SKID BIOCIDE
PUMP SKID CORR. INHIBITOR
PUMP SKID SCALE INHIBITOR
PUMP SKID SODIUM HYPOCHLORITE

5'-0" X 7'-0" PIER

6" CURB W/ WATERSOP, PVC, 6"

6" TALL CURB

6'-6" 8'-6" 12'-6" 8'-6" 11'-6"

12'-6" X 6'-6" PIER

P2 - 1'-6" SQ PIER FOR MPS

9'-6" X 7'-6" PIER

4'-6" 3'-10" 11'-0" 4'-6" 2'-6" 6'-0" 4'-6" 33'-0"

CCS-AH-0002

CCS-RIO-701

CCS-DLG-001

11'-0"

21'-0"

P1 - 2'-0" SQ PIER FOR ENCLOSURE COLUMNS

P3 - 1'-6" SQ PIER FOR ENCLOSURE COLUMNS

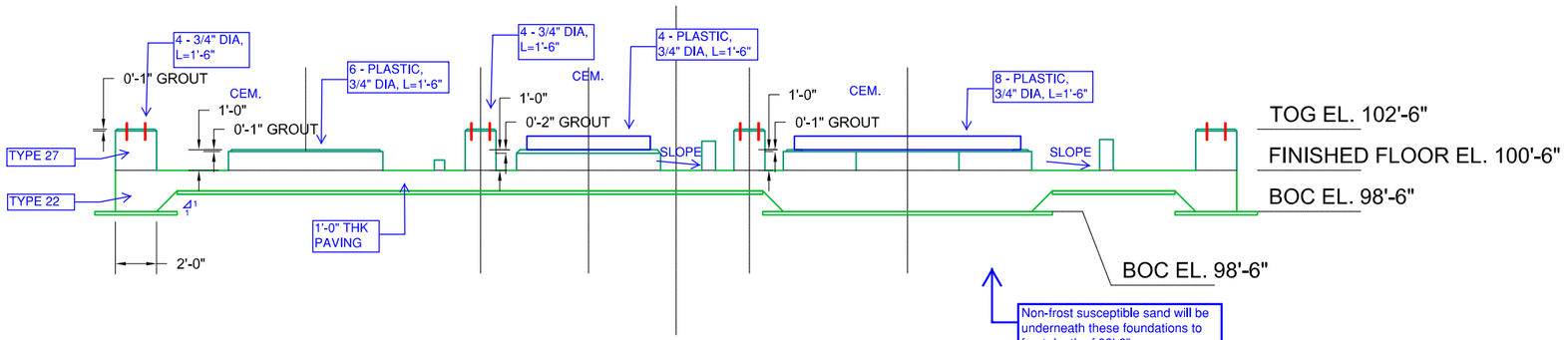
'' COAL O/H 69kV POWERLINE

CCS-CTS-001

	No. of PED
P1	8
P2	12
P3	4

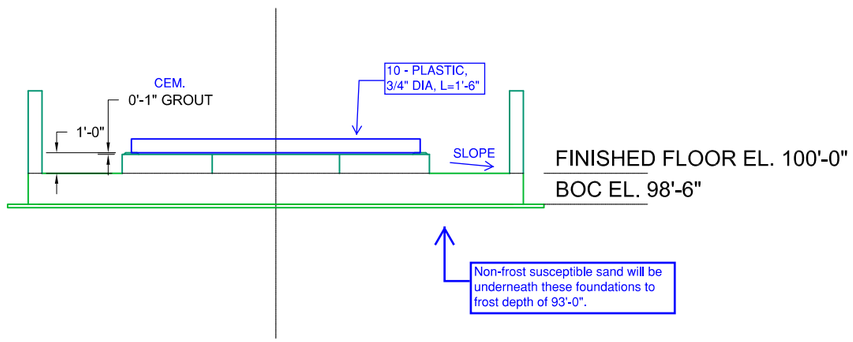
CHEMICAL INJECTION FDN SKETCH

DATE: 10/15/2020
BY: JG
CHKD: CTK
SHEET NO: 2 OF 2

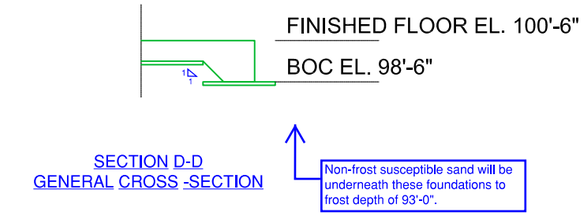


SECTION A-A
GENERAL CROSS -SECTION

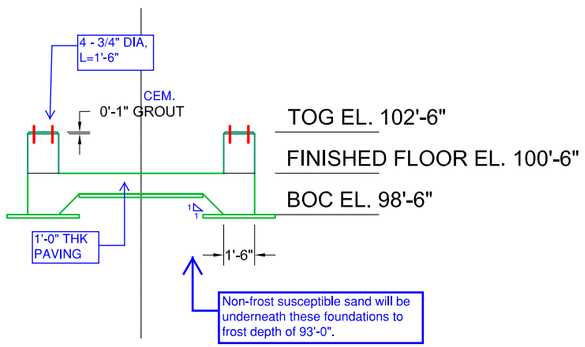
	No. of Anchors	
	3/4" DIA, L=1'-6"	PLASTIC, 3/4" DIA, L=1'-6"
P1	32	-
P2	48	-
P3	16	-
SULFURIC TANK	-	10
PK-701 A/B/C/D TANKS	-	32
PUMP SKIDS	-	30
OTHER SKIDS	-	12



SECTION B-B
GENERAL CROSS -SECTION



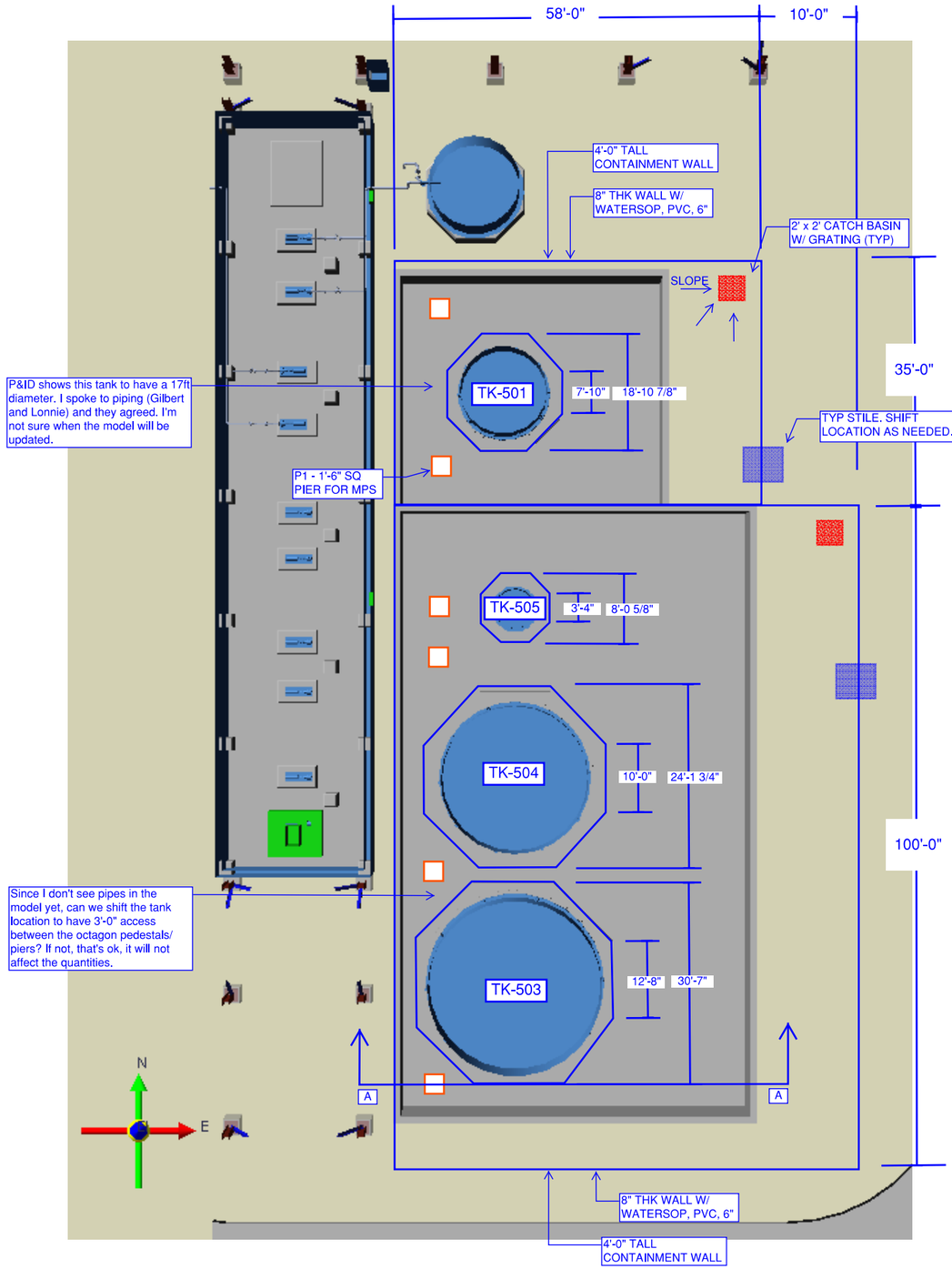
SECTION D-D
GENERAL CROSS -SECTION



SECTION C-C
GENERAL CROSS -SECTION

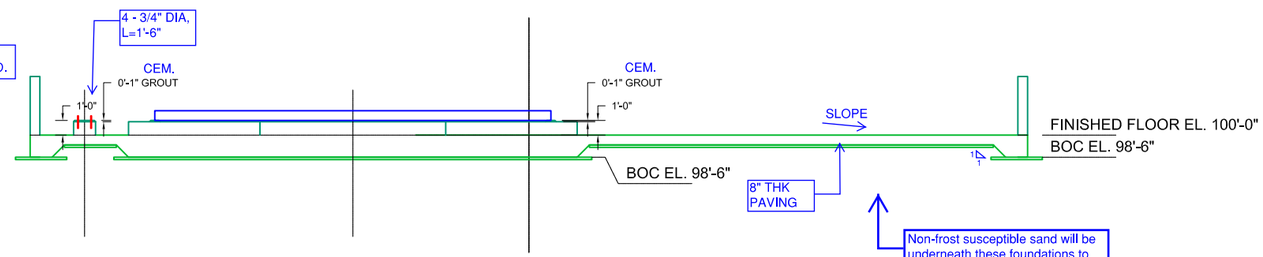
DATE: 10/16/2020
BY: JG
CHKD: CTK
SHEET NO: 1 OF 1

TANKS AND CONTAINMENT AREA FDN SKETCH



No. of PED	
P1	6

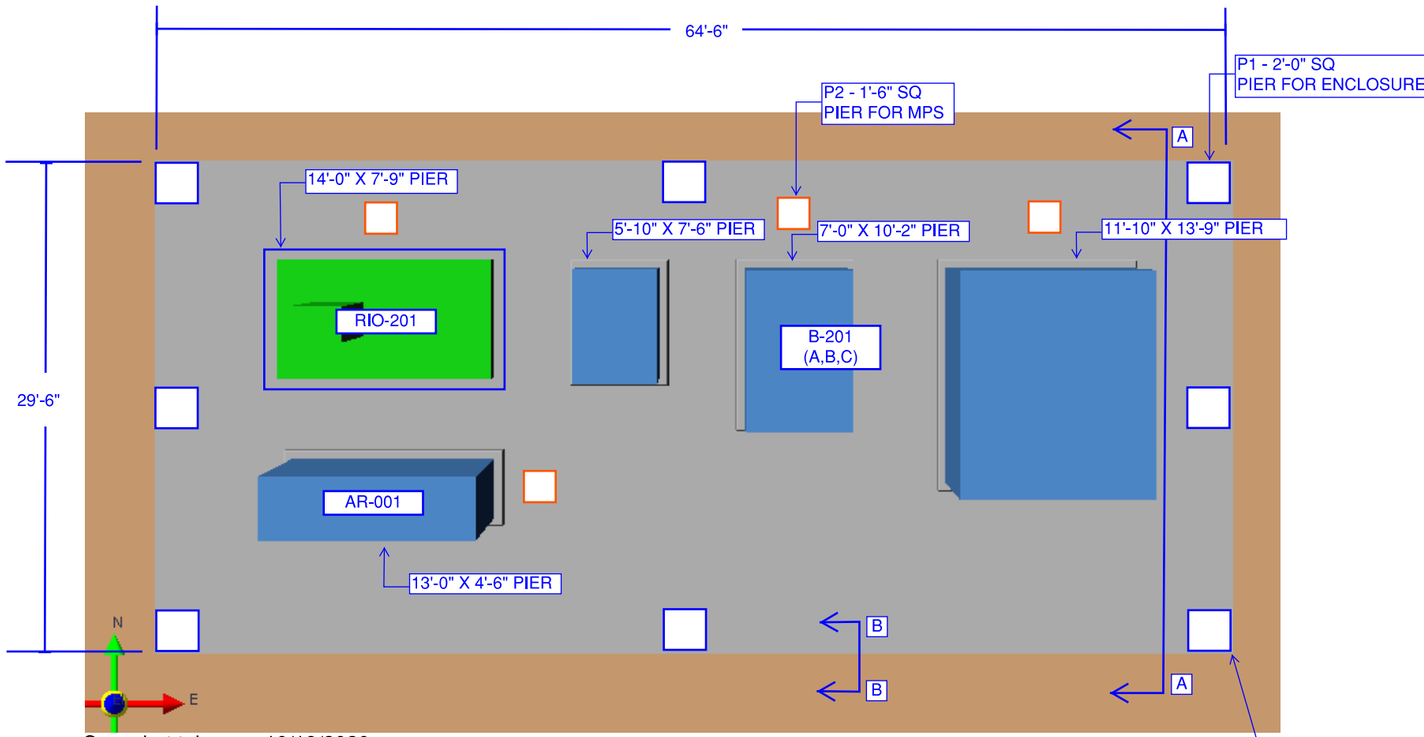
	No. of Anchors	
	3/4" DIA, L=1'-6"	PLASTIC, 3/4" DIA, L=1'-6"
P1	24	-
TK-501	-	14
TK-505	-	6
TK-504	-	20
TK-503	-	26



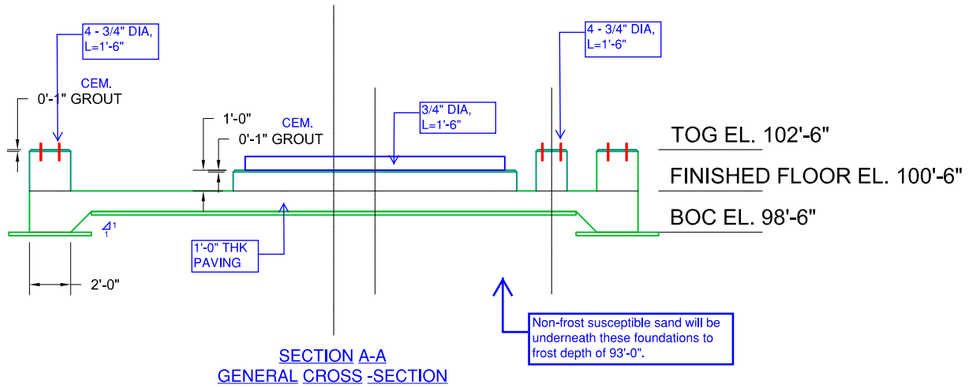
SECTION A-A
GENERAL CROSS -SECTION

BLOWER ENCLOSURE FDN SKETCH

DATE: 10/15/2020
BY: JG
CHKD: CTK
SHEET NO: 1 OF 2



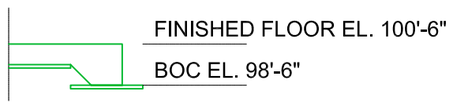
Snapshot taken on 10/19/2020



SECTION A-A
GENERAL CROSS -SECTION

	No. of PED
P1	8
P2	4

	No. of Anchors
	3/4" DIA, L=1'-6"
P1	32
P2	16
RIO-201	6
AR-001	8
B-201 (A)	4
B-201 (B)	4
B-201 (C)	8



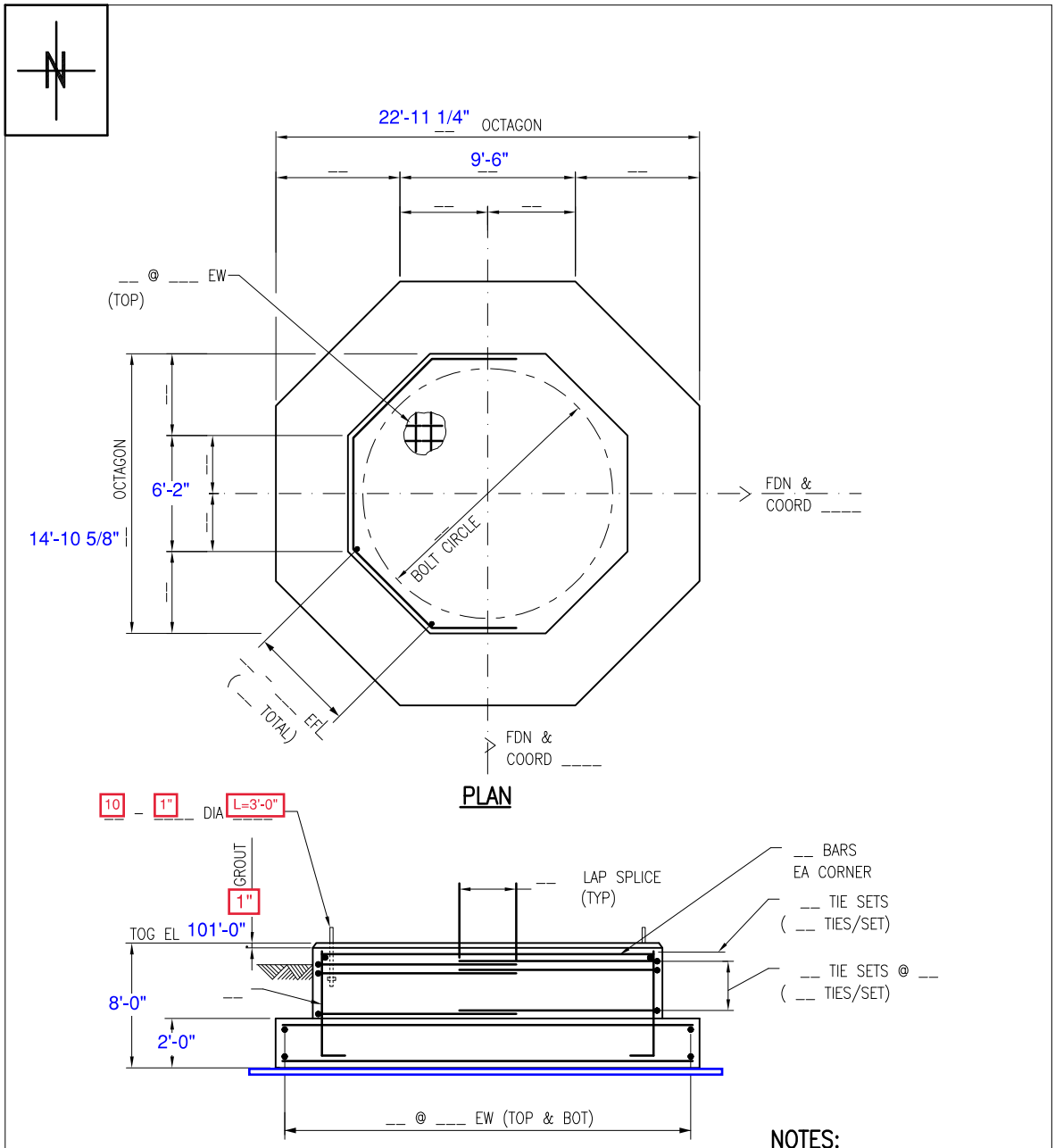
SECTION B-B
GENERAL CROSS -SECTION

FLUOR

CALCULATIONS and SKETCHES

DATE 2020-10-13
CONT. NO.
BY JG CHK'D
SHEET NO. 1 of 2

VERTICAL VESSEL FOUNDATION (ON SOIL) (TYPE III)



Non-frost susceptible soil will be underneath these foundations to frost depth of 93'-0".

FOUNDATION FOR V-601A/B

NOTES:

1. ENGINEER TO LOCATE VESSEL DRAIN (TO BE POSITIONED TOWARDS SUMP).
2. ENGINEER TO INDICATE IF BOLT LOCATION IS STRADDLING ON CENTERLINE OR NOT.

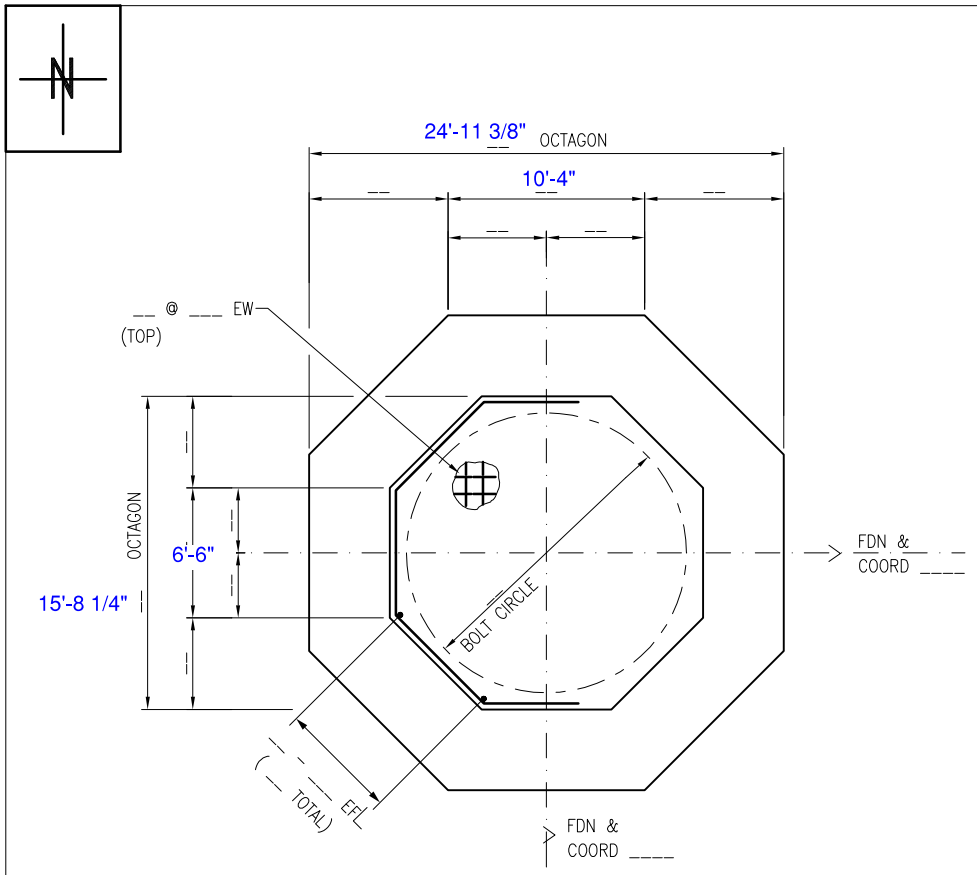
FILENAME: SKETCH_FOUNDATION_ON SOIL_VERTICAL VESSEL III

FLUOR

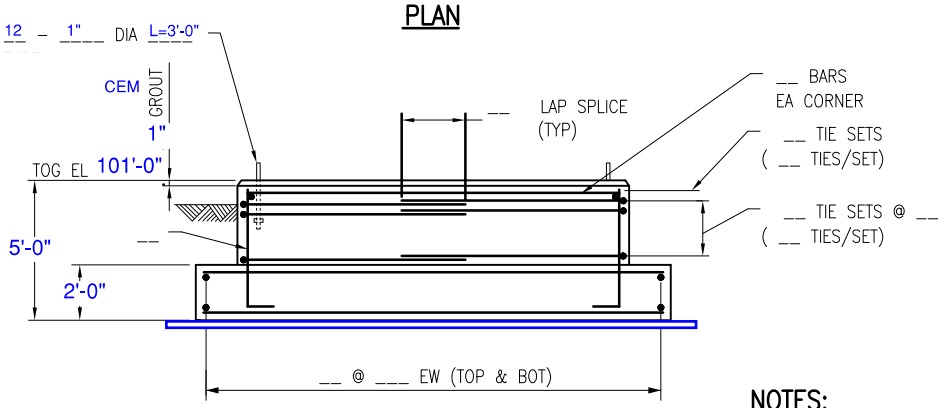
CALCULATIONS and SKETCHES

DATE 2020-10-19
CONT. NO.
BY JG CHK'D
SHEET NO. 2 of 2

VERTICAL VESSEL FOUNDATION (ON SOIL) (TYPE III)



PLAN



Non-frost susceptible soil will be underneath these foundations to frost depth of 93'-0".

ELEVATION

FOUNDATION FOR VS-601

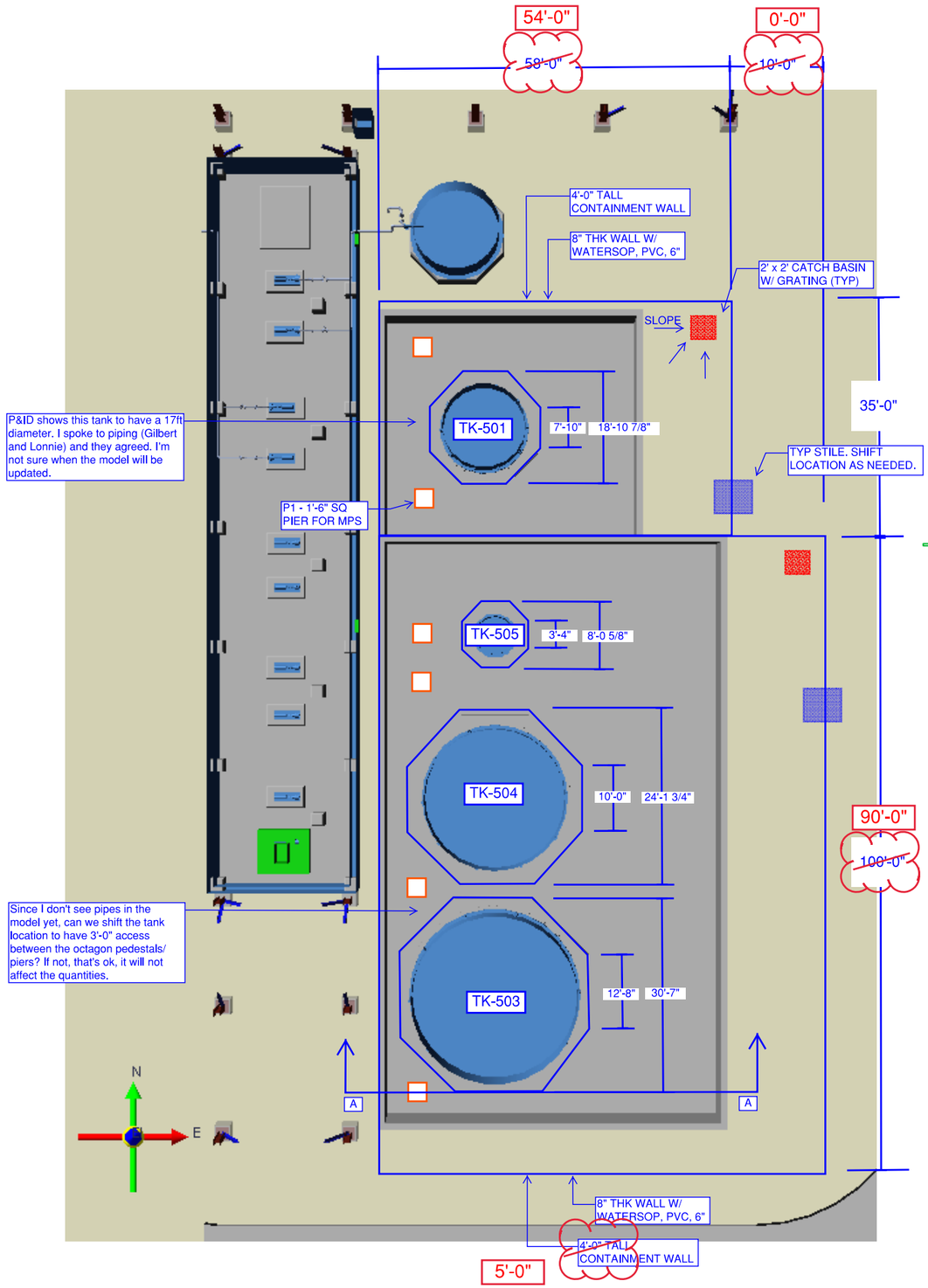
NOTES:

1. ENGINEER TO LOCATE VESSEL DRAIN (TO BE POSITIONED TOWARDS SUMP).
2. ENGINEER TO INDICATE IF BOLT LOCATION IS STRADDLING ON CENTERLINE OR NOT.

FILENAME: SKETCH_FOUNDATION_ON SOIL_VERTICAL VESSEL III

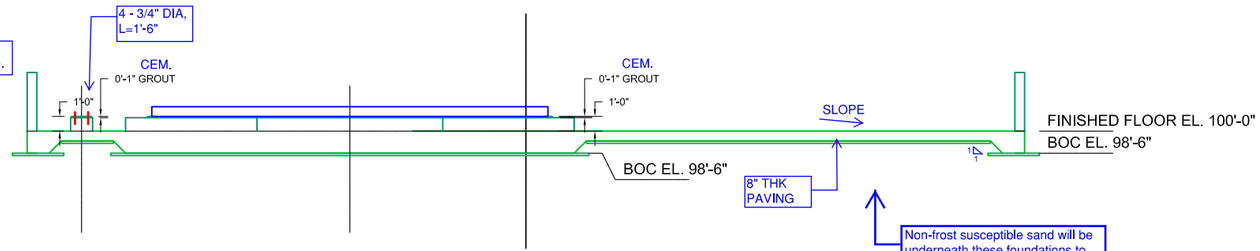
DATE: 10/22/2020
BY: JG
CHKD: CTK
SHEET NO: 1 OF 1

TANKS AND CONTAINMENT AREA FDN SKETCH



	No. of PED
P1	6

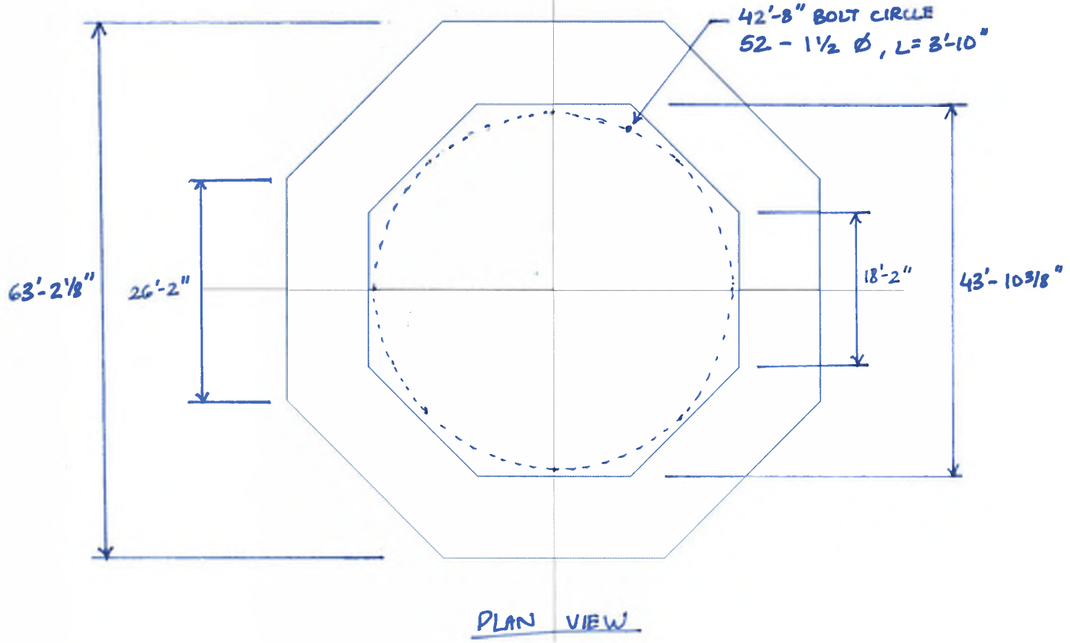
	No. of Anchors	
	3/4" DIA, L=1'-6"	PLASTIC, 3/4" DIA, L=1'-6"
P1	24	-
TK-501	-	14
TK-505	-	6
TK-504	-	20
TK-503	-	26



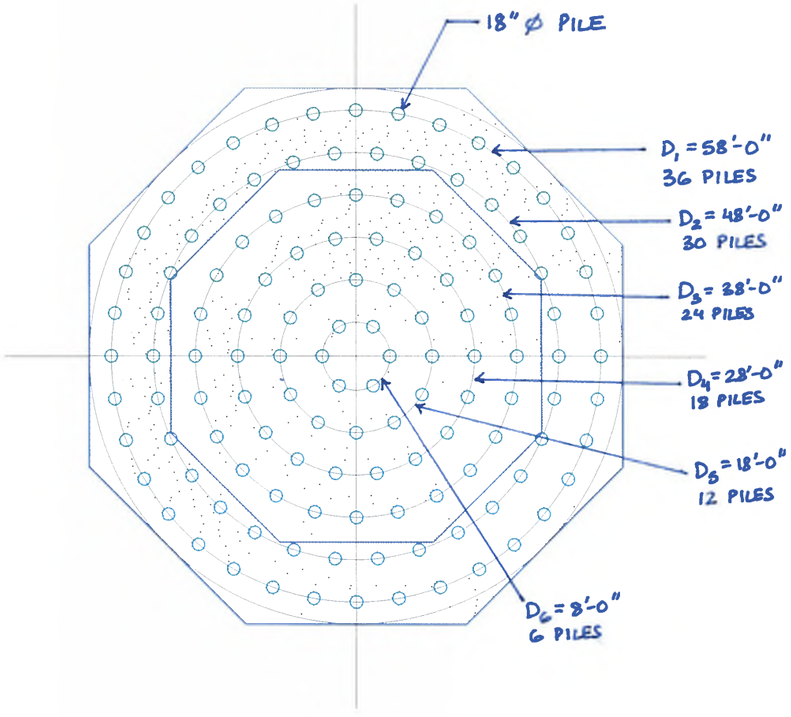
SECTION A-A
GENERAL CROSS -SECTION

DATE: 10/26/2020
BY: JG
CHKD: CTK
SHEET NO: 1 OF 1

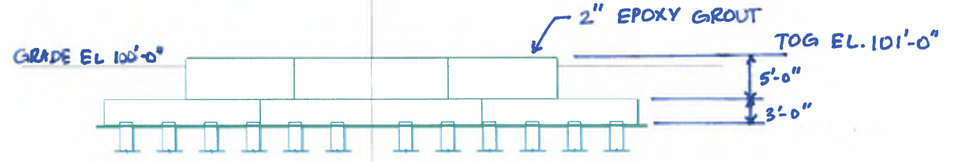
C-301 STRIPPER FDN SKETCH



PLAN VIEW



PILE LAYOUT
126 - PILE ARRANGEMENT



ELEVATION VIEW

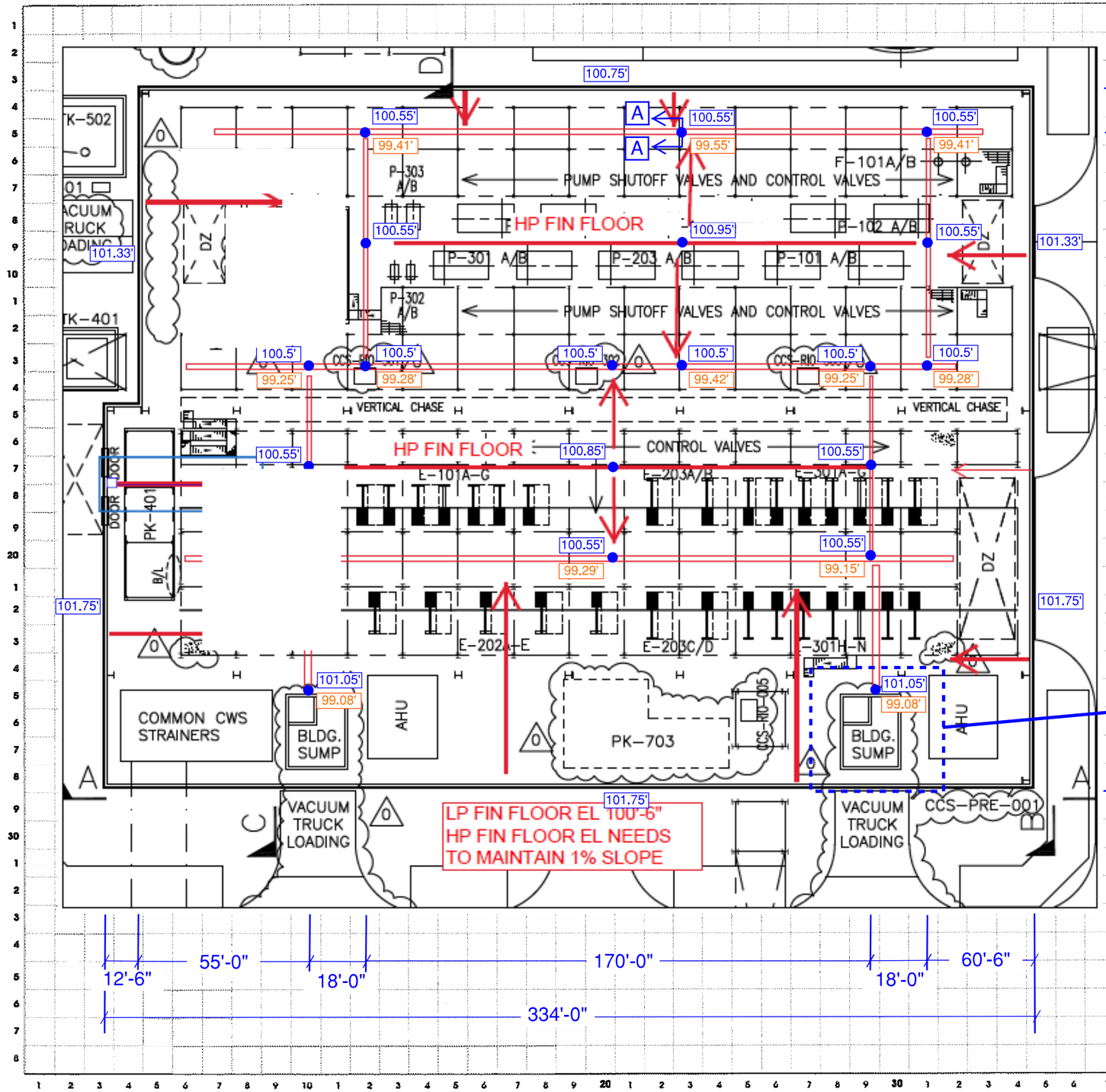
FLUOR®

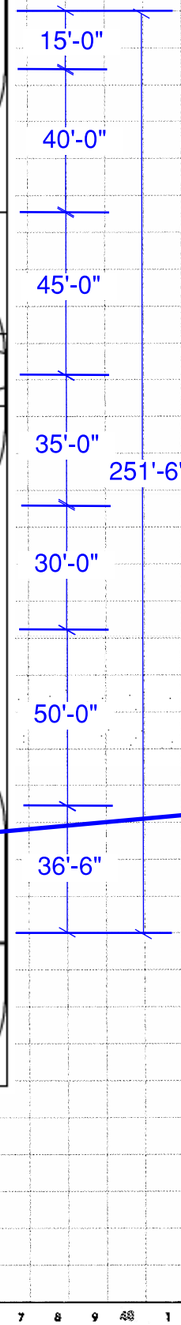
FORM E52 (Rev. 2-05)

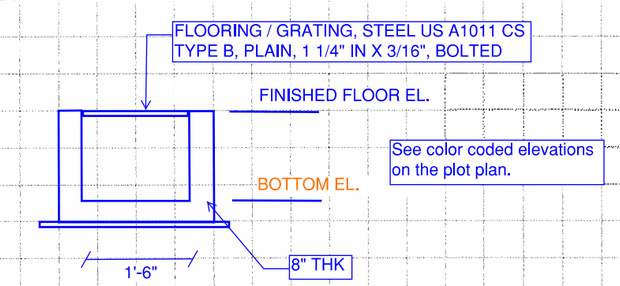
CALCULATIONS AND SKETCHES

DATE 10/26/2020
CONT. NO.
BY JG CHK'D
SHEET NO. SHEET 1 OF 2

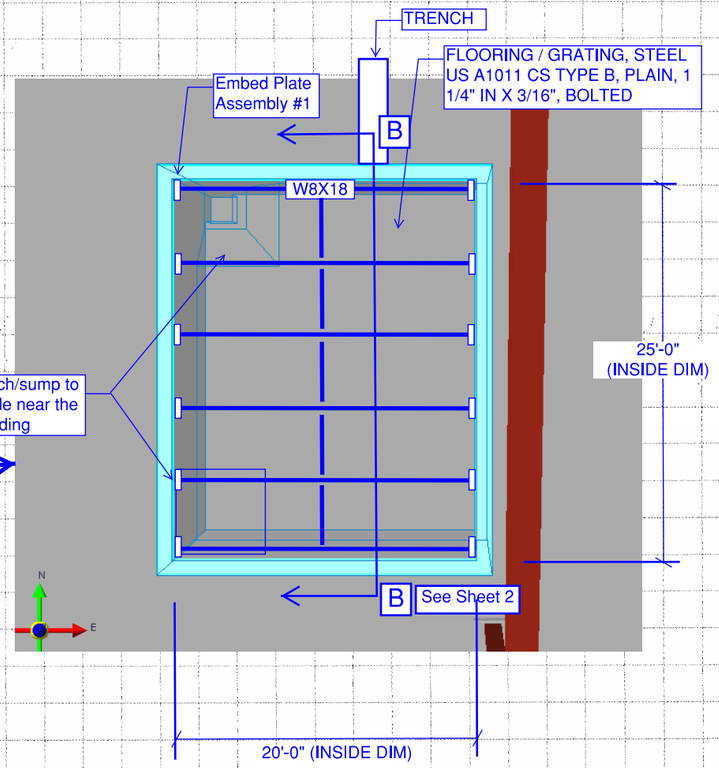
TRENCH & SUMP INSIDE PROCESS ENCLOSURE







GENERAL TRENCH SECTION A-A



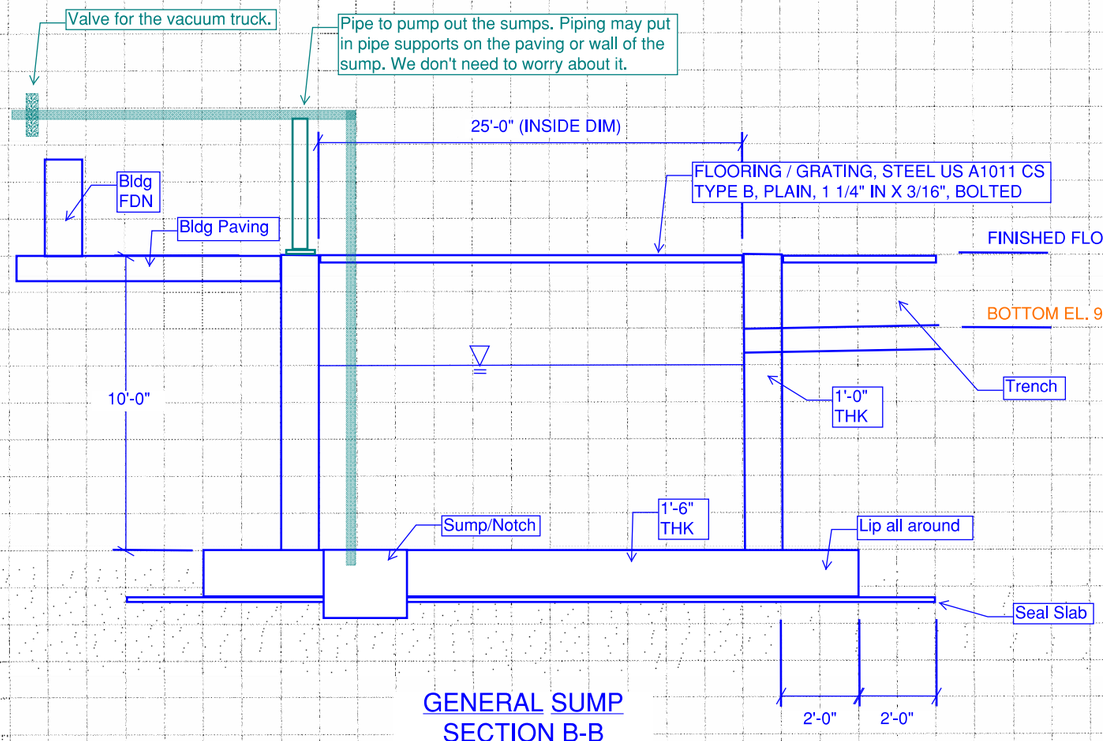
FLUOR®

FORM E52 (Rev. 2-05)

CALCULATIONS AND SKETCHES

DATE	10/26/2020
CONT. NO.	
BY	JG CHK'D
SHEET NO.	SHEET 2 OF 2

TRENCH & SUMP INSIDE PROCESS ENCLOSURE



GENERAL SUMP
SECTION B-B

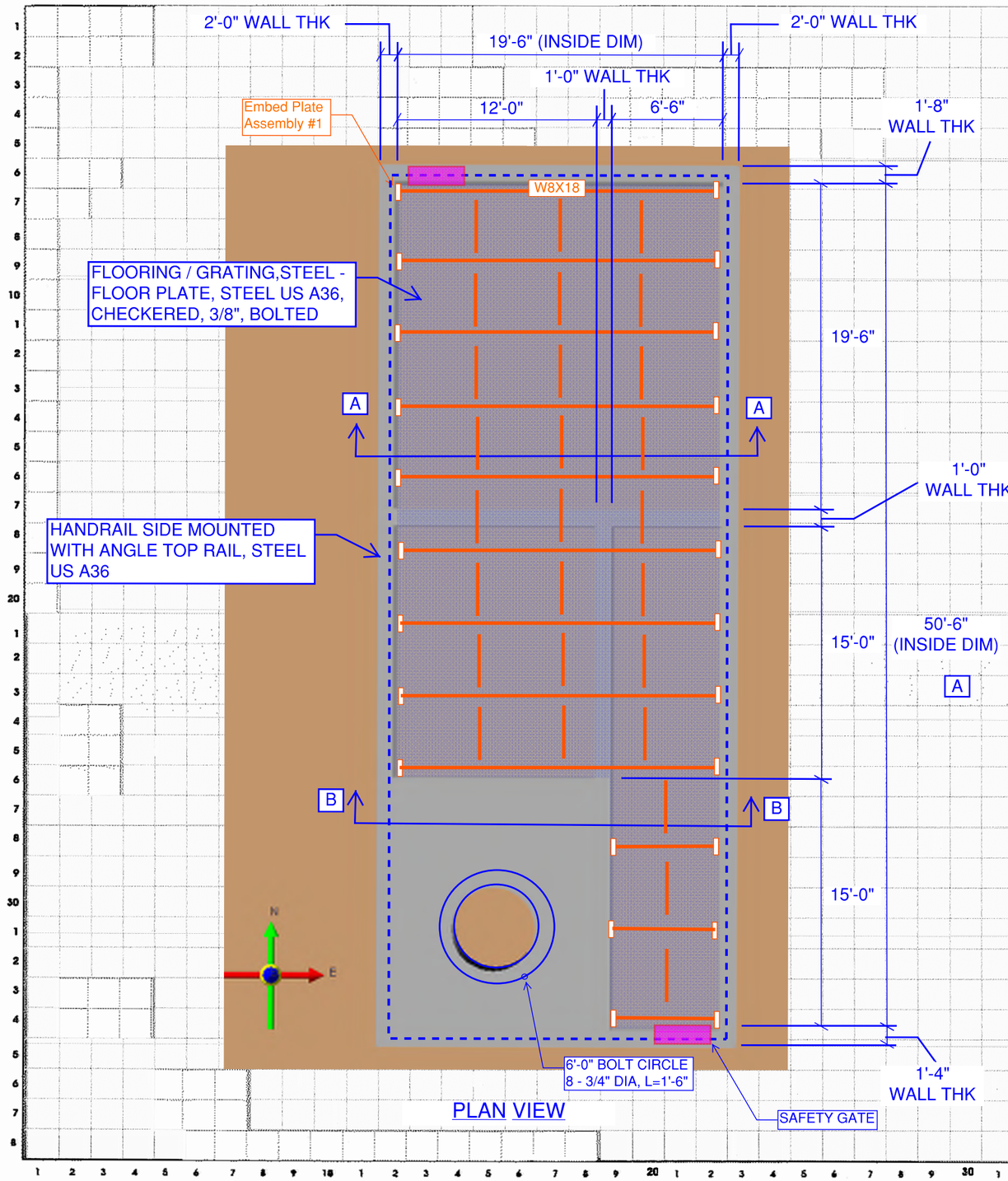
FLUOR®

FORM E52 (Rev. 2-05)

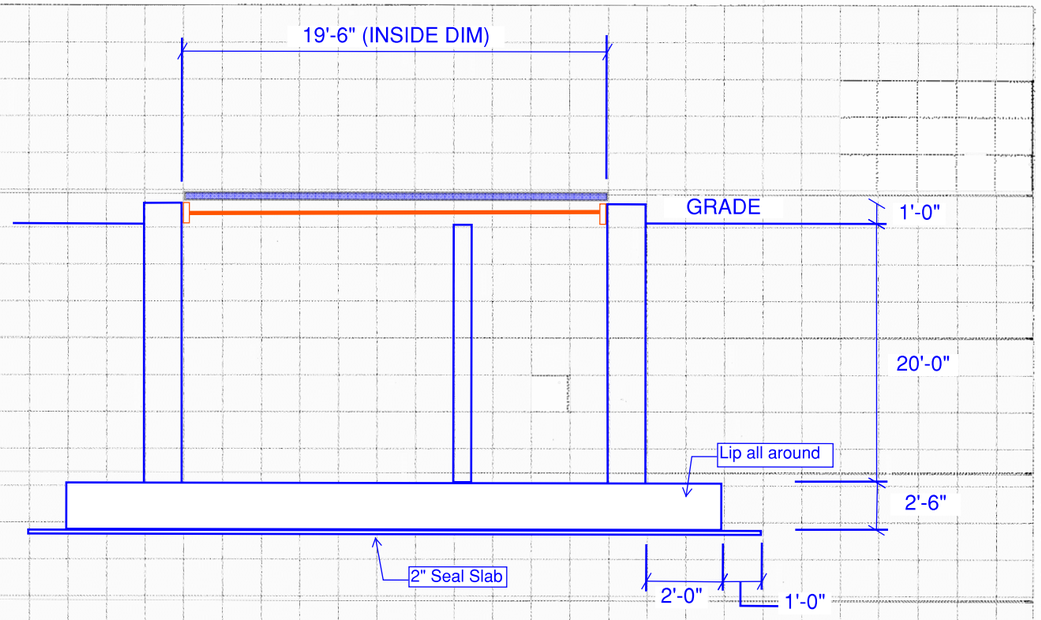
CALCULATIONS AND SKETCHES

DATE	10/30/2020
CONT. NO.	
BY	JG CHK'D
SHEET NO.	SHEET 1 OF 1

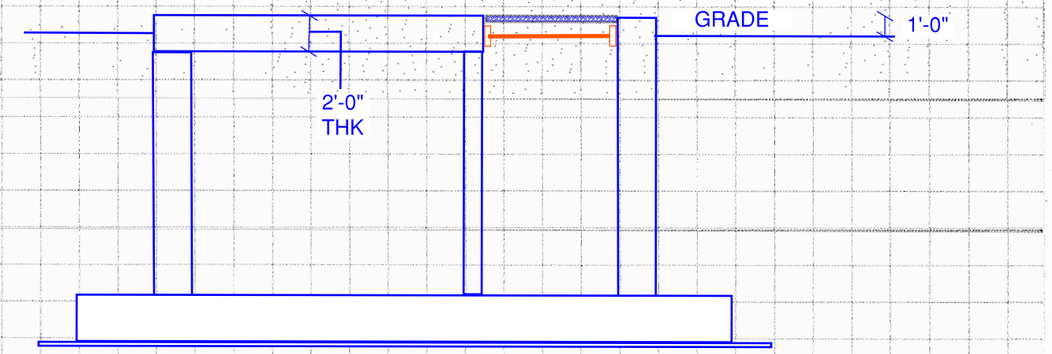
PCSW SUMP FOUNDATION SKETCH



PLAN VIEW



SECTION A-A



SECTION B-B

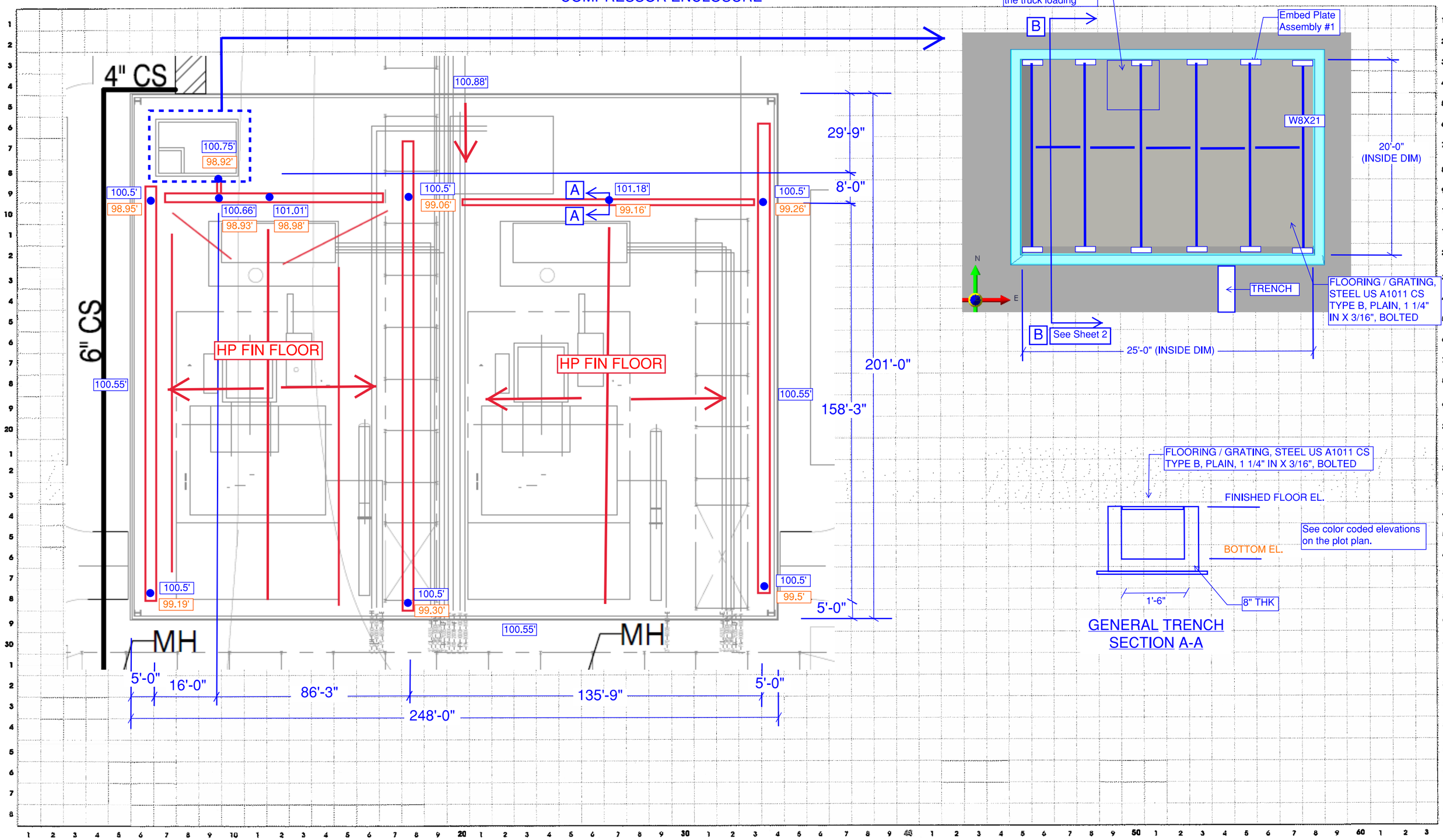
FLUOR®

FORM E52 (Rev. 2-05)

CALCULATIONS AND SKETCHES

DATE	11/09/2020
CONT. NO.	
BY	JG CHK'D
SHEET NO.	SHEET 1 OF 2

TRENCH & SUMP INSIDE COMPRESSOR ENCLOSURE



GENERAL TRENCH SECTION A-A

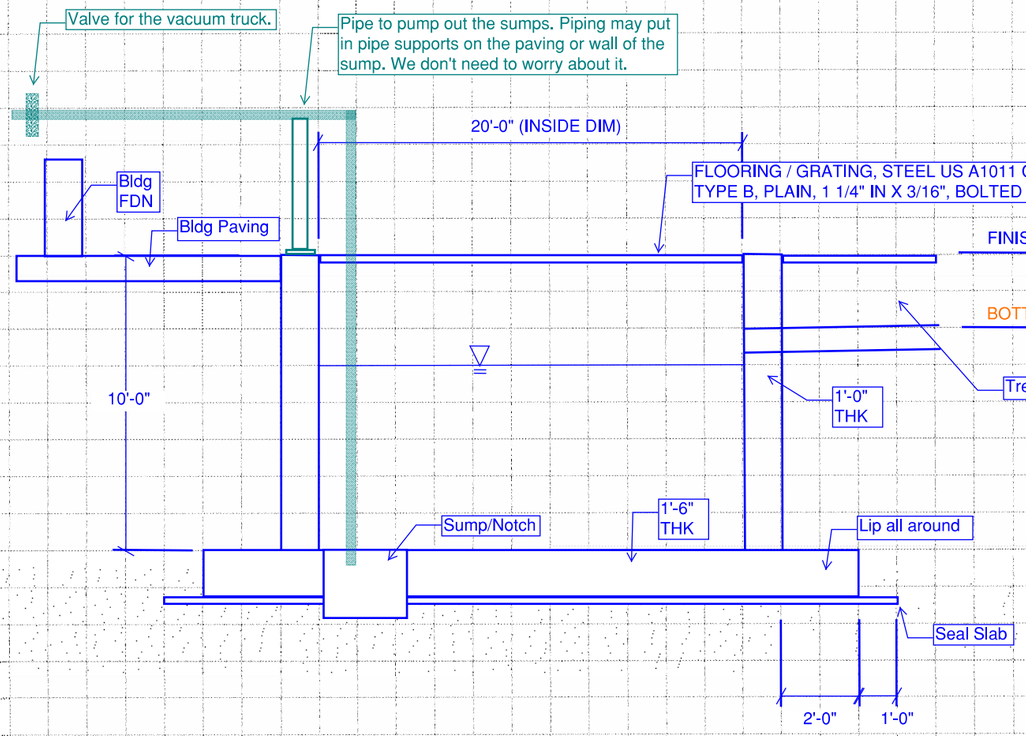
FLUOR®

FORM E52 (Rev. 2-05)

CALCULATIONS AND SKETCHES

DATE	11/09/2020
CONT. NO.	
BY	JG CHK'D
SHEET NO.	SHEET 2 OF 2

TRENCH & SUMP INSIDE COMPRESSOR ENCLOSURE



GENERAL SUMP SECTION B-B

FLUOR®

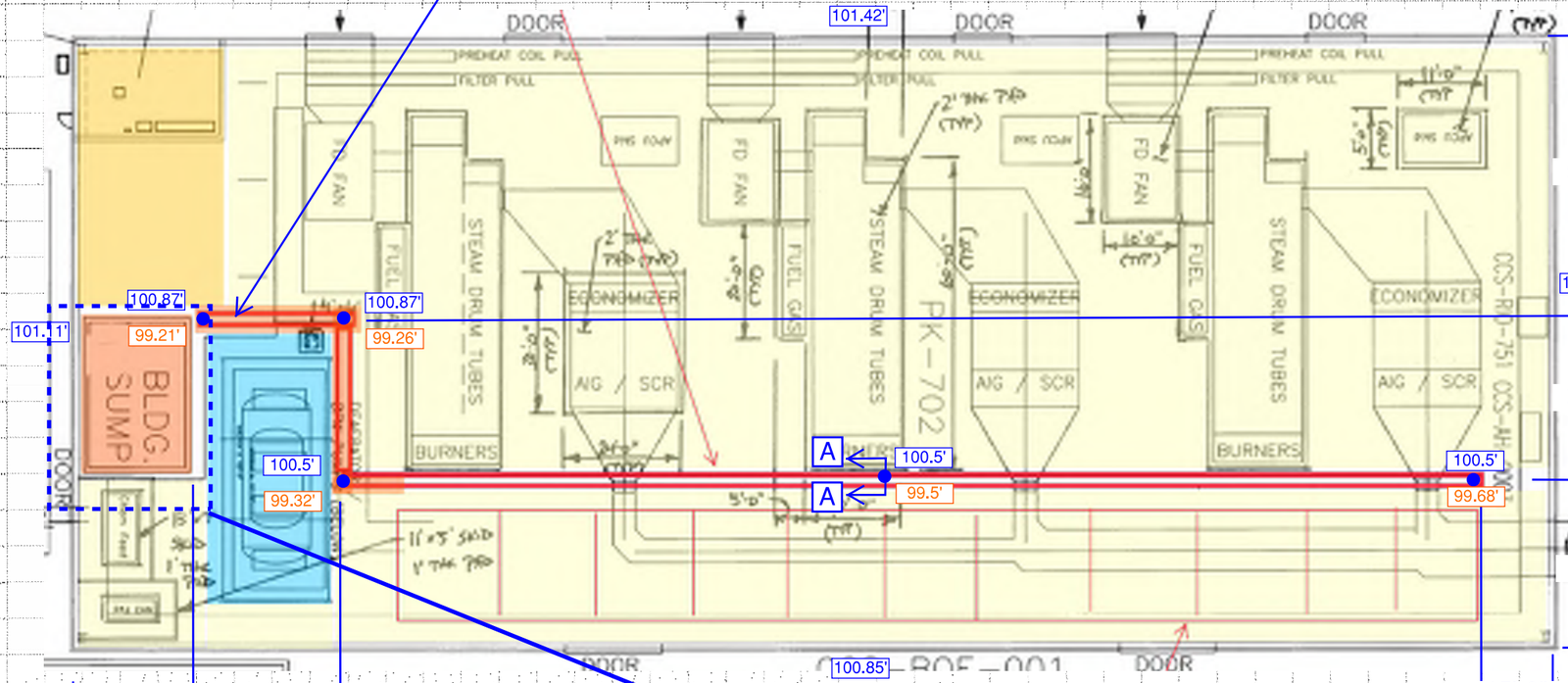
FORM E52 (Rev. 2-05)

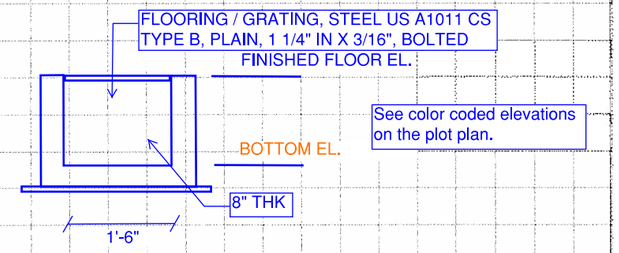
CALCULATIONS AND SKETCHES

DATE 11/11/2020
CONT. NO.
BY JG CHK'D
SHEET NO. SHEET 1 OF 2

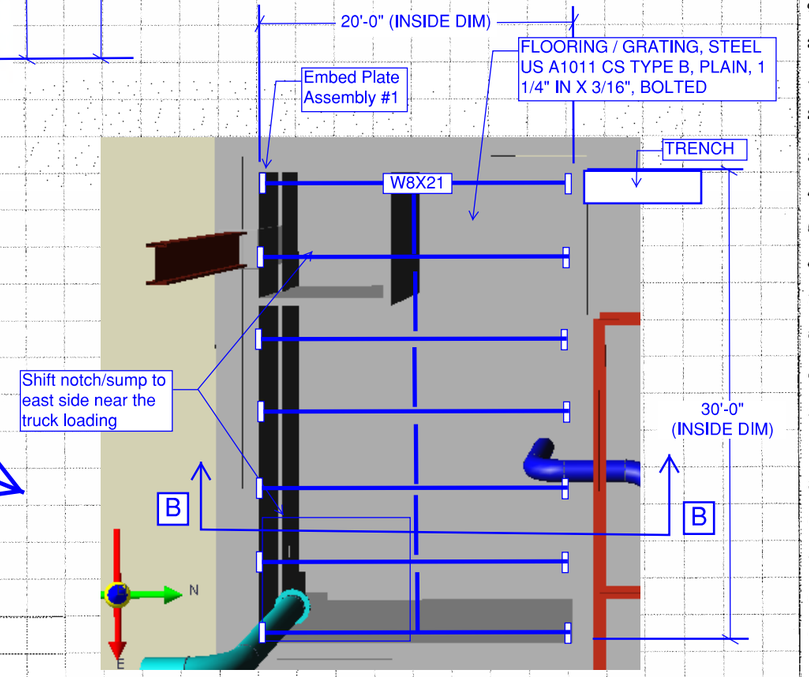
TRENCH & SUMP INSIDE BOILER ENCLOSURE

The orange area (sump and trench) will need to have thermal concrete coating for high temp. To account for the thk of this material (unknown), the trenches will be widened to 2'-0" instead of 1'6" as shown in section A-A.





GENERAL TRENCH SECTION A-A



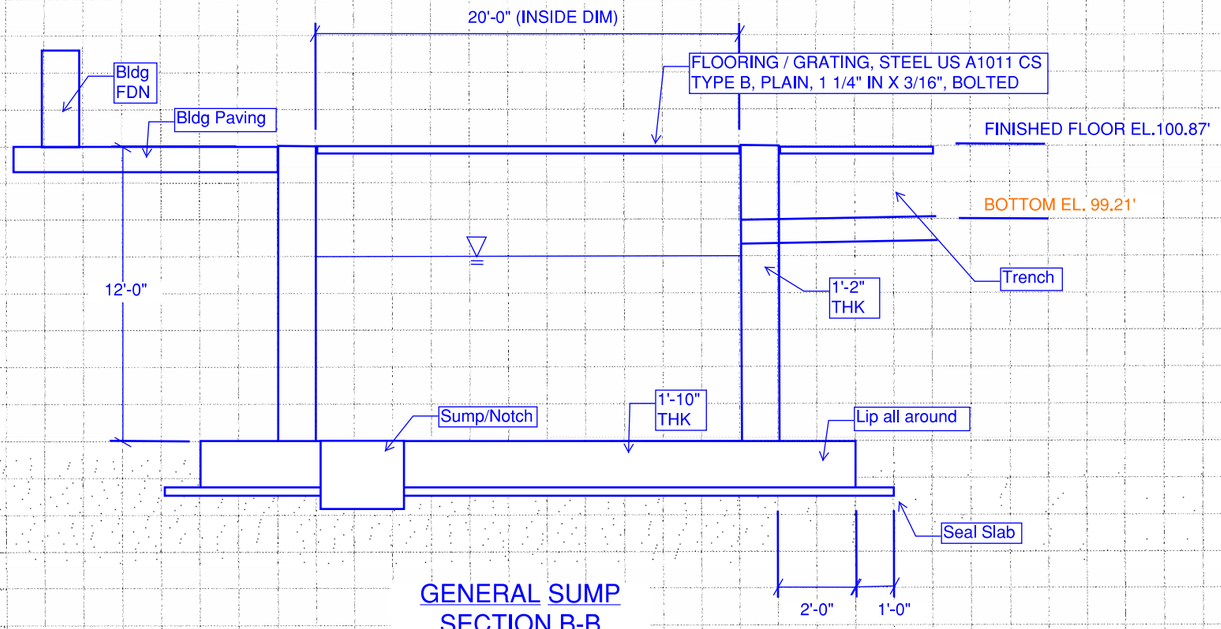
FLUOR®

FORM E52 (Rev. 2-05)

CALCULATIONS AND SKETCHES

DATE	11/11/2020
CONT. NO.	
BY	JG CHK'D
SHEET NO.	SHEET 2 OF 2

TRENCH & SUMP INSIDE BOILER ENCLOSURE



GENERAL SUMP
SECTION B-B

FLUOR®

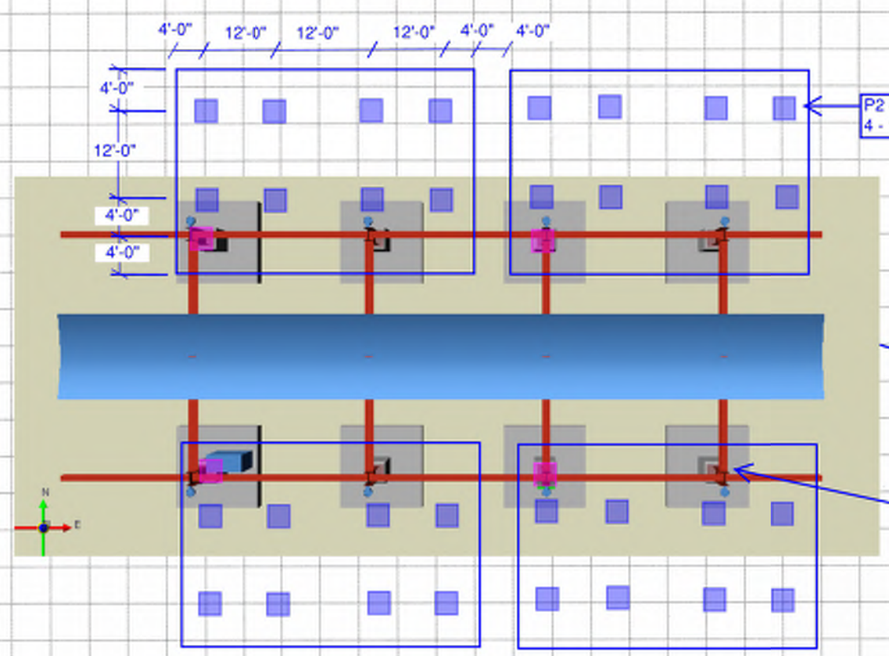
FORM E52 (Rev. 2-05)

CALCULATIONS AND SKETCHES

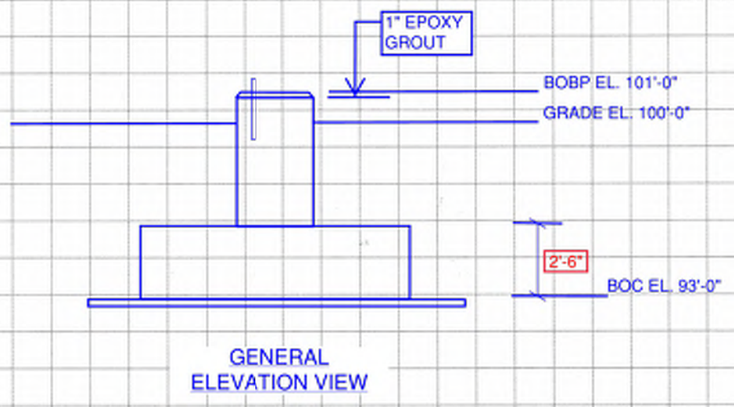
IMPURITY REMOVAL PACKAGE

FDN SKETCH

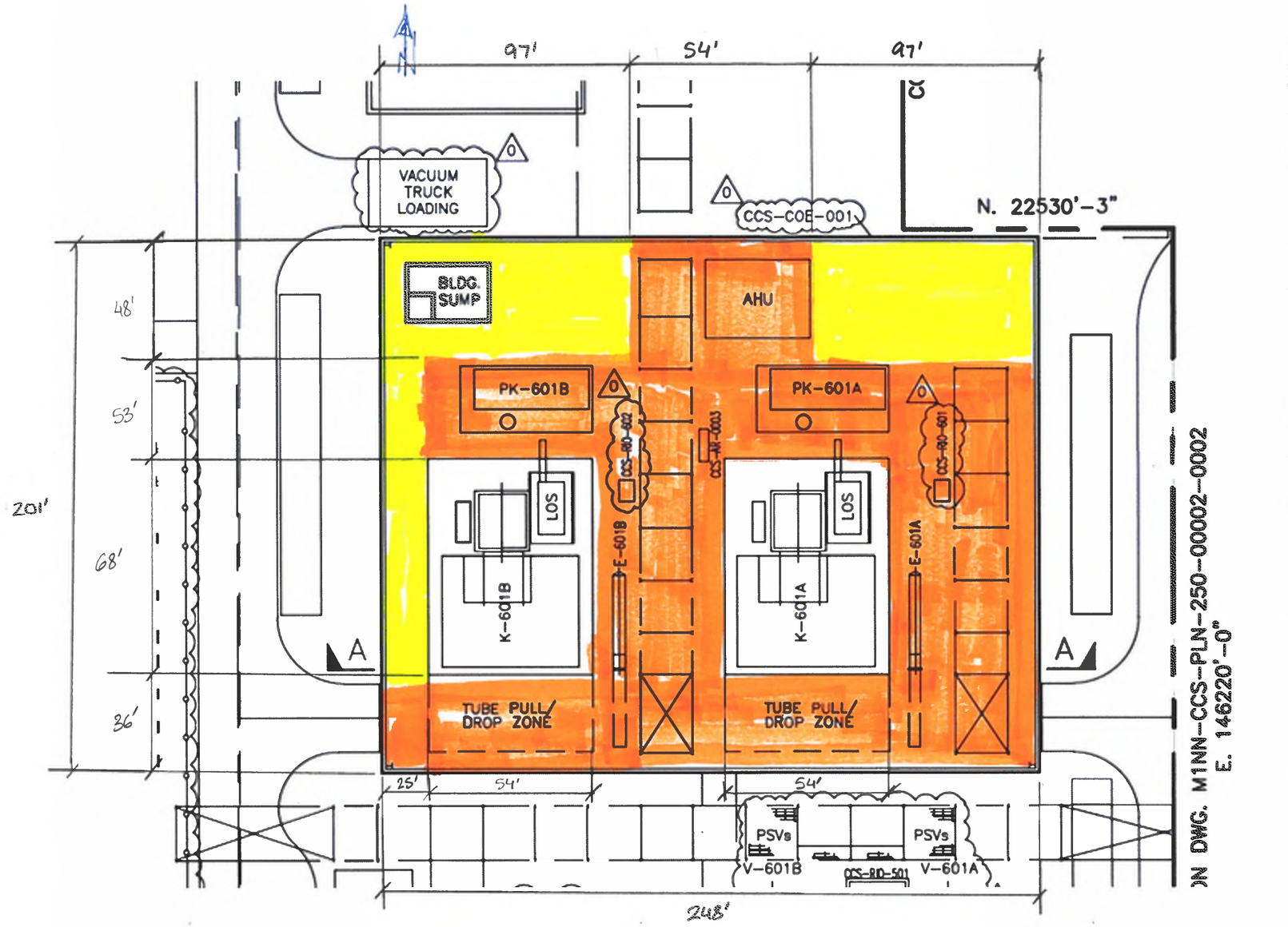
DATE 2020-11-10
CONT. NO. PIPERACK 0001-06
BY JG CHK'D
SHEET NO. 1 OF 1



GENERAL PLAN VIEW
(Snapshot taken on 11/10/2020)



GENERAL
ELEVATION VIEW



COMPRESSOR ENCL
PAVING PLAN

8" PAVING

2'-0" THICKENED PAVING

FLUOR PROPRIETARY INFORMATION

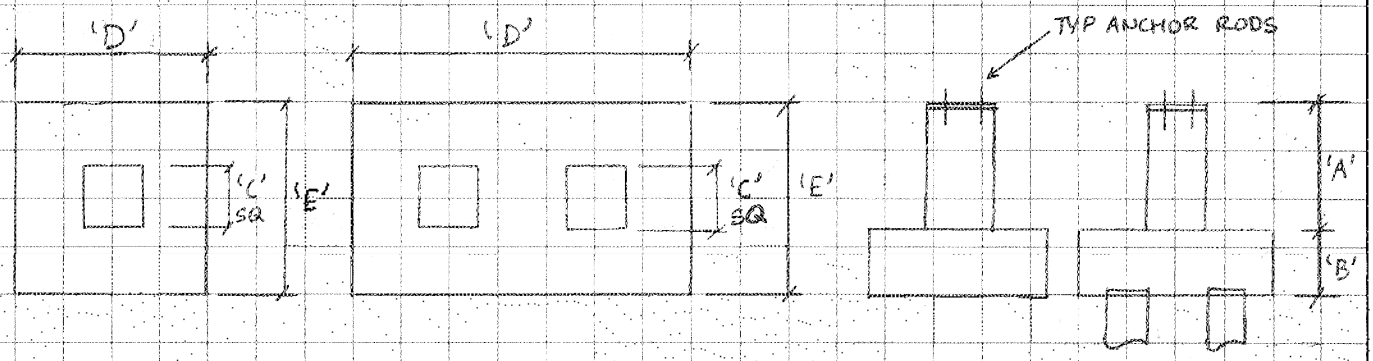
FLUOR.

CALCULATIONS and SKETCHES

DATE 10/29/2020
CONT. NO. HINN
BY JG CHK'D
SHEET NO. 1 OF 4

CONCRETE FOR PRE-CAST CONSIDERATION

PIPERACK FOUNDATIONS:



TYPE 1 TYPE 2 FOOTING PILE CAP

PLAN VIEW ELEVATION VIEW

STRUCTURE	TYPE	# OF	A	B	C	D	E	CONCRETE [CY] EACH	CONCRETE [CY] TOTAL
	1, FOOT	14	6'-0"	2'-0"	2'-6"	10'-0"	10'-0"	8.8	123.1
E-W RACK	1, PILE	8	5'-6"	2'-6"	2'-6"	5'-0"	9'-0"	5.4	43.5
	2, PILE	2	5'-6"	2'-6"	2'-6"	13'-6"	9'-0"	13.8	27.6
	1, PILE	8	5'-6"	2'-6"	2'-6"	9'-0"	9'-0"	8.8	70.2
N-S RACK TO COOLING TOWER	1, FOOT	8	6'-0"	2'-0"	2'-6"	10'-0"	10'-0"	8.8	70.4
N-S RACK TO MULTI-BLDG	1, FOOT	10	6'-0"	2'-0"	2'-6"	10'-0"	10'-0"	8.8	88.0
RACK TO WESP	1, FOOT	30	6'-0"	2'-0"	2'-6"	10'-0"	10'-0"	8.8	263.9

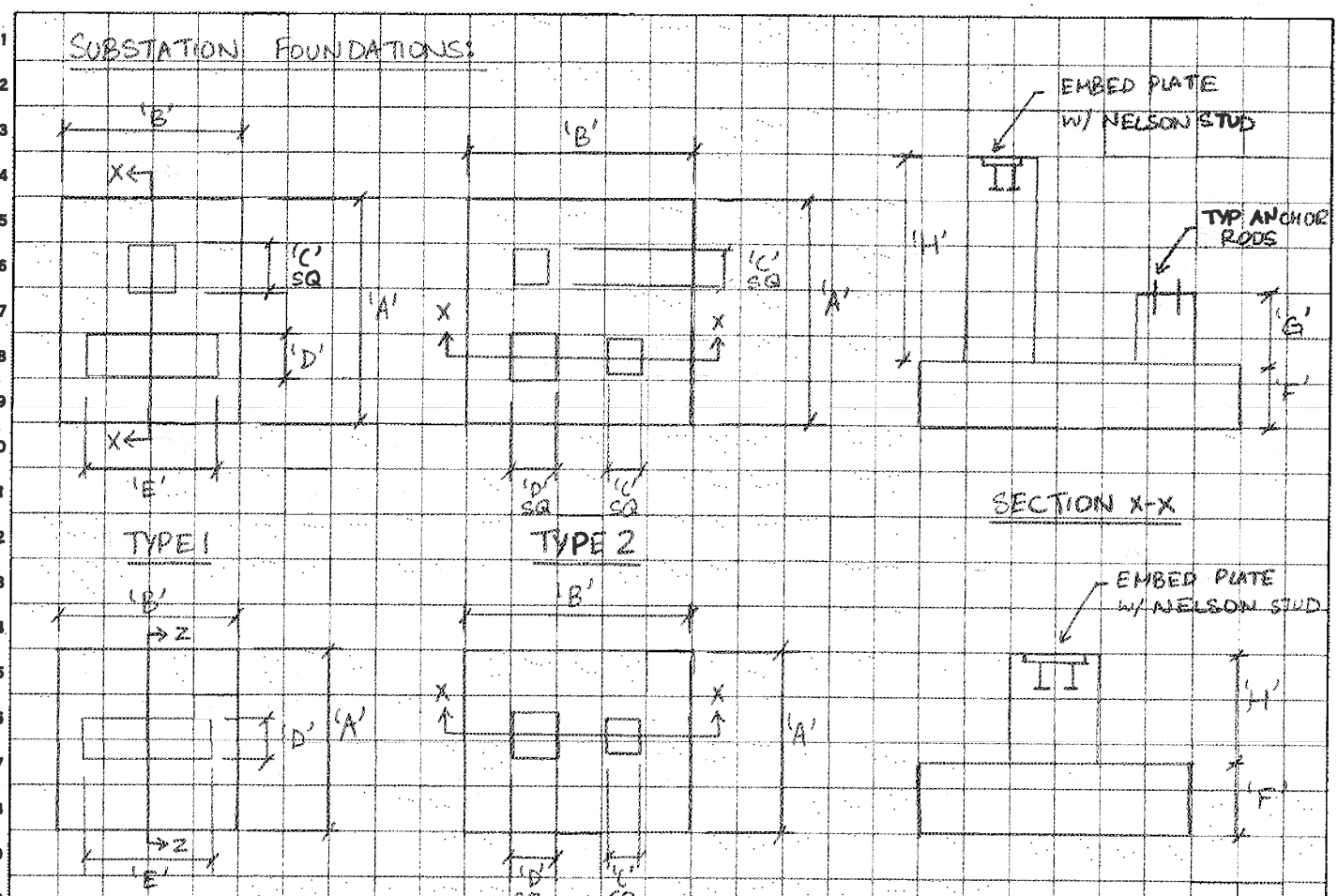
FLUOR.

CALCULATIONS and SKETCHES

DATE 10/29/2020
CONT. NO. HINN
BY JCa CHK'D
SHEET NO. 2 OF 4

CONCRETE FOR PRE-CAST CONSIDERATION

SUBSTATION FOUNDATIONS:



TYPE 1 TYPE 2

TYPE 3 TYPE 4

PLAN VIEW ELEVATION VIEW

TYPE	# OF	A	B	C	D	E	F	G	H	CONCRETE [CY] EACH	CONCRETE [CY] TOTAL
1	2	10'-0"	8'-0"	1'-6"	1'-10"	3'-0"	2'-0"	6'-0"	15'-0"	9.5	19.0
2	4	10'-0"	10'-0"	1'-6"	1'-10"	—	2'-0"	6'-0"	15'-0"	10.3	41.1
3	11	8'-0"	8'-0"	—	1'-10"	3'-0"	2'-0"	—	15'-0"	7.8	85.7
4	22	8'-0"	10'-0"	1'-6"	1'-10"	—	2'-0"	6'-0"	15'-0"	8.3	182.3
3 (W/ ANCHOR RODS)	4	4'-0"	4'-0"	—	1'-6"	1'-6"	2'-0"	—	6'-0"	1.7	6.7

FORM E50 (Rev. 08)

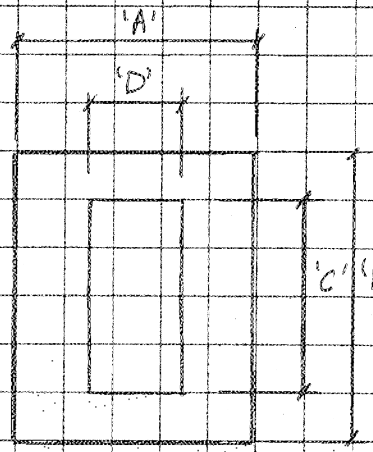
FLUOR.

CALCULATIONS and SKETCHES

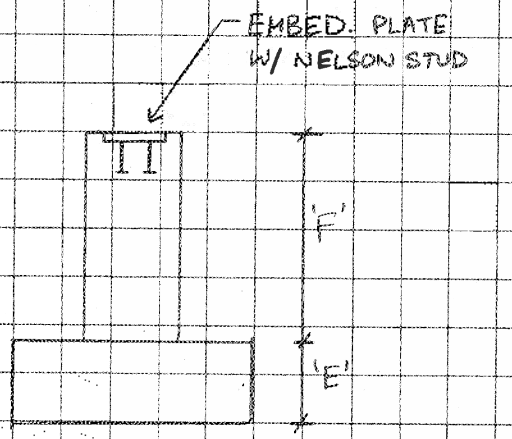
DATE 10/29/2020
CONT. NO. MINN
BY JG CHK'D
SHEET NO. 3 OF 4

CONCRETE FOR PRE-CAST CONSIDERATION

FOUNDATIONS NEAR COOLING TOWER:



PLAN VIEW



ELEVATION VIEW

STRUCTURE	# OF	A	B	C	D	E	F	CONCRETE [CY] EACH	CONCRETE [CY] TOTAL
SLEEPER 1	10	8'-0"	8'-0"	7'-0"	2'-0"	2'-0"	7'-0"	8.4	83.7
SLEEPER 2	27	5'-0"	5'-0"	4'-6"	1'-6"	1'-8"	7'-4"	3.4	91.3
PLATFORM FOOTINGS	10	7'-0"	7'-0"	2'-0"	2'-0"	1'-8"	6'-4"	4.0	39.7

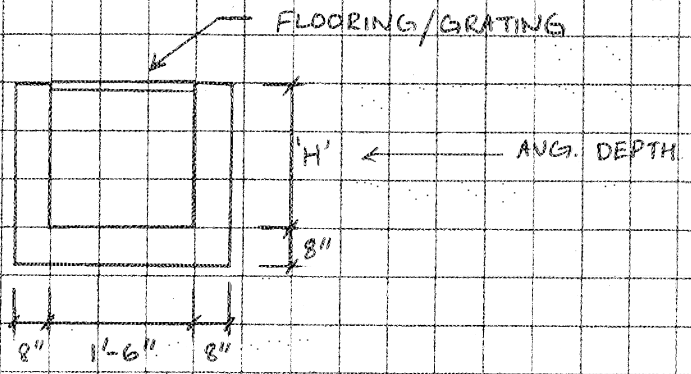
FLUOR.

CALCULATIONS and SKETCHES

DATE 10/29/2020
CONT. NO. MINN
BY JG CHK'D
SHEET NO. 4 OF 4

CONCRETE FOR PRE-CAST CONSIDERATION

TRENCH INSIDE ENCLOSURE:



ENCLOSURE	LF	H	CONCRETE PER LF [CF]	TOTAL [CY]
PROCESS	1225	1'-6"	3.91	177.5
COMPRESSOR	453	1'-6"	3.91	65.6
BOILER	435	1'-6"	3.91	63.1

FORM E50 (Rev. 03-08)

RING_DESIGN_DATA\215E_014_R_Proj_Calculations_Sketches\FEED Calculations\EC-CCS-215-0003-17\MTO\[Concrete MTO - PK-702 Boiler Vent Stack.xls]Sheet1

FOUNDATION MTO SUMMARY

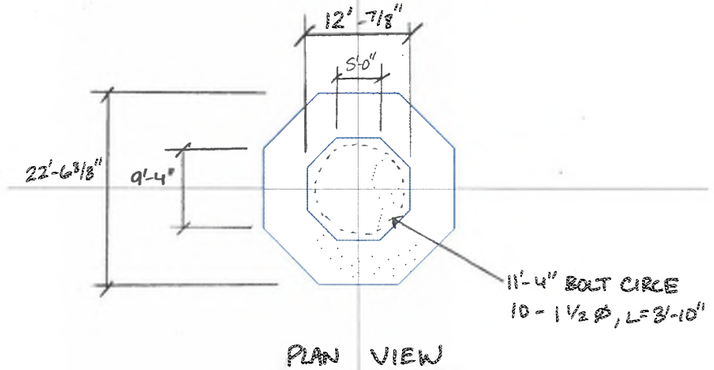
CWP No. BPBE00 By: JG
Associated Calculation No. EC-0003-17
Item Description: PK-702 Boiler Vent Stack Rev: 0

CIVIL, DEMO, ANCHOR AND PILING:	Qty	Units
Water Proofing Barriers, Asphalt Bitumen		SF
Concrete Waterstop [Type, Width]		LF
Soil Rigid Insulation - 9" thk		SF
Soil Void Form		SF
Anchor Bolts [Type, Size] - GR 36, 1 1/2" DIA, L = 3'-10"	10	EA
Anchor Bolts [Type, Size]		EA
Steel Embeds [Wt]		LB
DRIVEN PILES [18" DIA. x 50']	18	EA
EXCAVATION	132	CY
BACKFILL AND COMPACTION - NON FROST SUSCEPTIBLE SOIL	57	CY
Bond Breaker	384	SF

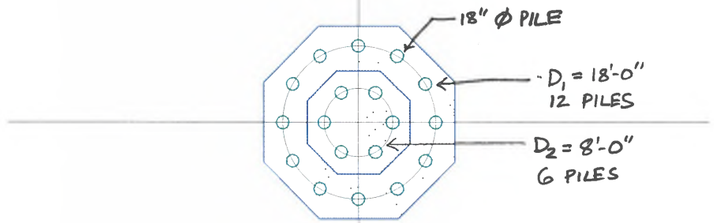
TYPE	CONCRETE DESCRIPTION		Units
TYPE 1	Structures, Pipe Supports, Columns, Beams		CY
TYPE 2	Elev. Slab		CY
TYPE 3	Pier & Footing		CY
TYPE 4	Tee Support		CY
TYPE 5	Horiz.Shell and Sleeper (< 4 ft height)		CY
TYPE 6	Horiz.Shell and Sleeper (> 4 ft height)		CY
TYPE 7	Octagon (w/o Projection)		CY
TYPE 8	Octagon (w/ Projection)	69	CY
TYPE 9	Small Block (<= 3 CY)		CY
TYPE 10	Large Block (> 3 CY)		CY
TYPE 11	Grade Beam		CY
TYPE 12	Tank Ring Walls		CY
TYPE 14	Medium Pour (>= 10 CY)		CY
TYPE 15	Large Pour (>= 25 CY)		CY
TYPE 16	Building Fdn		CY
TYPE 17	Cooling Tower Basin and Separator		CY
TYPE 18	Trenches and Retaining Wall (W/D < 2 ft, D <= 6.6 ft)		CY
TYPE 19	Trenches and Retaining Wall (W/D < 2 ft, D > 6.6 ft)		CY
TYPE 20	Catch Basin, MH, Valve Boxes		CY
TYPE 21	Ground Floor Slab		CY
TYPE 22	Area Paving		CY
TYPE 23	Electrical Duct Banks		CY
TYPE 24	UG Ducts, Box Culverts		CY
TYPE 25	Cementitious Grout		CF
TYPE 26	Epoxy Grout	1.60	CF
TYPE 27	Paving Piers		CY
TYPE 28	Profiled Metal Decking and Precast Element Topping		CY
TYPE 29	Precast Concrete Elements		CY
TYPE 30	Un-Reinforced Concrete		CY
TYPE 31	Vertical Walls		CY
	Mud Mat (Lean Concrete 2000 psi)	3.1	CY

PK-702 BOILER VENT STACK

11/11/2020

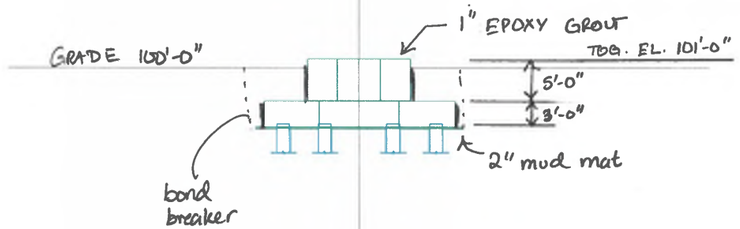


PLAN VIEW



PILE LAYOUT

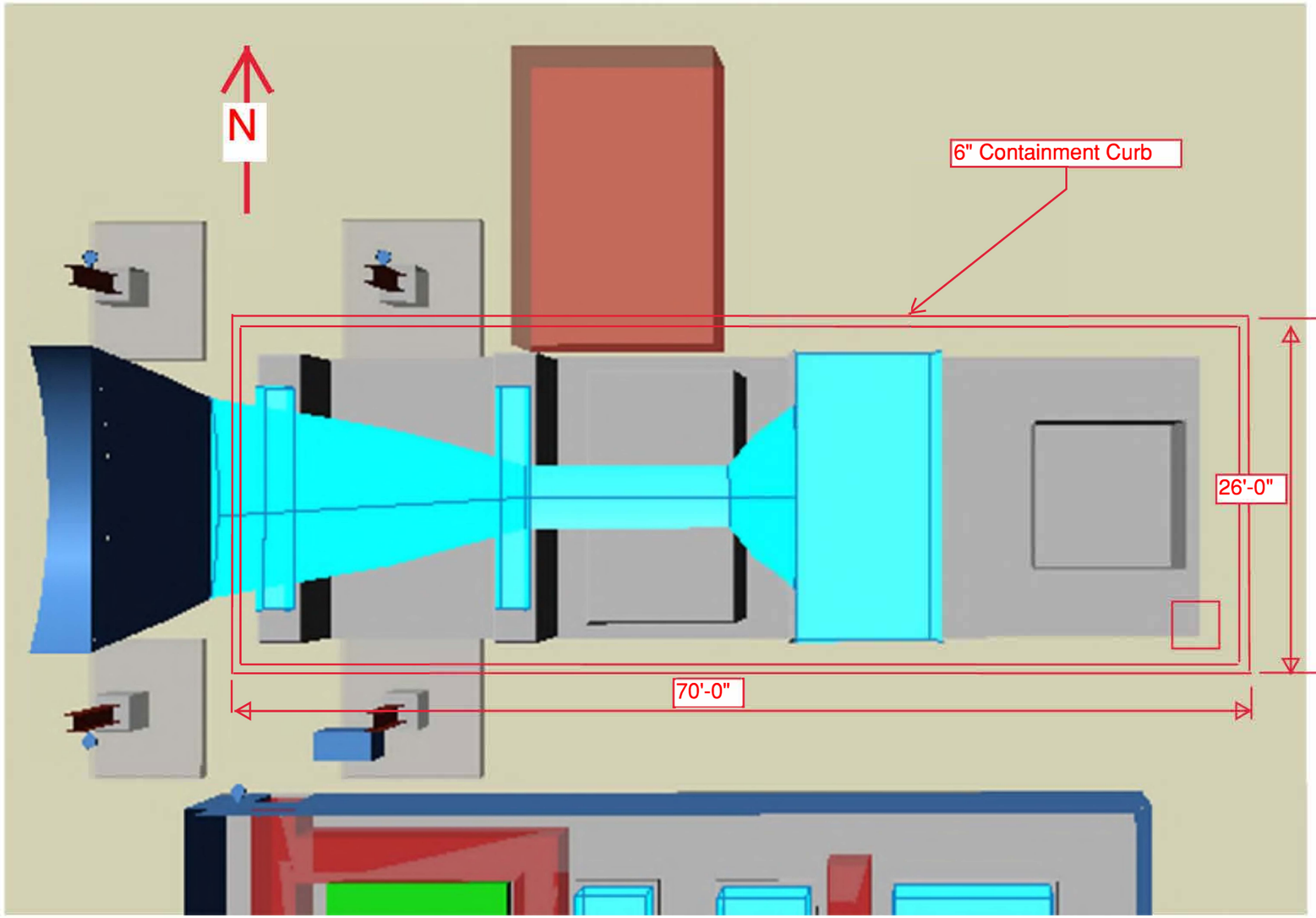
18-PILE LAYOUT

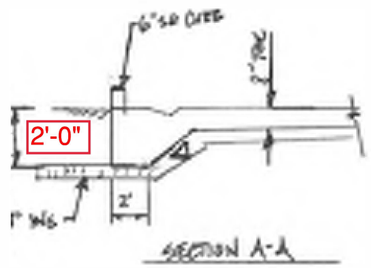


ELEVATION VIEW

MTO

	QTY	UNIT
* DRIVEN PILE – 18" ø, L = 50'-0"	18	EA
* ANCHOR BOLT – GR. 36, 1 1/2" ø, L = 3'-10"	10	EA
* TYPE 8 – CONCRETE	69	CY
$V = V_{ped} + V_{foot}$		
$V = 0.828\,(12.071')^2(5' - 0.09') + 0.828\,(22.533')^2(3')$		
$V = 1854.4\ ft^3 = 68.7\ yd^3$		
* TYPE 26 – EPOXY GROUT – 1" thk	1.6	CF
6" on either side of bot circle		
$V = \frac{\pi}{4}\left[(12.071' + 0.5')^2 - (12.071' - 0.5')^2\right] \cdot 0.09'$		
$V = 1.58\ ft^3$		
* MUD MAT – 2" thk	3.1	CY
$V = 0.828\,(22.533' + 2')^2 \cdot 0.17' = 84.7\ ft^3 = 3.1\ yd^3$		
* BOND BREAKER	384	SF
$A = A_{ped} \cdot 8\,sides + A_{foot} \cdot 8\,sides$		
$A = [(5')(4')(8) + (9.33')(3')(8)] = 383.92\ ft^2$		
* EXCAVATION	132	CY
$V = 0.828\,(22.533' + 2')^2 \cdot (7' + 0.17') = 3573.1\ ft^3 = 132.3\ yd^3$		
* BACKFILL (NON-FROST)	57	CY
Using 1.1 compaction factor		
$V = 1.1\left(V_{EX} - V_{foot} - 0.828\,(12.071')^2(4') - V_{mud\ mat}\right)$		
$V = 1.1\left(3573.1\ ft^3 - 1619.4\ ft^3 - 482.6\ ft^3 - 84.7\ ft^3\right)$		
$V = 1.1\,(1386.4\ ft^3) = 1525.1\ ft^3 = 56.5\ yd^3$		





CONTAINMENT PAVING FOR BL-201

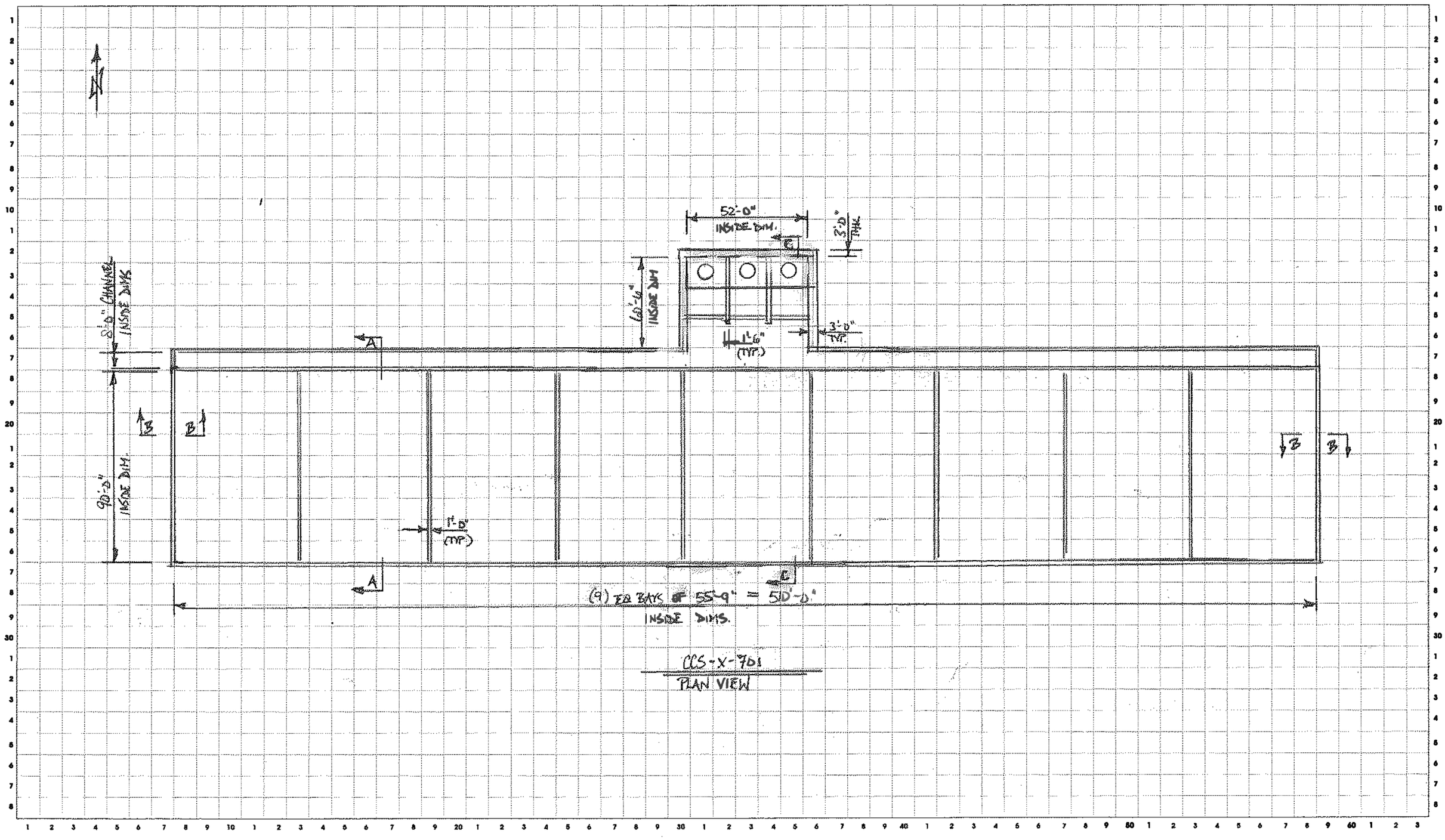
FLUOR®

CALCULATIONS AND SKETCHES

FORM E52 (Rev. 2-05)

CCS-X-701 COOLING TOWER BASIN & SUMP

DATE 20-OCT-2020
CONT. NO. M1NN
BY CTK CHK'D
SHEET NO. EE CCS-0065-01



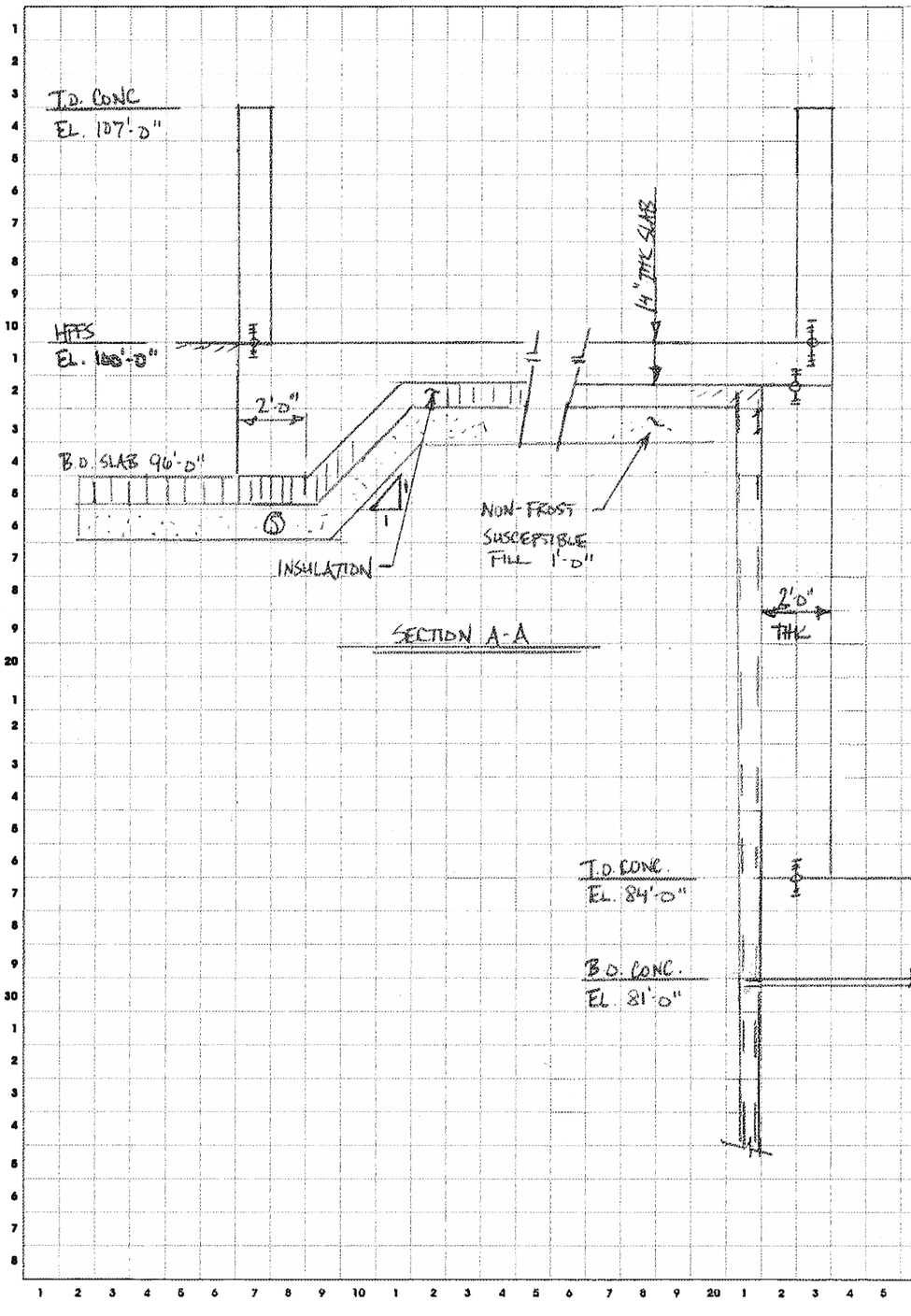
CCS-X-701
PLAN VIEW

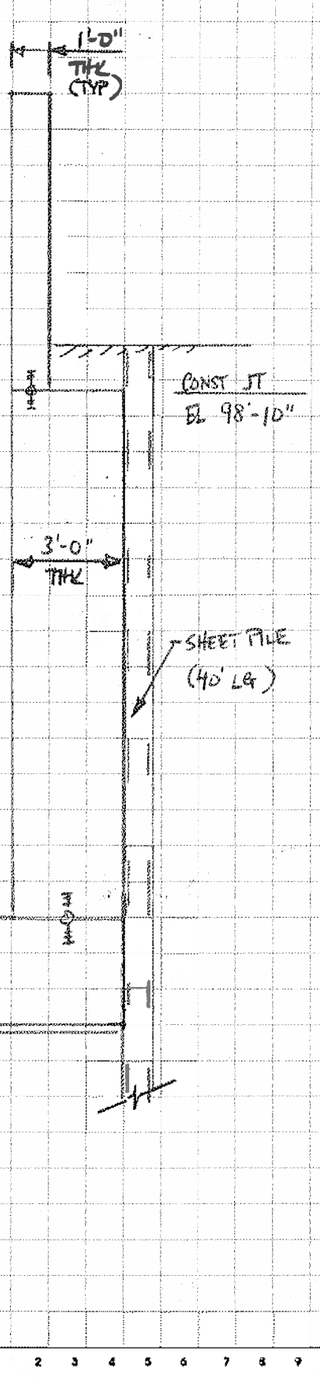
FLUOR®

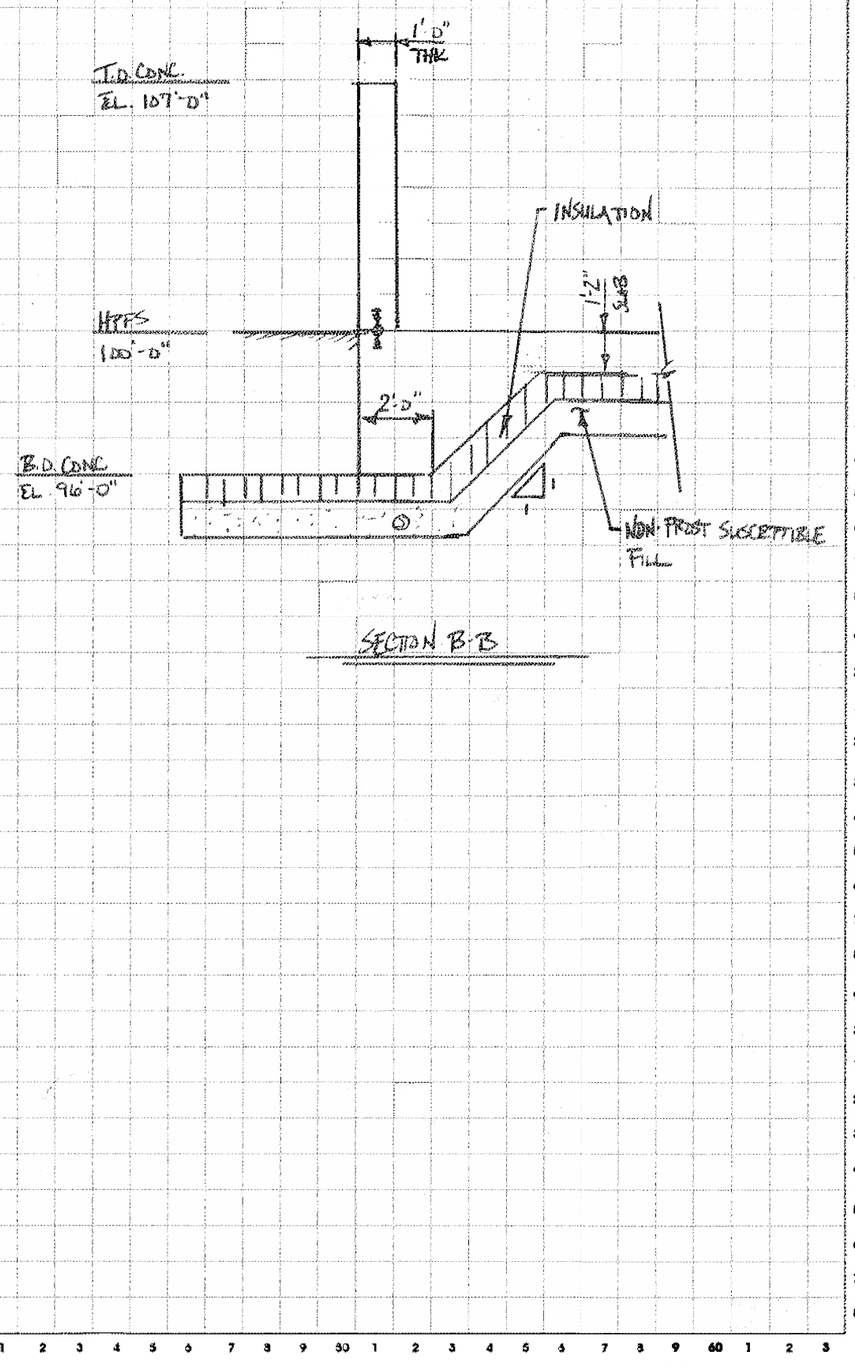
CALCULATIONS AND SKETCHES

FORM E52 (Rev. 2-05) CCS-X-701 COOLING TOWER BASIN & SUMP

DATE 23-OCT-2020
CONT. NO. MINN
BY GTK CHK'D
SHEET NO. EC-CCS-0005-21







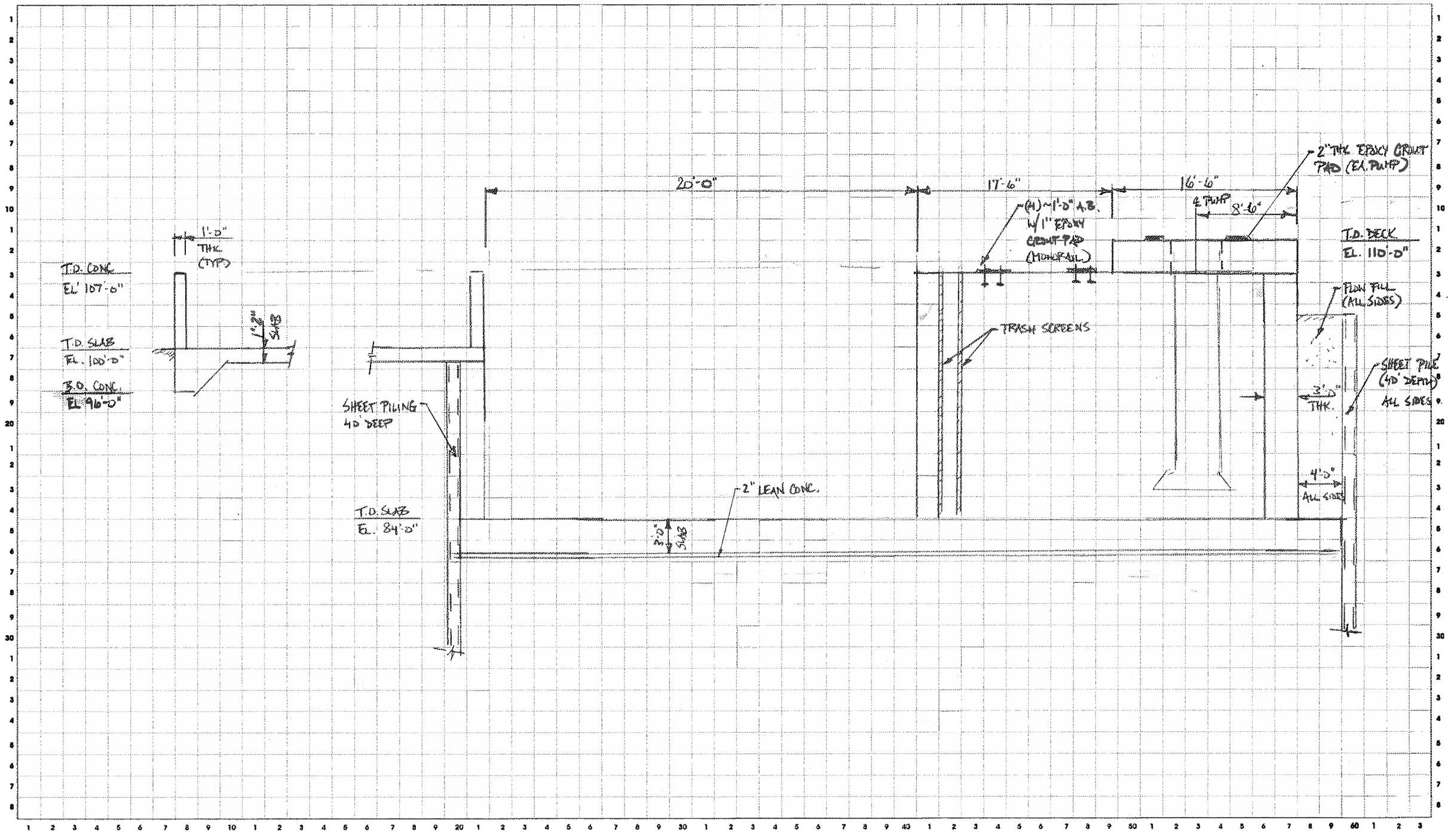
FLUOR

FORM E52 (Rev. 2-05)

CALCULATIONS AND SKETCHES

CCS-X-T01 COOLING TOWER BASIN & SUMP

DATE 26-OCT-2020
CONT. NO. M1NN
BY CTK CHK'D
SHEET NO. EC-CCS-0005-01



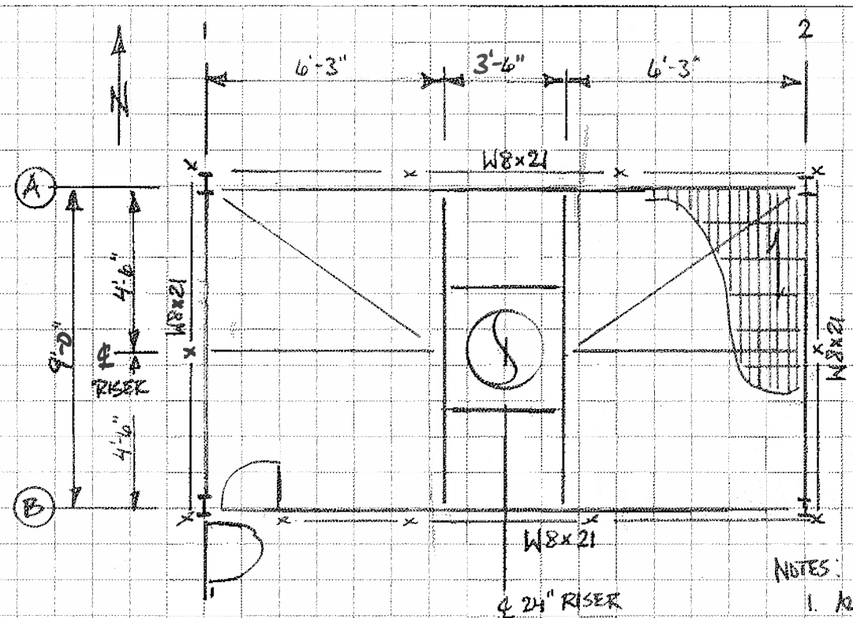
FLUOR®

CALCULATIONS AND SKETCHES

FORM E52 (Rev. 2-05)

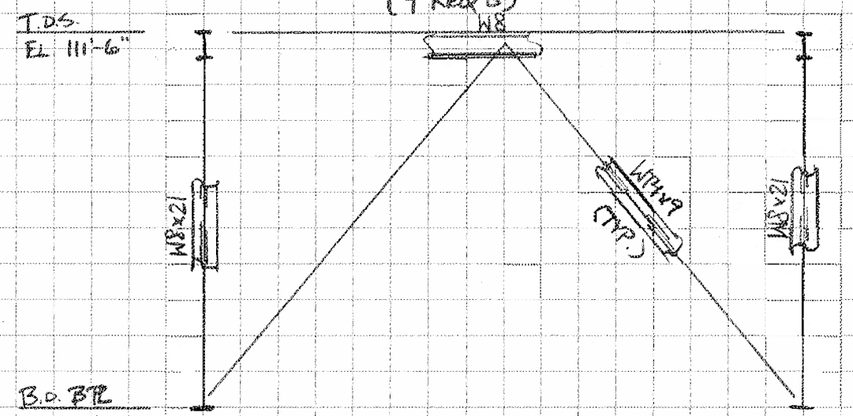
COOLING WATER RETURN RISER PLATFORMS

DATE 12-NOV-2020
CONT. NO. MINN
BY CMC CHK'D
SHEET NO. FEC-CCS-215-0007-13



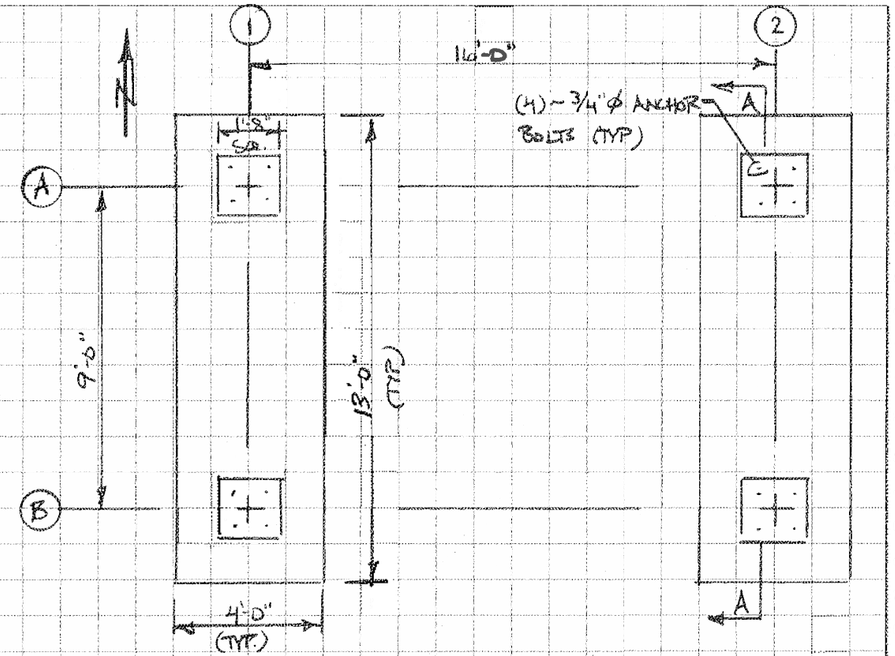
PLAN VIEW

T.O.S. EL. 111'-6"
(9 REQ'D)

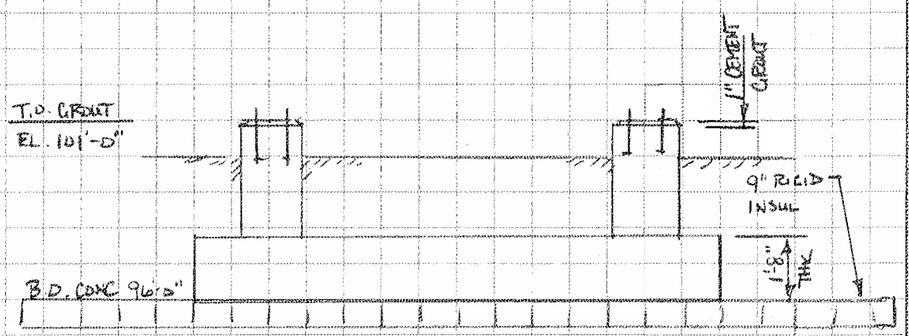


ELEVATION VIEW
COL. LINES A & B

NOTES:
1. ALL BEAMS ARE W10×15 UNO
2. ALL BRACES ARE WT4×9



FOUNDATION PLAN



SECTION A-A

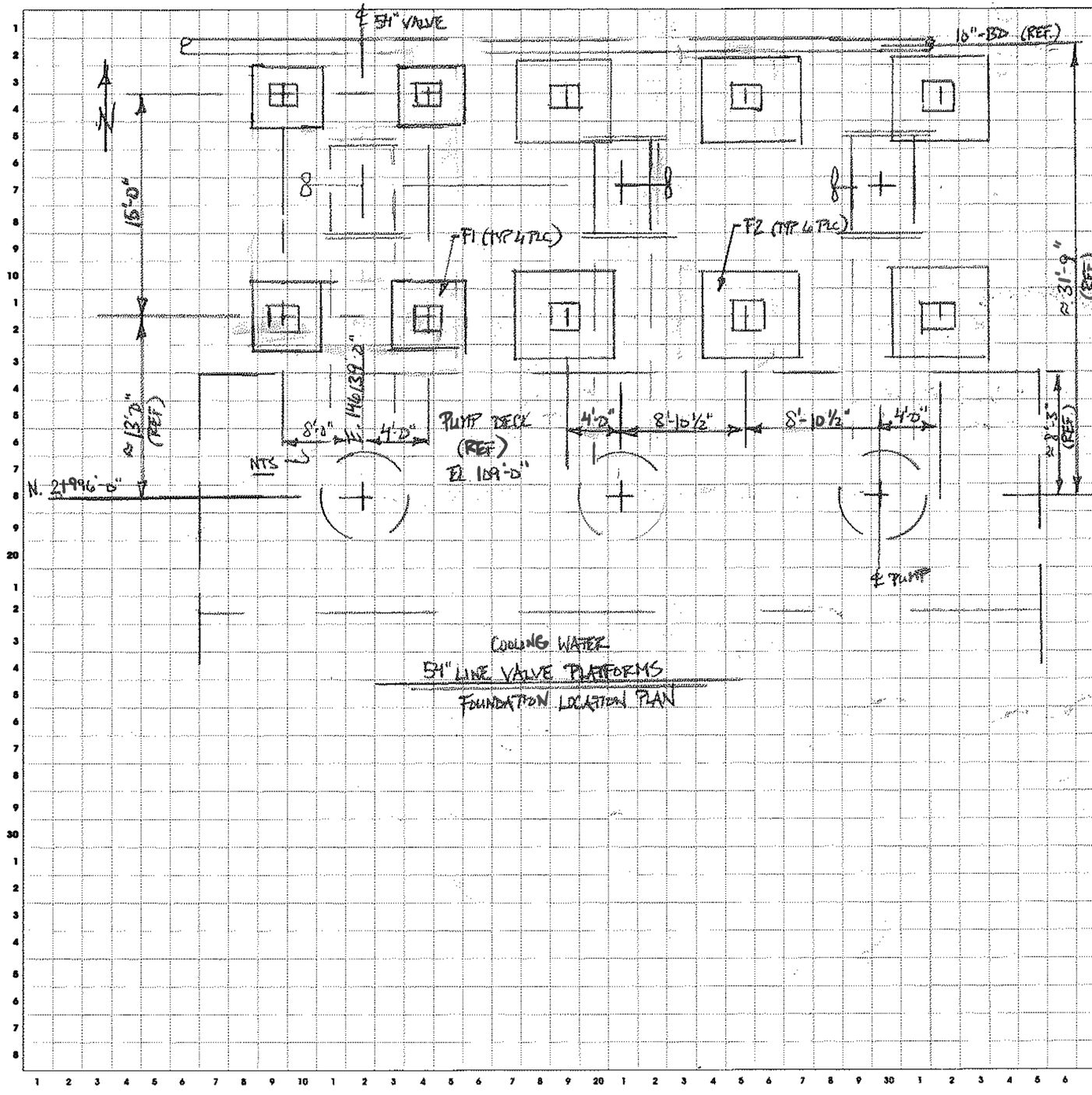
FLUOR®

CALCULATIONS AND SKETCHES

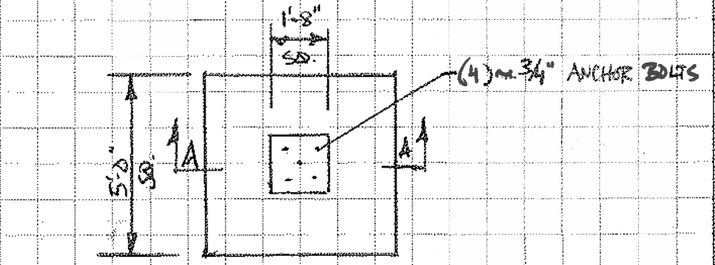
DATE 22-OCT-2020
CONT. NO. M1NN
BY CJL CHK'D
SHEET NO. EC-CCS-0005-01

FORM E52 (Rev. 2-05)

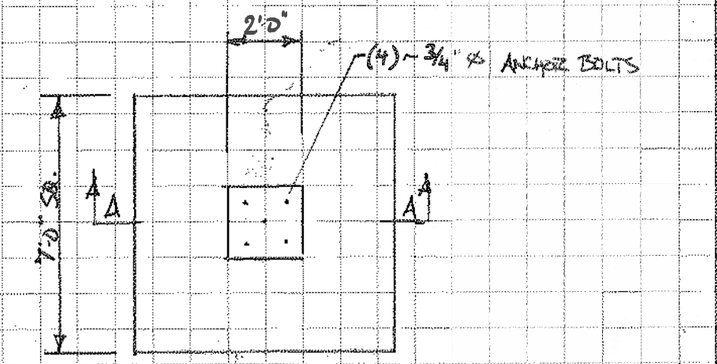
CCS-X-T01 COOLING WATER SUPPLY VALVE PLATFORMS



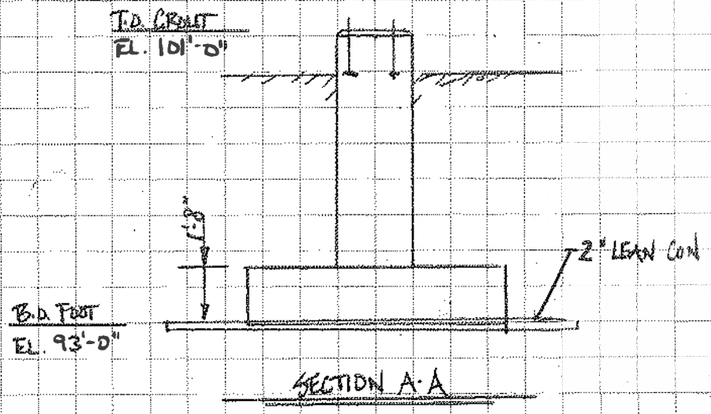
COOLING WATER
54" LINE VALVE PLATFORMS
FOUNDATION LOCATION PLAN



F1 PLAN



F2 PLAN



SECTION A-A

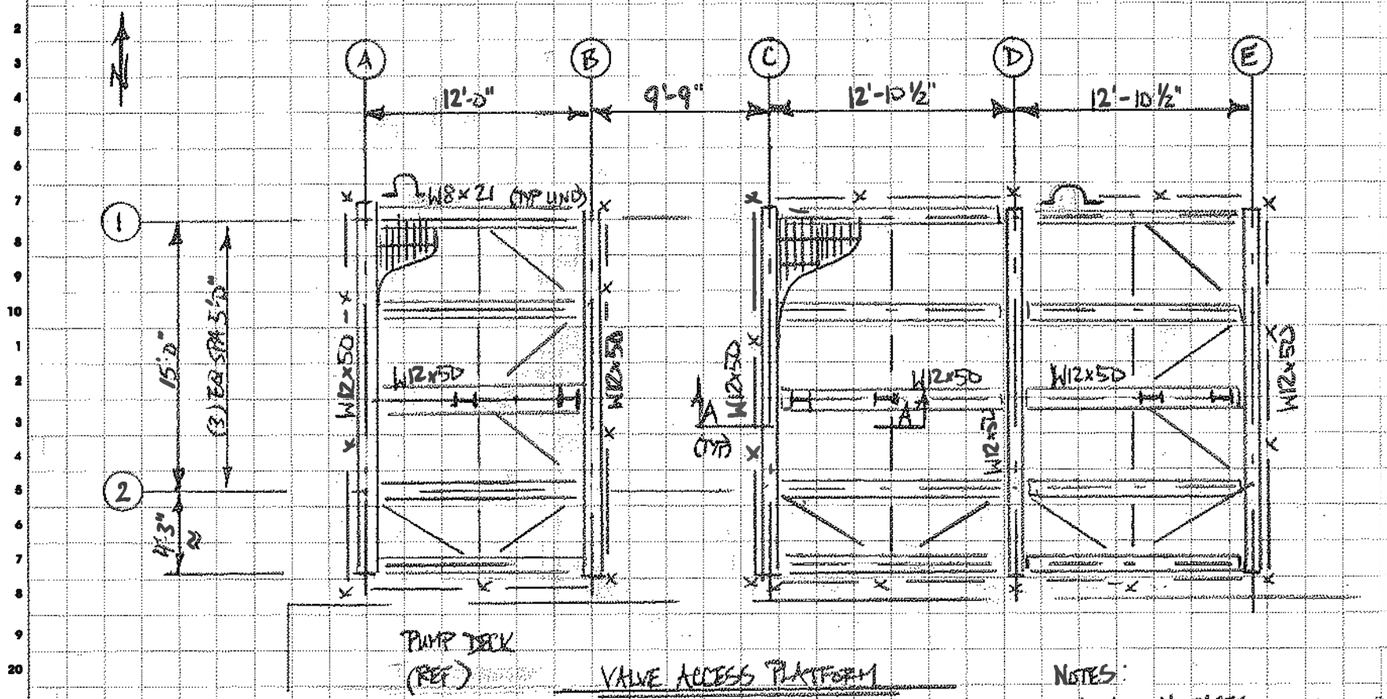
FLUOR®

FORM E52 (Rev. 2-05)

CALCULATIONS AND SKETCHES

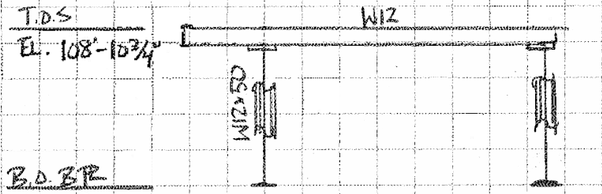
DATE 22-OCT-2020
CONT. NO. M1NN
BY CTL CHK'D
SHEET NO. EC-CCS-0005-01

CCS-X-701 COOLING WATER SUPPLY VALVES - STEEL

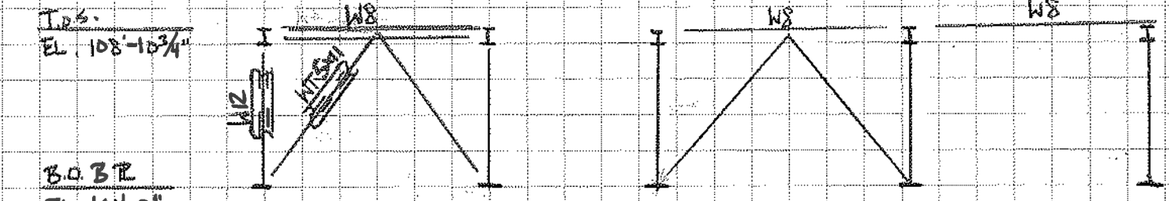


VALVE ACCESS PLATFORM
T.O. GRATING EL. 109'-0"

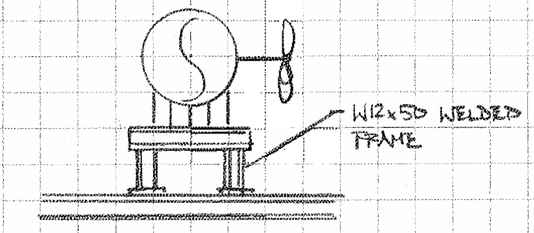
NOTES:
1. ALL HBRACES ARE WT4x9



COLUMN LINES A THRU E
(LOOKING WEST)

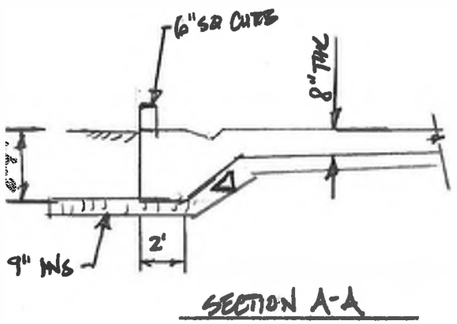


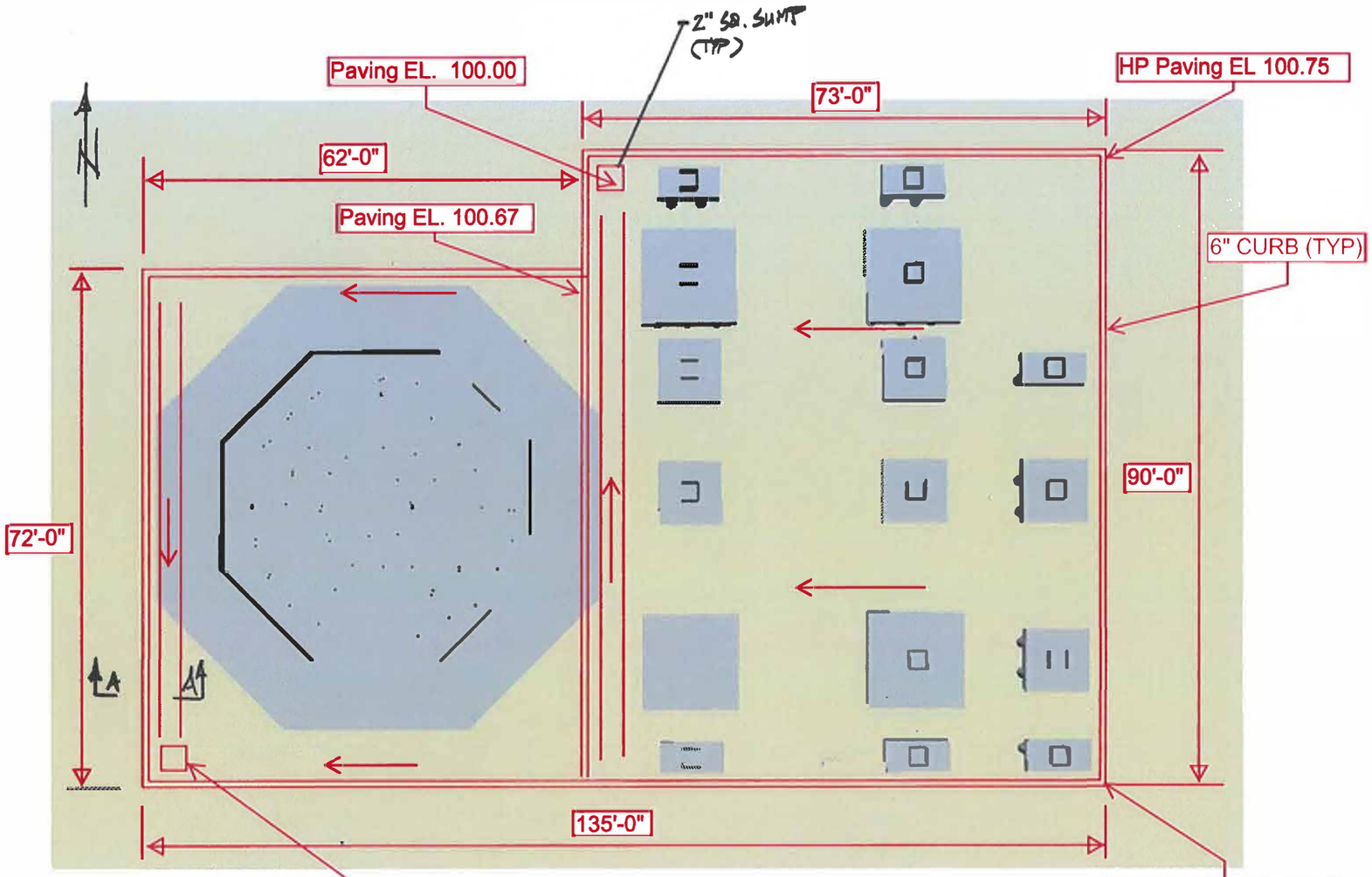
COLUMN LINES 1 & 2
LOOKING NORTH



SECTION A-A
PIPE SUPPORTS

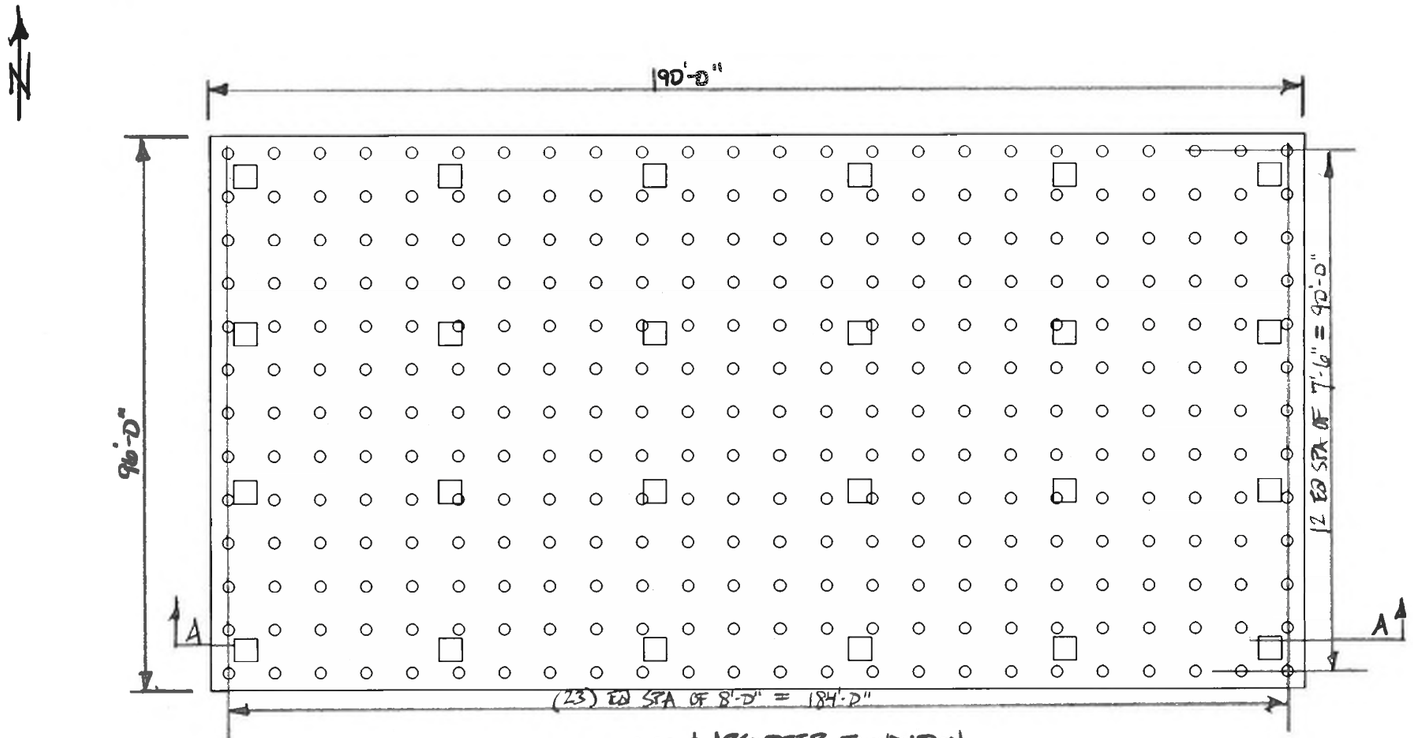
EC-CCS-215-0007-08
BY. CTC 04-NOV-2020





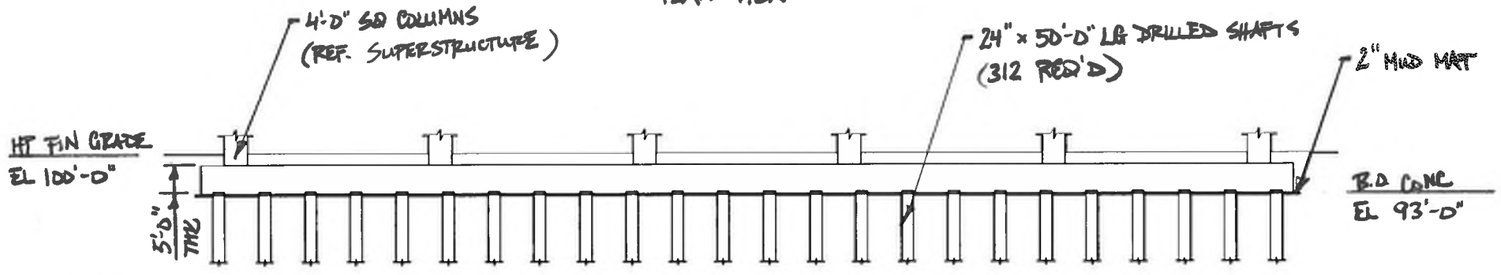
C-301 STRIPPER AND V-301 CONTAINMENT CURBS

PAVING AND CURBS TO BE COATED WITH SOLVENT RESISTANT EPOXY COATING.



DCC & ABSORBER FOUNDATION

PLAN VIEW



SECTION A-A

MTO QUANTITIES

TYPE 15 CONC. = (190')(96')(5')/27
= 3378 CY

MUD MAT = (192')(98')(2/12')/27
= 117 CY

BOND BREAKER = (5')(2×190' + 2×96')
= 2860 SF

24" × 50'* LG DRILLED SHAFTS = 312 EA

* SUPERSTRUCTURE QUANTITIES ARE SHOWN ON EC-CCS-0003-01 SK-001.

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
	DDMMMYY				

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV

REFERENCE DWG NUMBER	REFERENCE DRAWINGS

FLUOR®

CONTRACT MINN

CONTRACT	MINN
DESIGNED BY	C. KRISTEK
CHECKED BY	N. SWAMY
SUPERVISOR	N. SWAMY — APP DATE
LEAD ENGR/SPEC.	APP DATE
FLUOR	APP DATE
CLIENT	APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA
CARBON CAPTURE AND SEQUESTRATION

C-101 DCC AND C-201 ABSORBER
TABLETOP FOUNDATION
PLAN AND ELEVATION

SCALE	DRAWING NUMBER	REV
	EC-CCS-0003-01 SK-004	A

CAD FILE NAME Drawing1.dwg

PLOT DATE: C:\Users\kri87866\Documents\Drawing1.dwg 10-30-20 8:49 am Printed By: kri87866

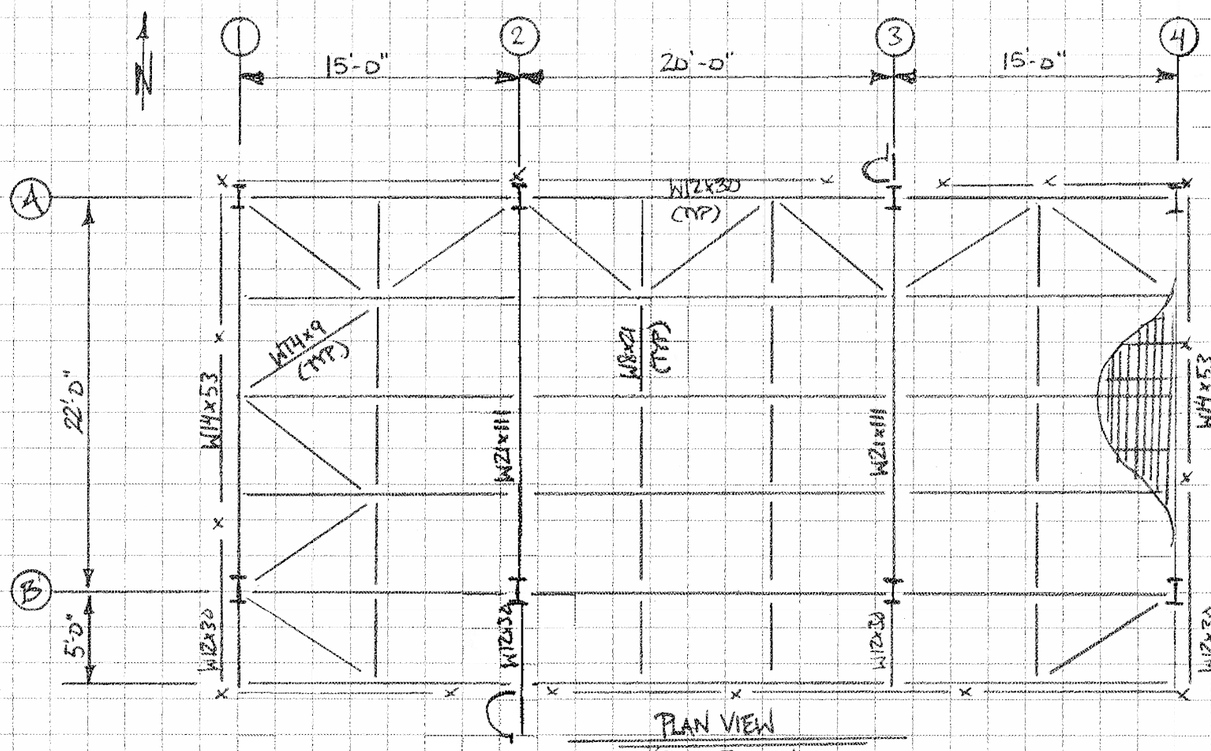
FLUOR®

CALCULATIONS AND SKETCHES

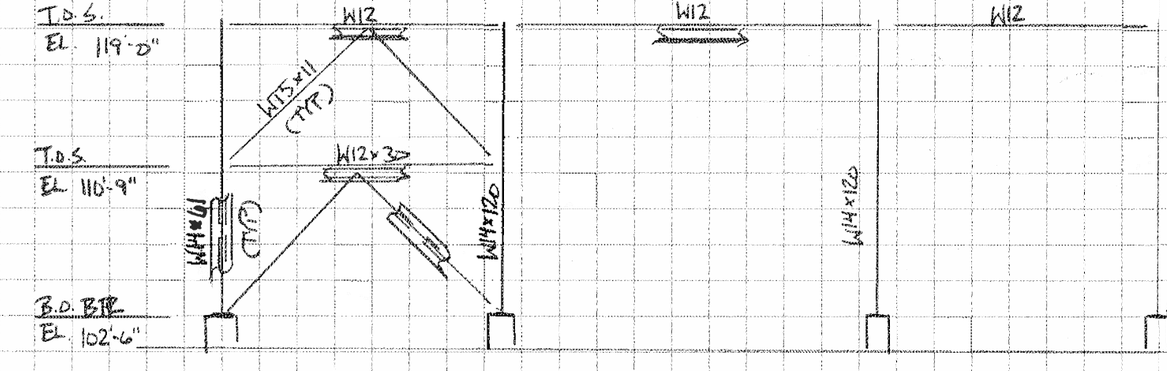
FORM E52 (Rev. 2-05)

BOILER ENCLOSURE - DEAERATOR STRUCTURE

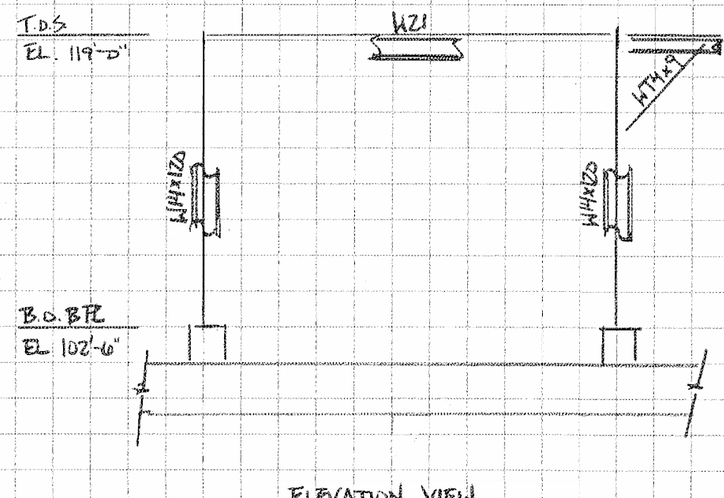
DATE 11-NOV-2020
CONT. NO. MINN
BY CTL CHK'D
SHEET NO.
FL-CCS-215-0003-33



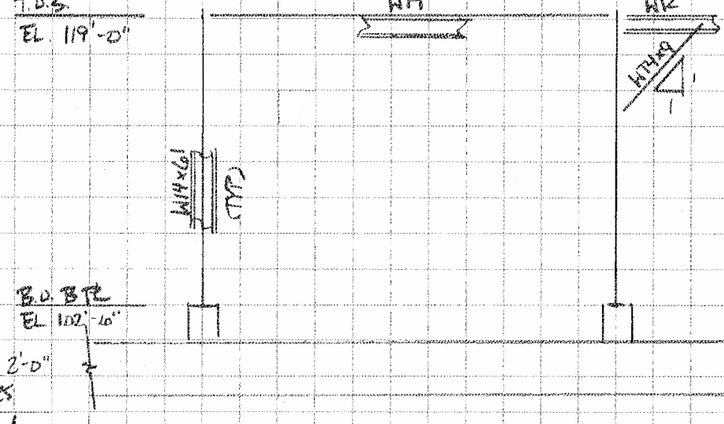
PLAN VIEW
(T.O.S EL. 119'-0")



ELEVATION VIEW
COL. LINE A & B



ELEVATION VIEW
COL. LINES 2 & 3
(LOOKING EAST)



ELEVATION VIEW
COL. LINES 1 & 4
(LOOKING EAST)

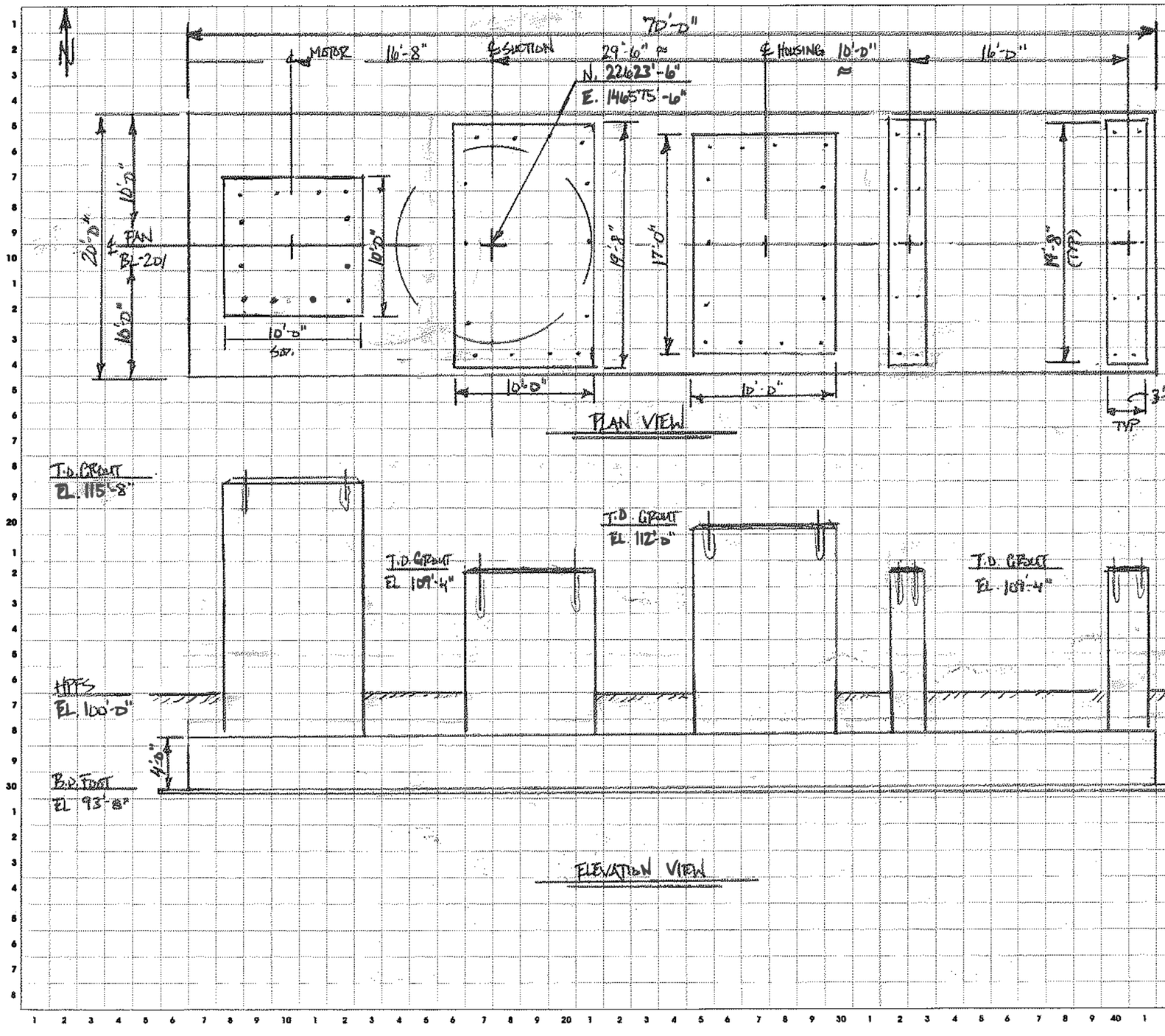
FLUOR

CALCULATIONS AND SKETCHES

FORM E52 (Rev. 2-05)

DATE 19-OCT-2020
CONT. NO. MINN
BY CTK CHK'D
SHEET NO. EC-CCS-0003-021 SK-001

BL-201 FOUNDATION



QUANTITIES

EXCAVATION = (74')(24')(7.17') /27
= 472 cy

TYPE 15 CONC = (70')(20')(4')/27
= 208 cy

TYPE 3 CONC = [(10')(10')(18.67') + (10')(19.67')(12.33')
+ (10')(17')(15')] /27
= 254 cy

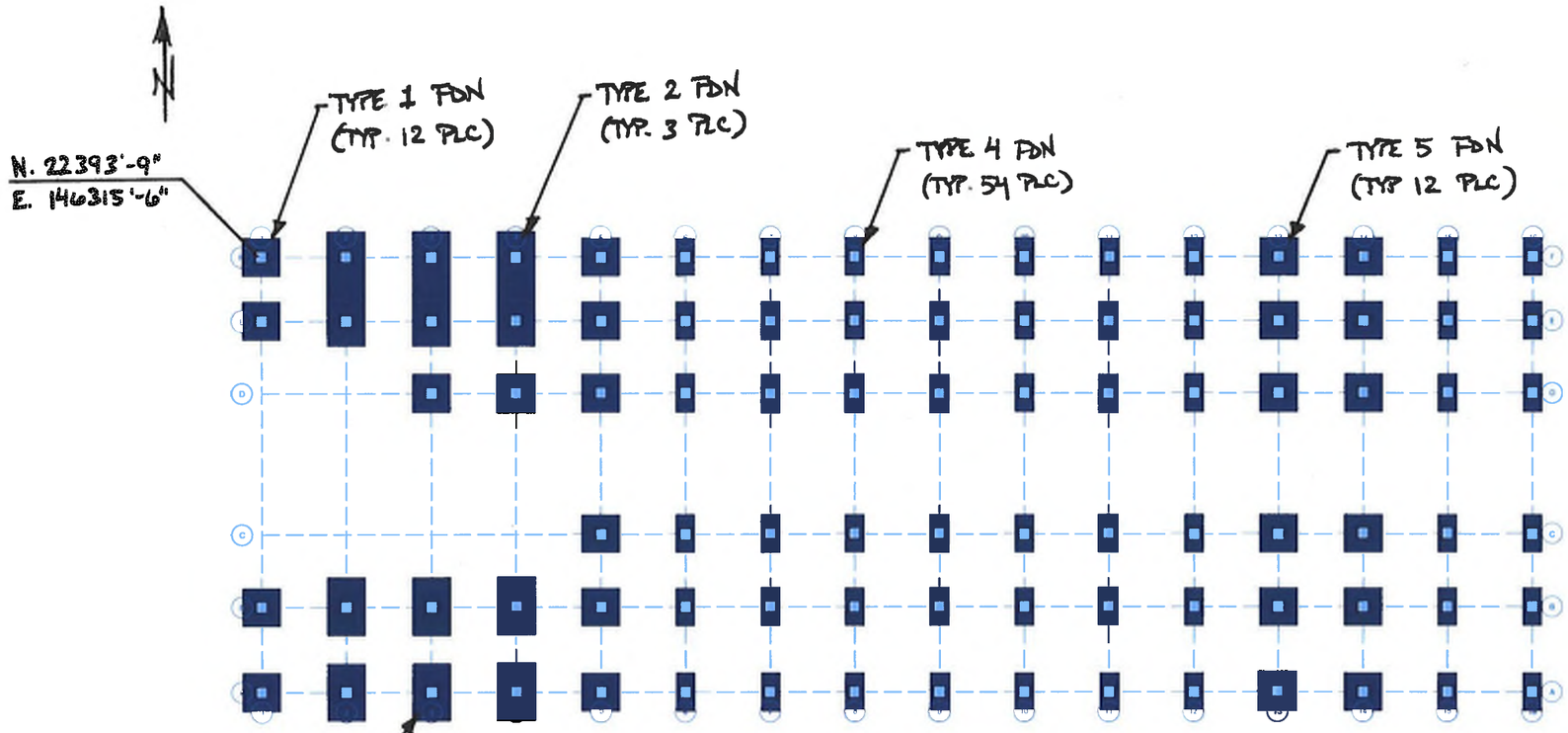
TYPE 4 CONC = [(2)(19.67')(3')(12.33')] /27
= 51 cy

LEAN CONC = (74')(24')(3/12') /27
= 11 cy

EPOXY GROUT = (2/12')[(10')(10') + (10')(19.67')
+ (17')(10') + (2)(19.67')(3')]
= 98 cf

BACKFILL = 472 cy − 11 cy (LEAN CONC) − 208 cy (MAT)
− (3')[(10')(10') + (10')(19.67') + (10')(17')
+ (2)(19.67')(3')] /27
= 188 cy × 1.10 CONT
= 207 cy

1 1/2 ϕ ANCHOR BOLTS W/ SLEEVE = 60 EA



PROCESS ENCLOSURE
NORTH PIPERACK & EQUIP STRUCTURE
FOUNDATION LOCATION PLAN

Results for LC 80, 1.4(Da + Do)

Minnkota Power Cooperative	EC-CCS-215-0002-01	SK - 1
CTK		Oct 29, 2020 at 12:48 PM
M1NN		Process Enclosure Racks and Equipment Supp...

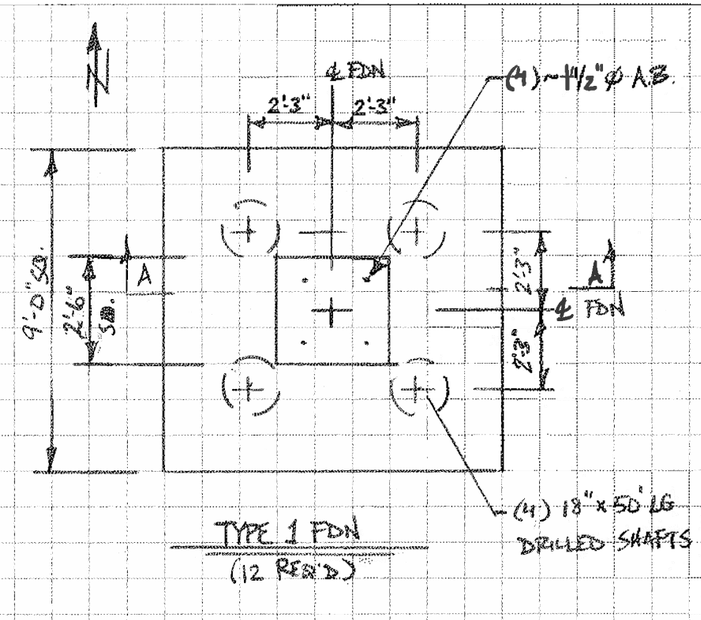
FLUOR®

FORM E52 (Rev. 2-05)

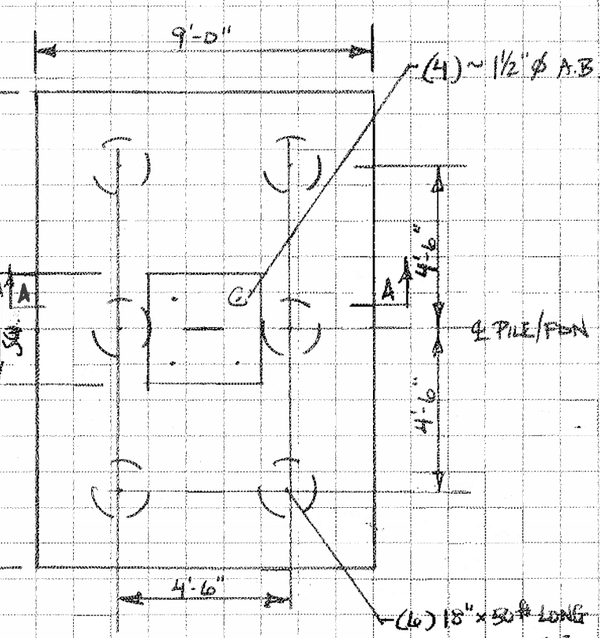
CALCULATIONS AND SKETCHES

DATE 29-OCT-2025
CONT. NO. MINN
BY GTZ CHK'D
SHEET NO. EC-CCS-215-0002-01

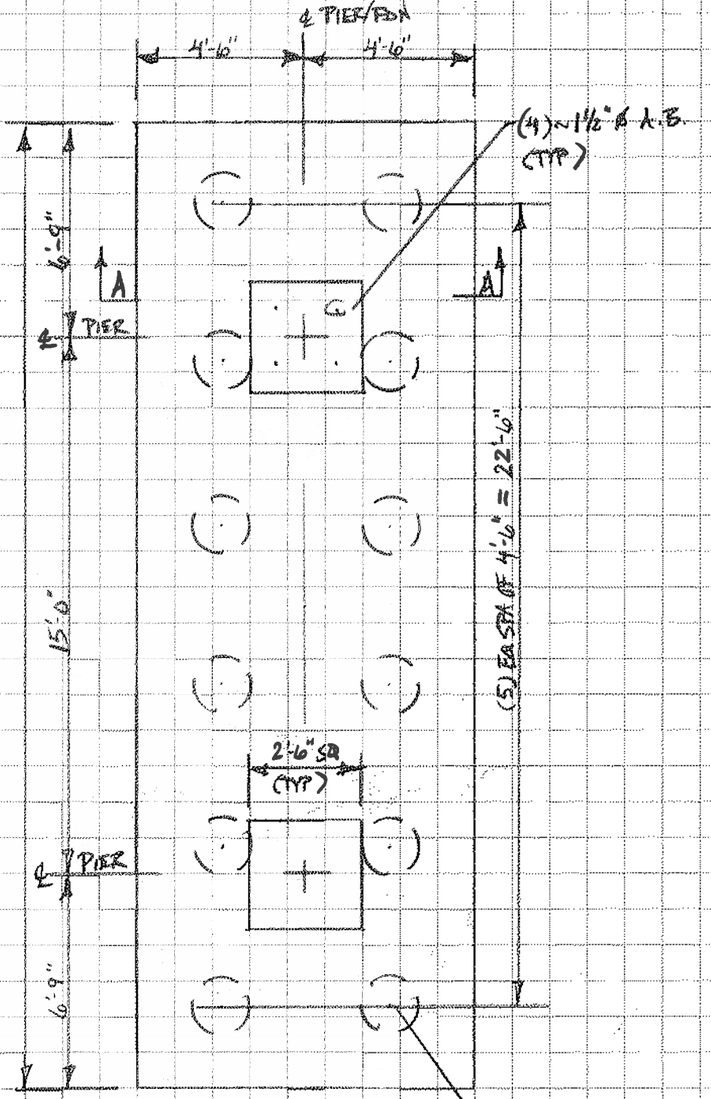
PROCESS ENCLOSURE - NORTH PIPERACK & EQUIP. STRUCTURE FDN DETAILS



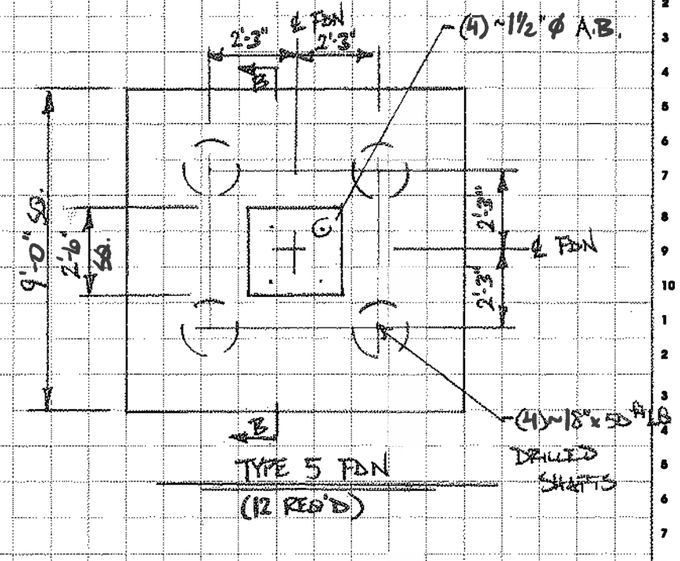
TYPE 1 FDN
(12 REQ'D)



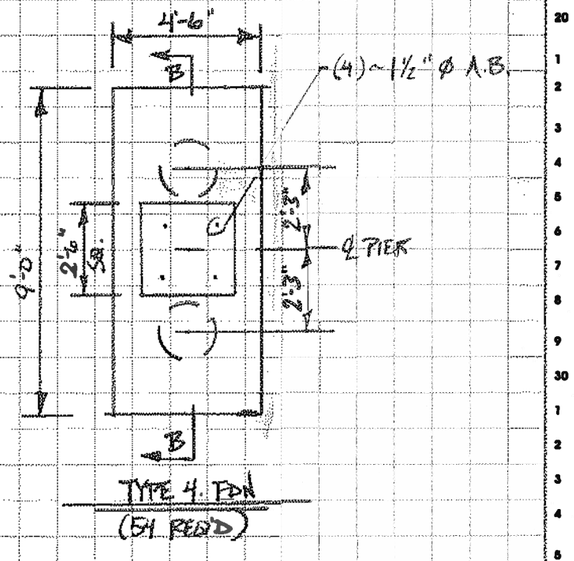
TYPE 3 FDN
(4 REQ'D)



TYPE 2 FDN
(3 REQ'D)



TYPE 5 FDN
(12 REQ'D)



TYPE 4 FDN
(5# REQ'D)

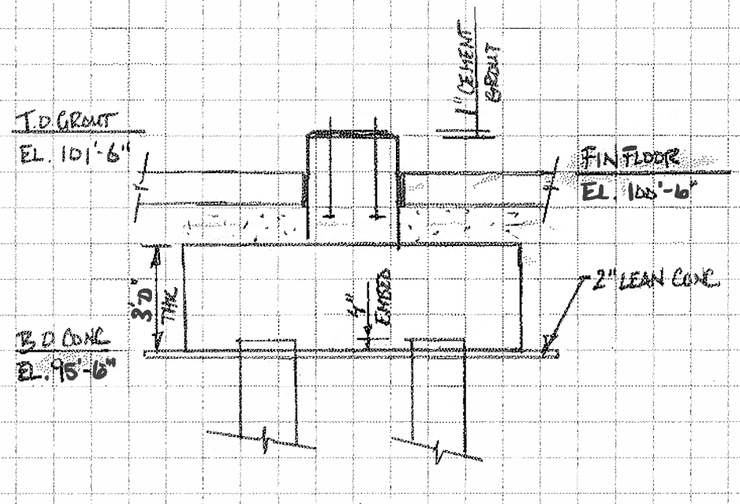
FLUOR®

CALCULATIONS AND SKETCHES

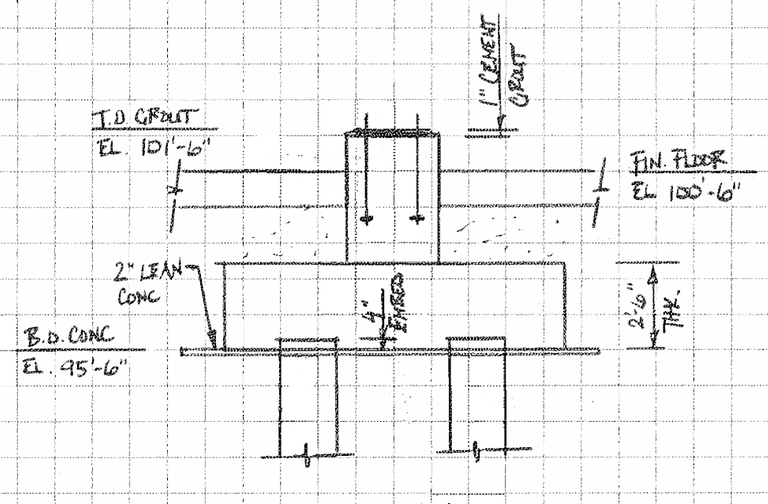
FORM E52 (Rev. 2-05)

PROCESS ENCLOSURE – NORTH PIPERACK & EQUIP. STRUCTURE FDN DETAILS

DATE 29-OCT-2020
CONT. NO. MINN
BY GK CHK'D
SHEET NO. EC-CCS-0002-01



SECTION A-A



SECTION B-B

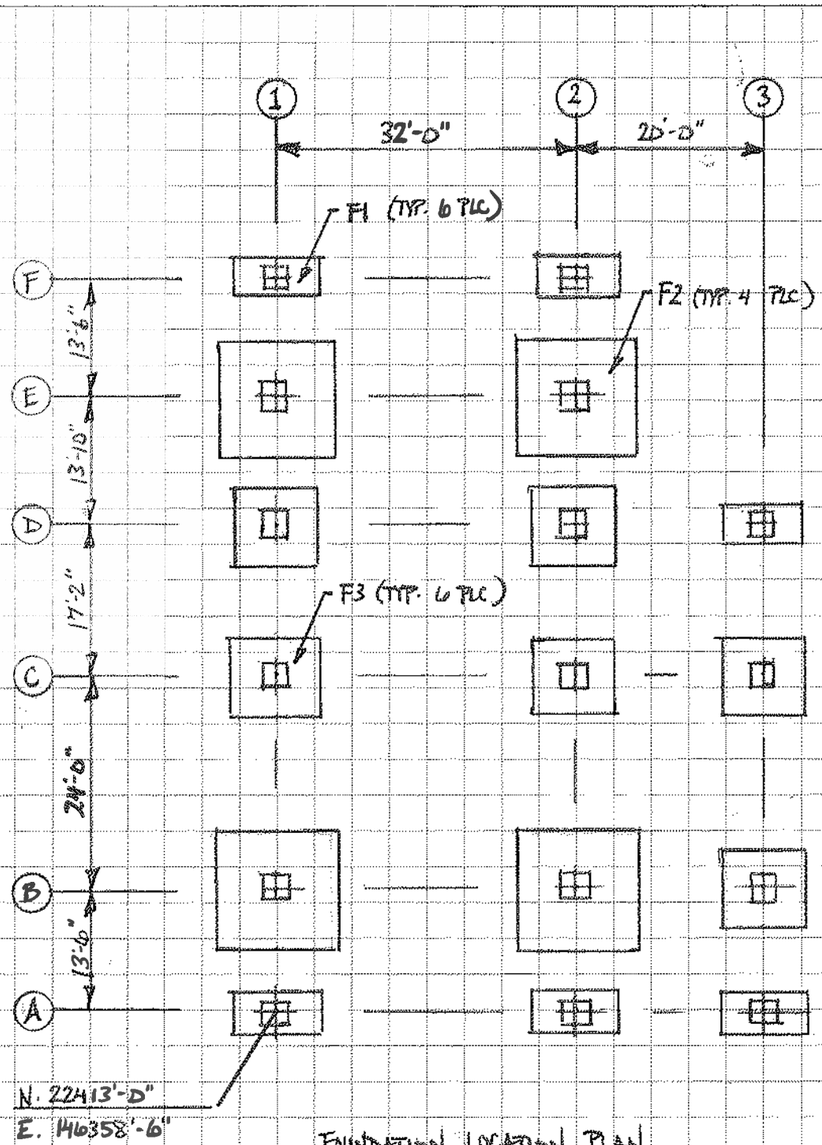
FLUOR®

FORM E52 (Rev. 2-05)

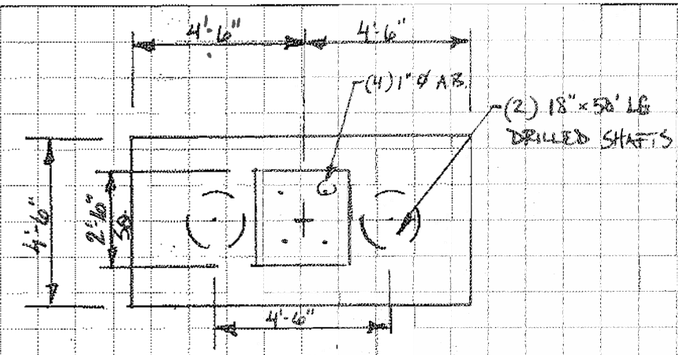
CALCULATIONS AND SKETCHES

V-301 EQUIP. STRUCTURE FOUNDATIONS

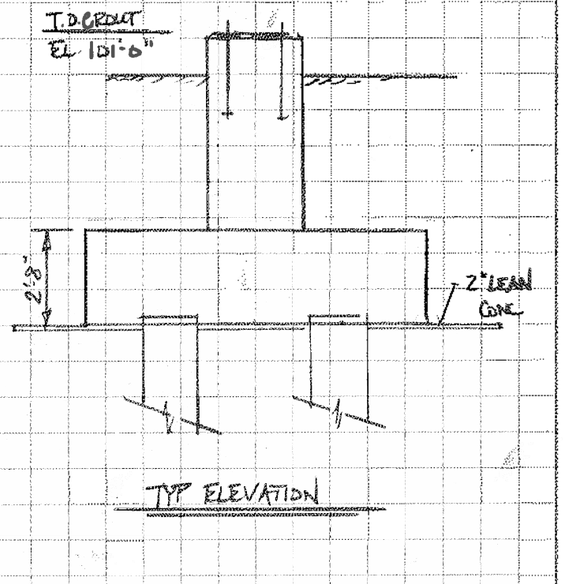
DATE 20-OCT-2022
CONT. NO. MINN
BY CTZ CHK'D
SHEET NO. EC-CCS-0003-20



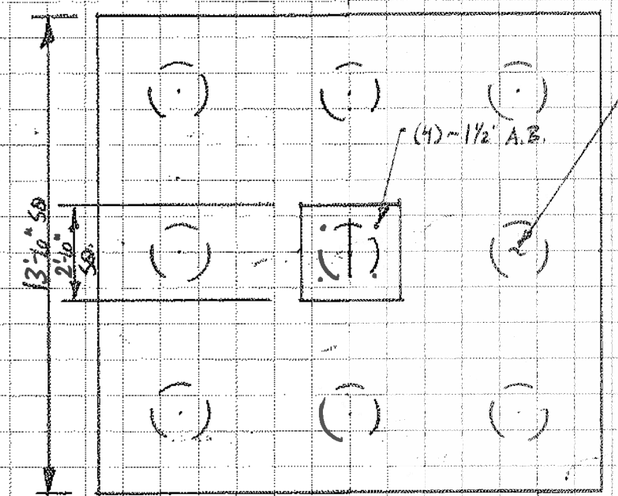
FOUNDATION LOCATION PLAN
(72 DRILLED SHAFTS)



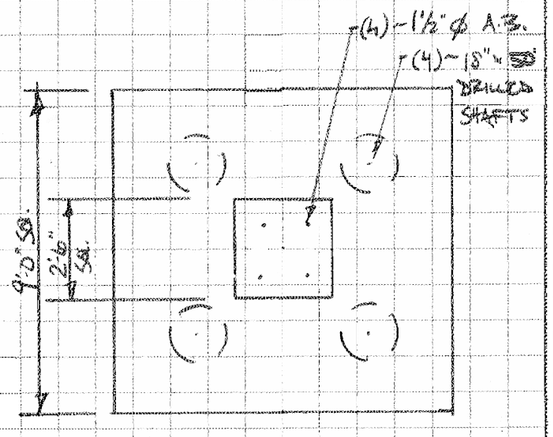
F1 FOUNDATION
(9'-0" x 4'-6")



TYP ELEVATION



F2 FOUNDATION
(13'-6" SQ.)



F3 FOUNDATION
(9'-0" SQ.)

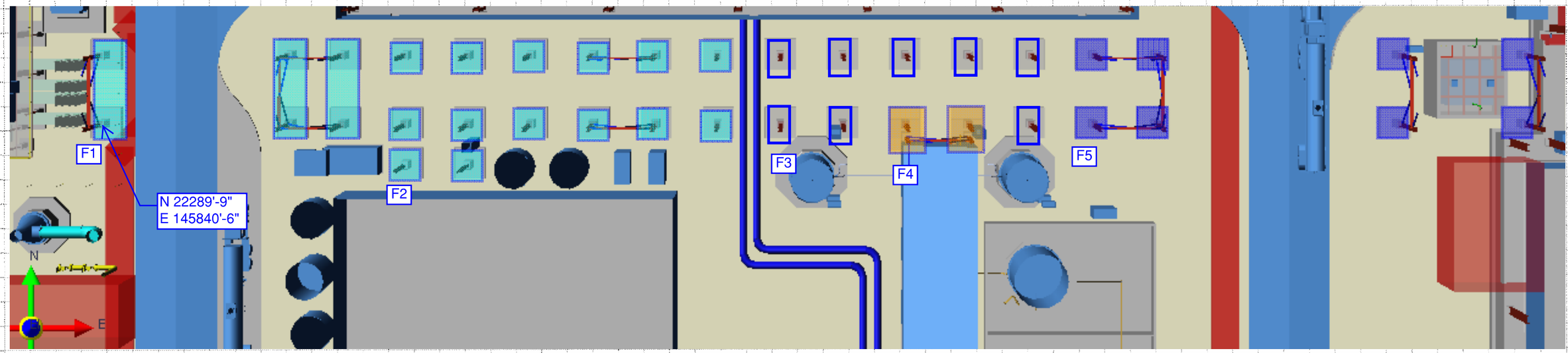
FLUOR®

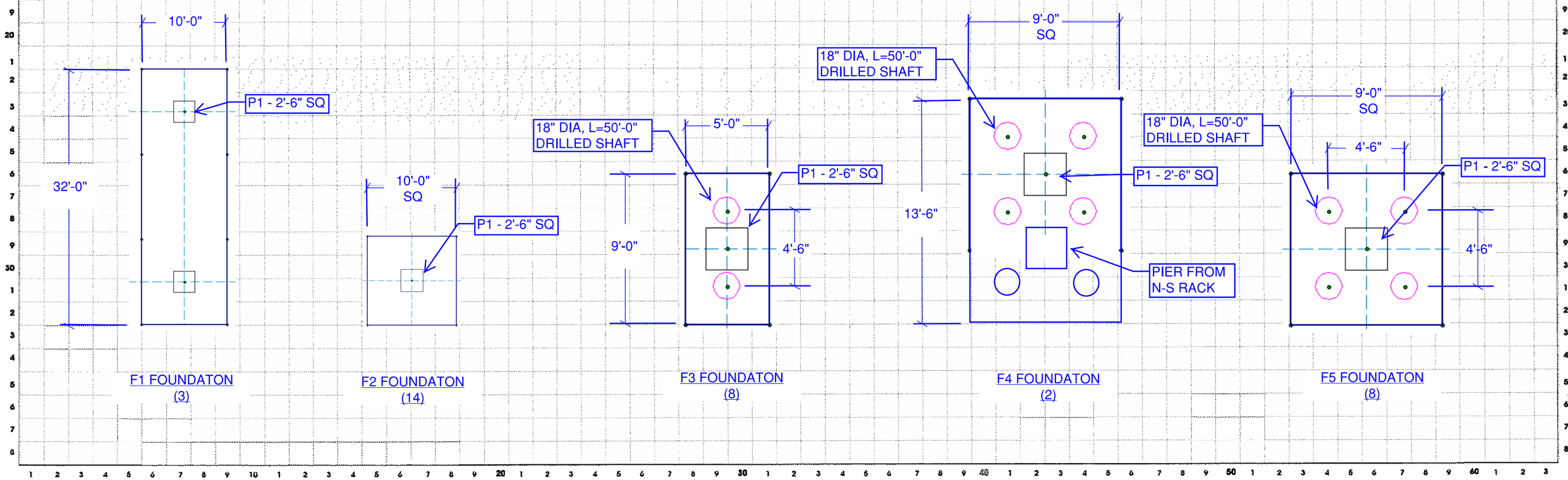
FORM E52 (Rev. 2-05)

CALCULATIONS AND SKETCHES

DATE 2020-10-27
CONT. NO. PIPERACK 0001-01
BY JG CHK'D
SHEET NO. 1 OF 2

E-W PIPERACK
FDN SKETCH





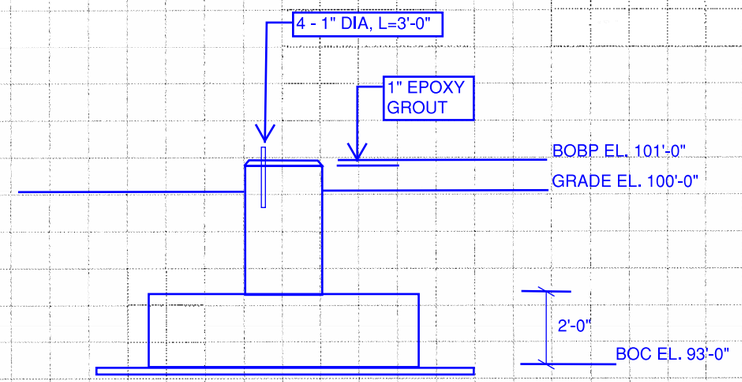
FLUOR®

FORM E52 (Rev. 2-05)

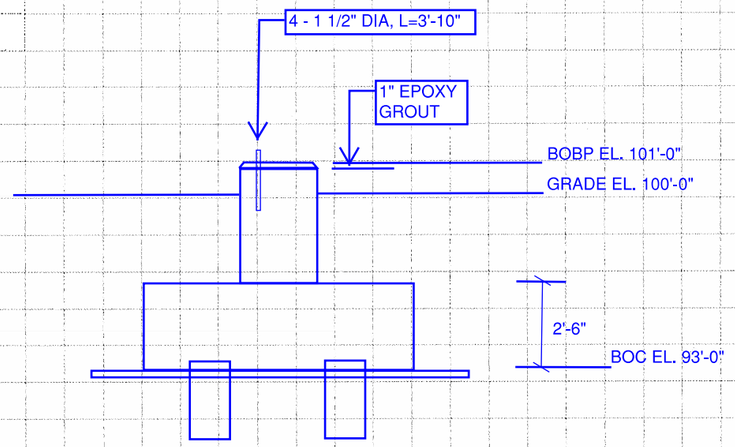
CALCULATIONS AND SKETCHES

DATE 2020-10-27
CONT. NO. PIPERACK 0001-01
BY JG CHK'D
SHEET NO. 2 OF 2

E-W PIPERACK FDN SKETCH



TYP ELEVATION FOR F1 and F2 FDN



TYP ELEVATION FOR F3, F4 and F5 FDN

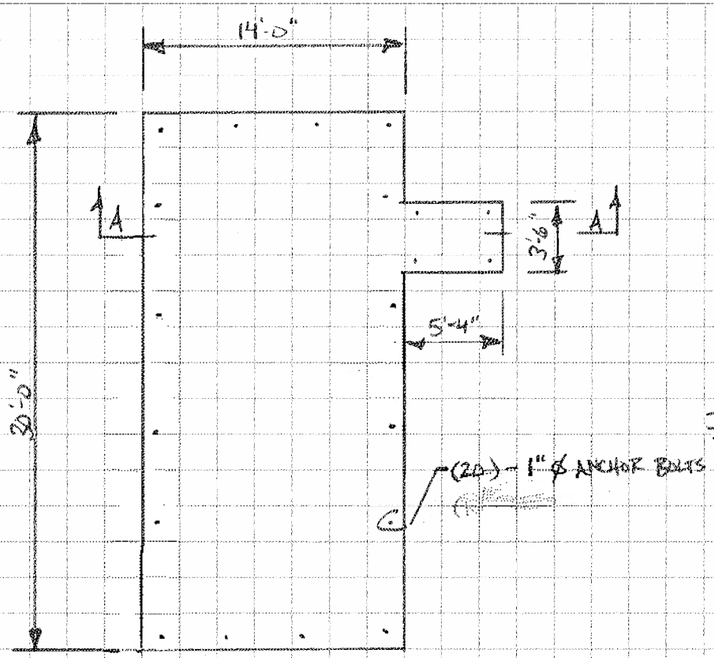
FLUOR®

FORM E52 (Rev. 2-05)

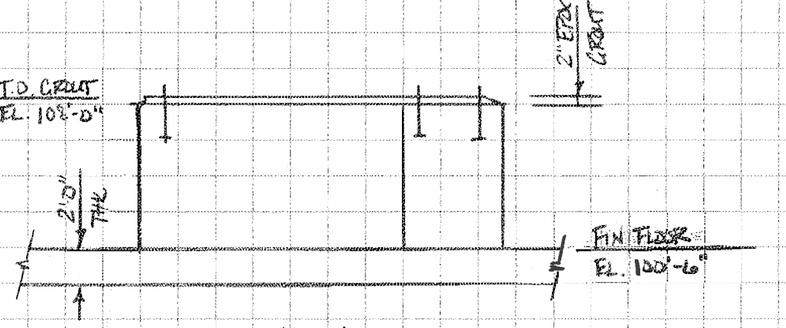
CALCULATIONS AND SKETCHES

DATE 05-NOV-2022
CONT. NO. M1NN
BY BRL CHK'D
SHEET NO. EC-CCS-215-00003

FOUNDATION SKETCH AND MTO



PLAN VIEW



SECTION A-A

MTO QUANTITIES

TYPE ID CONC = (7.5')[(30')(14') + (5.33')(3.5')]/27
= 122 CY

EPOXY GROUT = (2/12')[(30')(14') + (5.33')(3.5')]
+ (0.62)(2')(28')(12.5')
= 493 CF

1" ø ANCHOR BOLTS = 20 EA

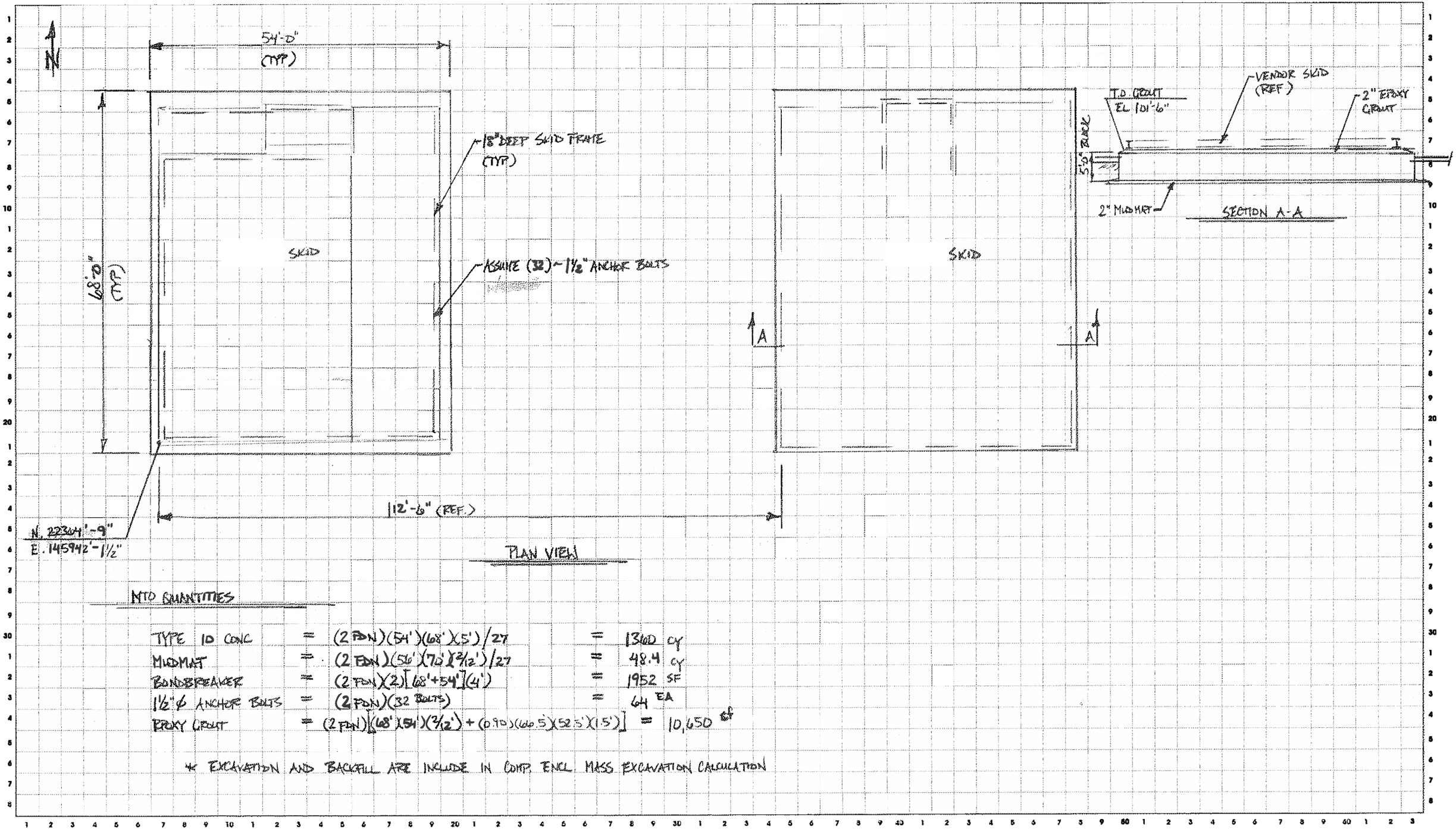
FLUOR®

FORM E52 (Rev. 2-05)

CALCULATIONS AND SKETCHES

DATE 09-NOV-2020
CONT. NO. MJWN
BY GTL CHK'D
SHEET NO. EC-ECS-215-0003-03

FOUNDATION SKETCH AND MTO



MTO QUANTITIES

TYPE 1D CONC	= (2 PDN)(54')(68')(5')/27	=	1360 CY
MUDMAT	= (2 PDN)(56')(76')(3/12')/27	=	48.4 CY
BONDBREAKER	= (2 PDN)(2)[68'+54'](4')	=	1952 SF
1½"ϕ ANCHOR BOLTS	= (2 PDN)(32 BOLTS)	=	64 EA
EPOXY GROUT	= (2 PDN)[(68')(54')(3/12') + (0.90)(66.5)(52.5')(1.5')]	=	10,650 CF

* EXCAVATION AND BACKFILL ARE INCLUDE IN COMP ENCL. MASS EXCAVATION CALCULATION

FLUOR.

CALCULATIONS and SKETCHES

DATE 11-NOV-2020
CONT. NO. M1NN
BY GK CHK'D
SHEET NO.
EC-CCS-215-0001-07

BOILER ENCLOSURE PIPERACK

MTO CALCULATION

MTO QUANTITIES

LIGHT STEEL = (4 BRACE)(15 plf)(149')
= 0.5 TONS

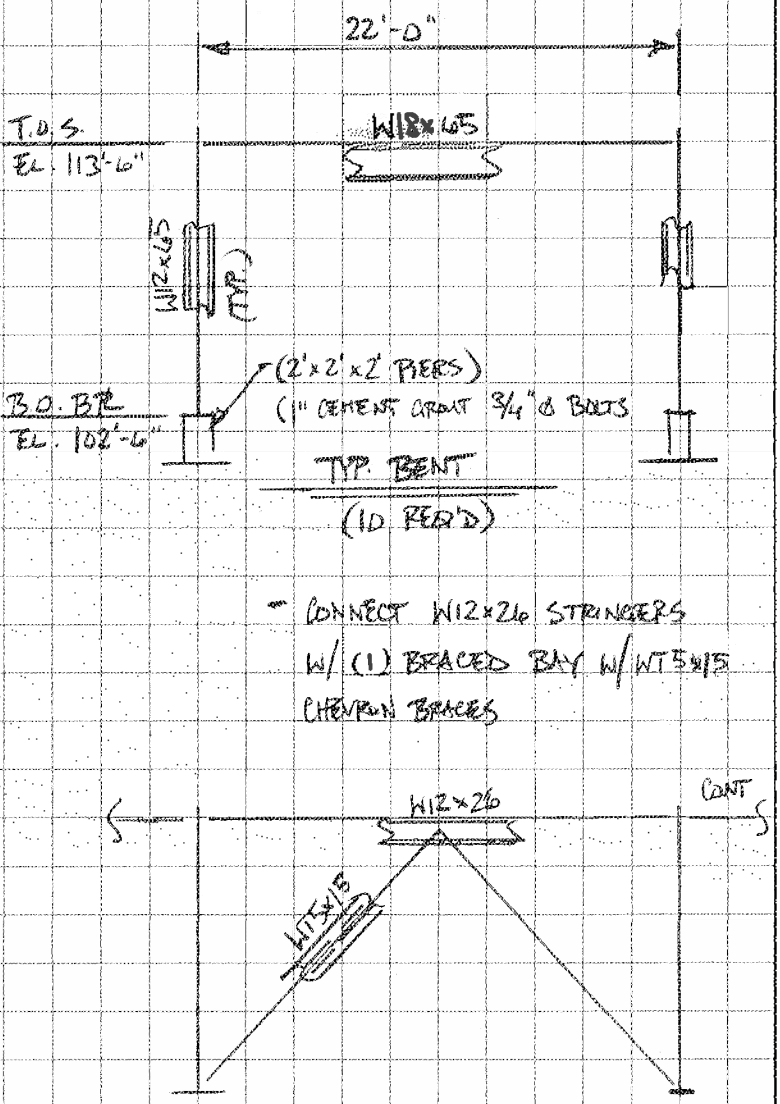
MEDIUM STEEL = (18 BEAMS)(20')(26 plf)
= 4.7 TONS

HEAVY STEEL = (10)(65 plf)(22')
+ (2)(10)(65 plf)(11')
= 14.3 TONS

TYPE 2T CONC = (20 PIER)(2')³/27
= 6.0 cy

3/4" ø ANCHORS = 80 EA

CEMENT GROUT = (2')²(1/12')(20 PIER)
= 6.7 cf



FORM E50 (Rev. 08-03)

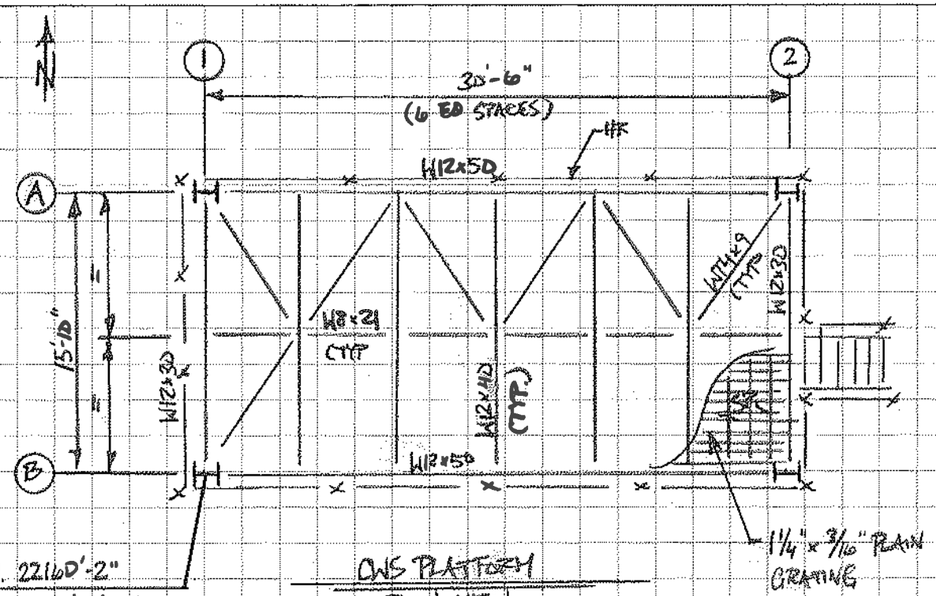
FLUOR

FORM E52 (Rev. 2-05)

CALCULATIONS AND SKETCHES

DATE Oct NOV-2020
CONT. NO. M1NN
BY CTE CHK'D
SHEET NO. EC-CCS-215-00007-11

CWS STRAINER PLATFORM STEEL & CONCRETE

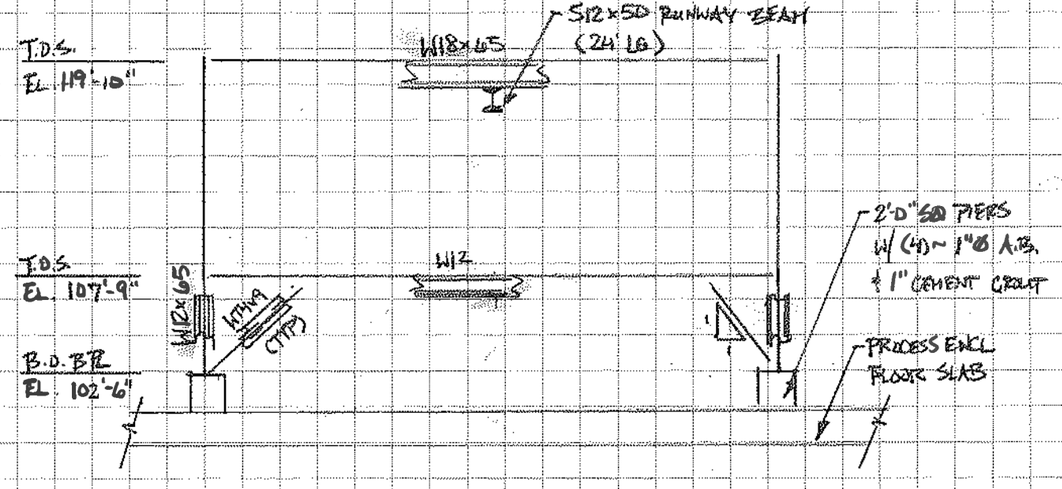


N. 221607'-2"
E. 141305'-0"

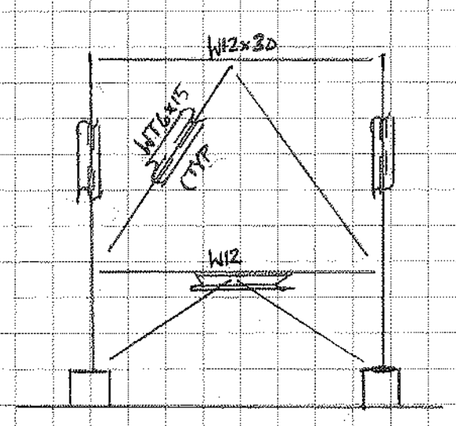
CWS PLATFORM
PLAN VIEW
(T.O.S. EL. 107'-9")

MTD QUANTITIES

TYPE 2Y CONC	= (4)(2')²(2')/27	=	1.2 CY
CEMENT GROUT	= (4)(2')(½')/12'	=	1.3 CF
1" ø ANCHORS	= (4)(4 BOLTS)	=	16 EA
EX LIGHT STEEL	= (7 BRACES)(9.41 ft)(9 plf) + (2 BRACE)(7.42 ft)(9 plf)	=	0.4 TONS
LIGHT STEEL	= (2)(15 plf)[14.44 ft + 9.99 ft]	=	0.4 TONS
MEDIUM STEEL	= (6)(5.08')(21 plf) + [(2)(30 plf) + (5)(40 plf)](15.83')	=	2.4 TONS
HEAVY STEEL	= (4)(17.33')(65 plf) + (2)(30.5')(50 plf) + (2)(30.5')(65 plf) + (24')(50 plf)	=	6.4 TONS
HANDRAIL	= (15 plf)[(2)(30.5') + (2)(15.83') - 3']	=	0.7 TONS
GRATING	= (9.20 psf)(30.5')(15.83')	=	2.2 TONS
STAIRS	= (135 lb/ft)(7.25')	=	0.5 TONS



COLUMN LINES A & B
(LOOKING NORTH)



COLUMN LINES 1 & 2

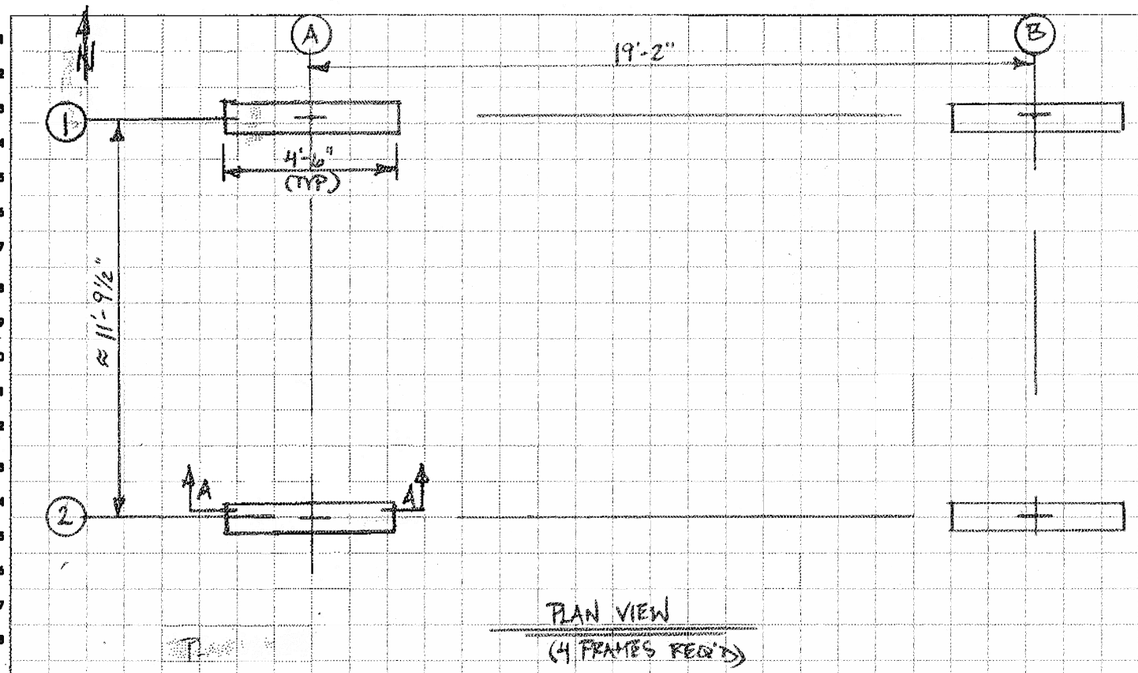
FLUOR®

CALCULATIONS AND SKETCHES

FORM E52 (Rev. 2-05)

E-305 A/B SUPPORT STEEL & PIERS — MTO SKETCH & CALCULATION

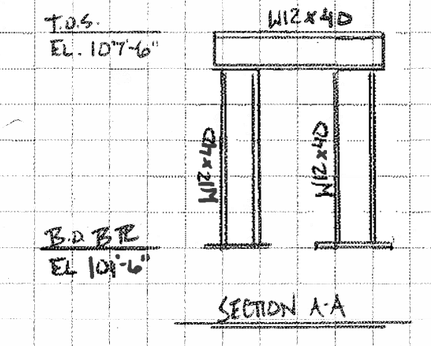
DATE 05-NOV-2020
CONT. NO. M1NN
BY GTK CHK'D
SHEET NO. EC-CCS-215-0003-25



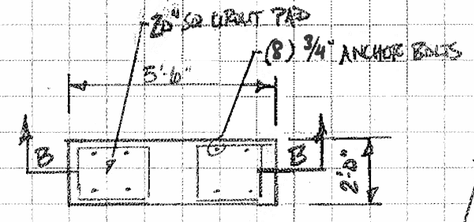
PLAN VIEW
(4 FRAMES REQ'D)

MTO QUANTITIES

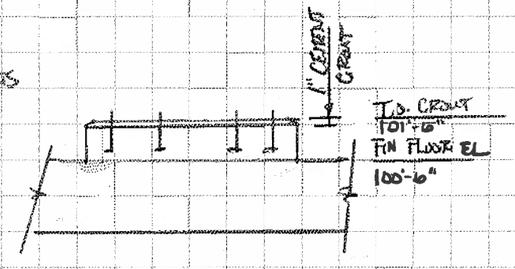
TYPE 27 CONC	= (4 PDN)(2')(5.5')(1')/27 =	1.6 CY
CEMENT GROUT	= (4)(2)(20/12)²(1/12') =	1.9 CF
¾" ⌀ ANCHORS	= (4)(8 BOLTS) =	32 EA
MEDIUM STEEL	= (4 FRAMES)(14.5')(40 PIF) =	1.2 TONS



SECTION A-A



PDN PLN
(4 REQ'D)



SECTION B-B

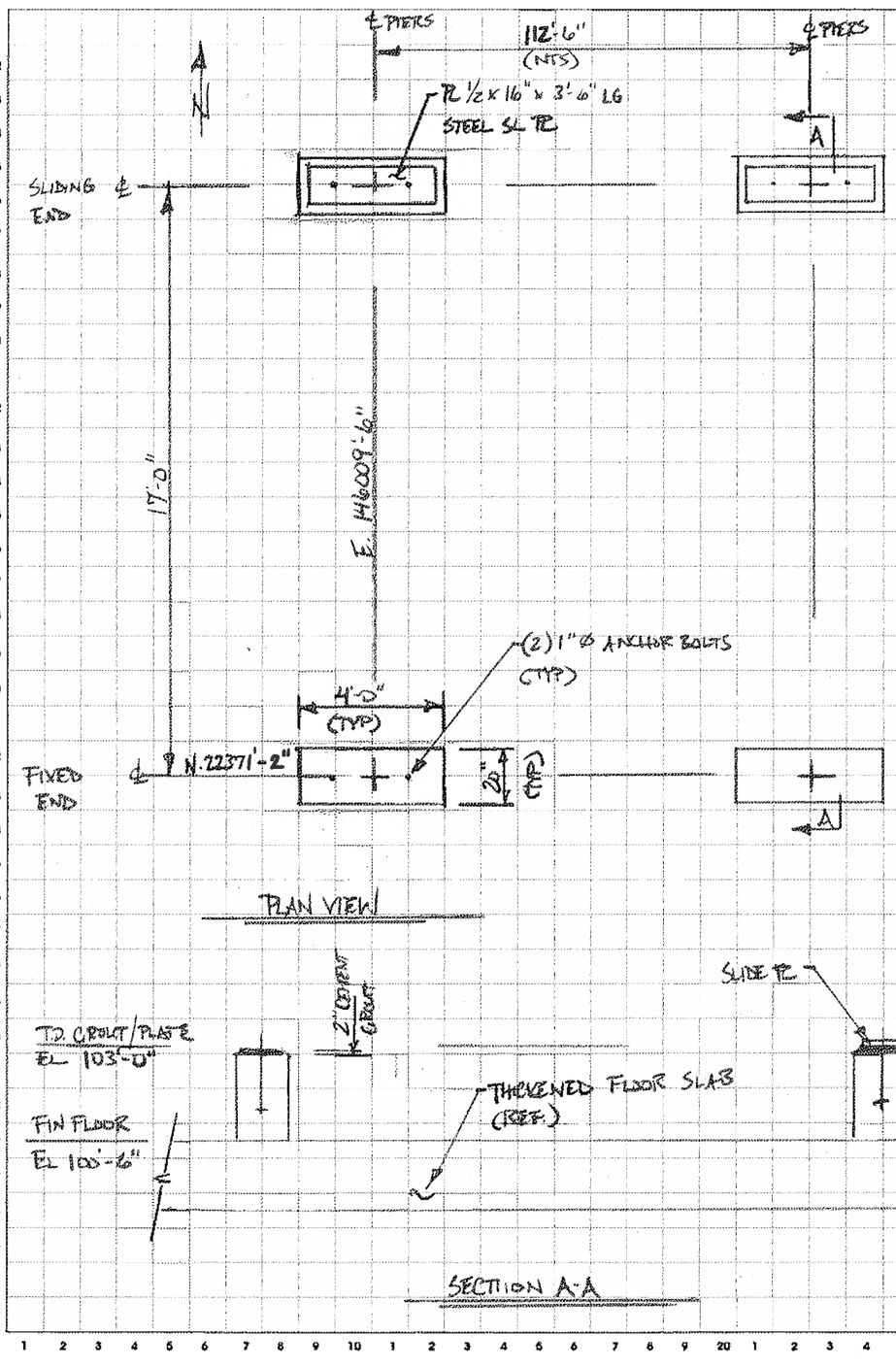
FLUOR

CALCULATIONS AND SKETCHES

DATE 9-NOV-2020
CONT. NO. M1NN
BY CJL CHK'D
SHEET NO. EC-CCS-215-00003-29

FORM E52 (Rev. 2-05)

E-601 A/B CO2 AFTERCOOLERS FOUNDATIONS SKETCH & MTO



MTO QUANTITIES

TYPE G3 CONC = (4 PIERS)(4')(23/12')(2.5')/27 = 2.5 CY

CEMENTITIOUS GROUT = (2 PIERS)(4')(28/12')[(2/12') + (1.5/12')] = 3.9 CF

1" Ø ANCHOR BOLTS = (4 PIERS)(2 BOLTS) = 8 EA

SLIDE PLATE (STEEL) ½" GR. A572 50 = (2 PL)(16/12')(3.5') = 9.3 FT^2

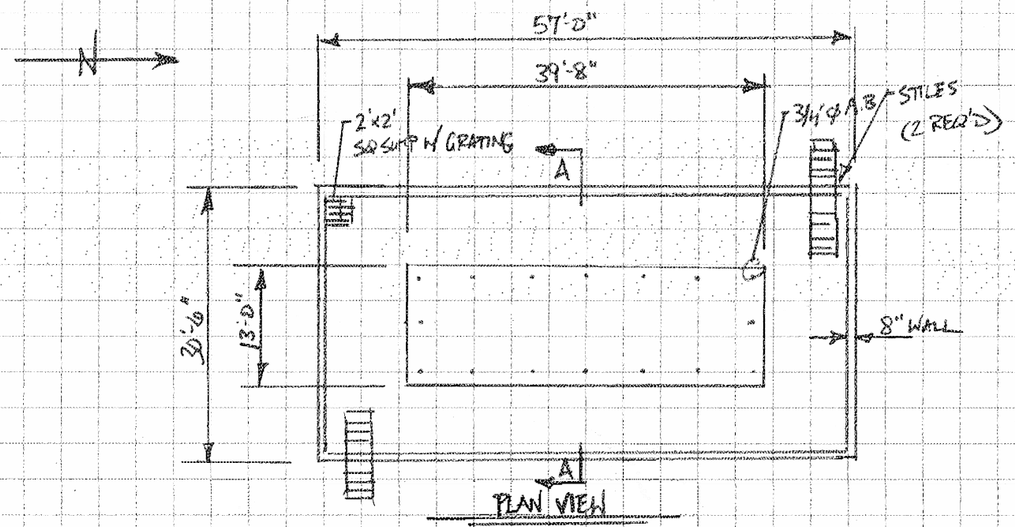
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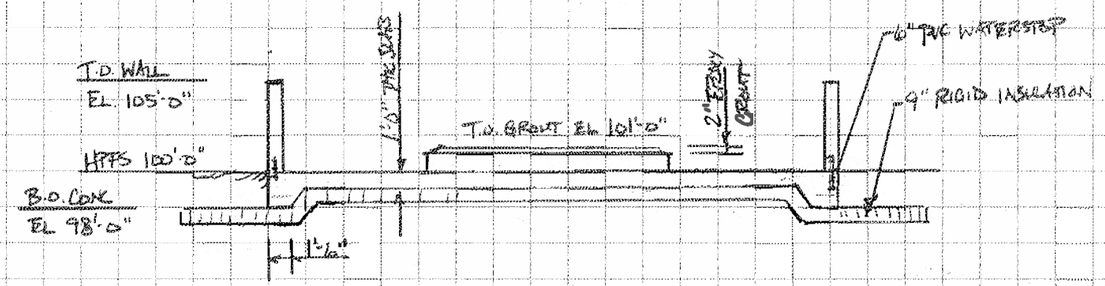
FORM E52 (Rev. 2-05)

CALCULATIONS AND SKETCHES

BOILER AREA NH3 STORAGE TANK

DATE 11-NOV-2020
CONT. NO. MANN
BY CMC CHK'D
SHEET NO. EE-CCS-215-0003-34





MATERIAL QUANTITIES

TYPE 22 CONC = $\left[(30.5')(57')(1.8') + (2\pi^2)\left[(57')(2)+(2)(28.5')\right]\right]/27$ = 77 cy

TYPE 31 CONC = $(5)(0.67')(2)\left[57'+29.16'\right]/27$ = 21.4 cy

EPOXY GROUT = $(39.67')(13')(2/12')$ = 86 cf

3/4" ϕ ANCHORS = = 16 EA

TYPE H CONC = $(39.67')(13')(1')/27$ = 19.1 cy

EXCAVATION = $(66')(39.5')(3.25')/27$ = 313.8 cy

9" RIGID INS. = $(66')(39.5')(1.05)$ = 2737 SF

BACKFILL = 313.8 cy − $(0.75')(2737\ SF)/27$ − 77 cy = 161 cy
× 1.10 COMP
TOTAL = 177 cy

WATERSTOP = $(2)(57'+30.5')+4(5')$ = 195 LF

BONDBREAKER = $(2')(2)\left[57'+30.5'\right]$ = 350 SF

STEEL

1¼ × 3/16 SERRATED GRATING = $\left[(3')(3')+(2)(3')(5)\right](9.20\ psf)$ = 0.2 TONS

LIGHT STEEL = 0.3 TONS

STAIRS = $(135\ plf)(7')(2)$ = 1.0 TONS

HANDRAIL = $(2)(2)(5')(15\ plf)$ = 0.2 TONS

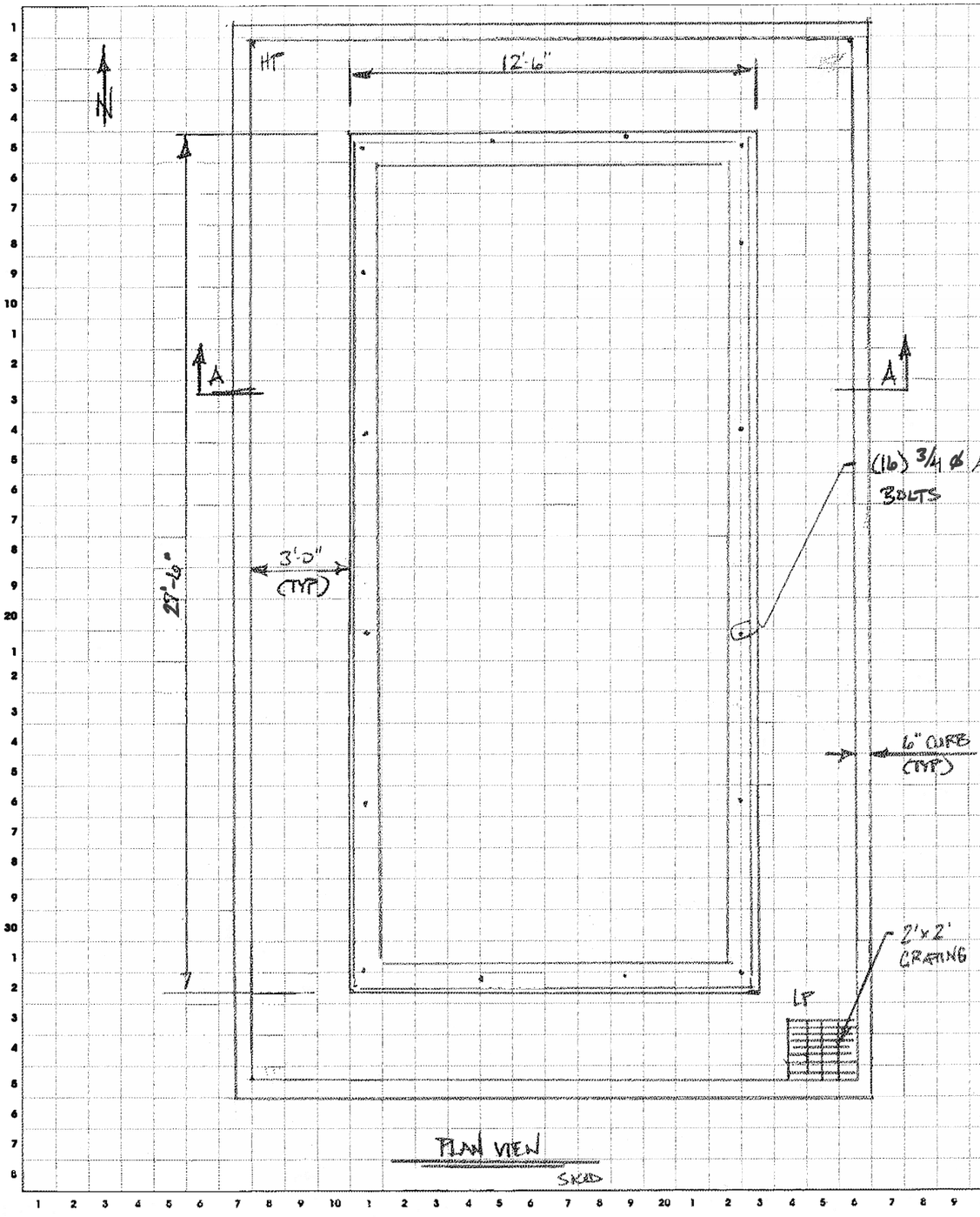
FLUOR®

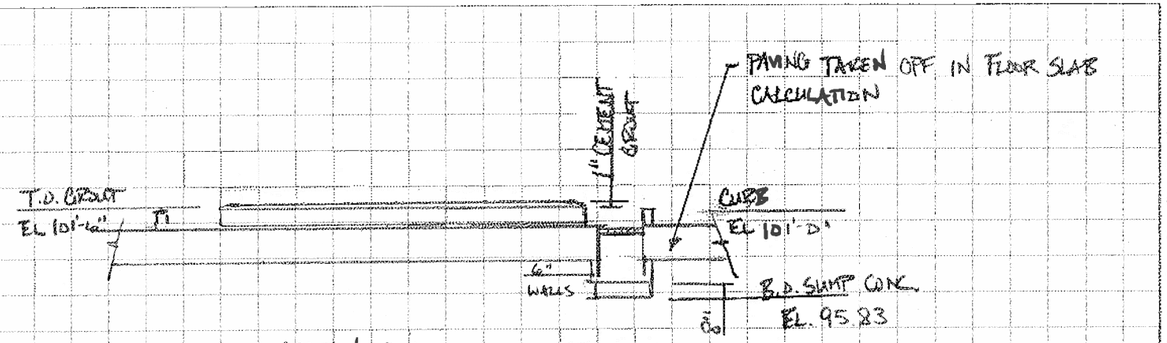
FORM E52 (Rev. 2-05)

CALCULATIONS AND SKETCHES

DATE 6-NOV-2020
CONT. NO. M1NN
BY CHL CHK'D
SHEET NO. TEC-CCS-215-00003-24

SKID & CONTAINMENT PAVING





MTD QUANTITIES

TYPE 27 CONC	= (12.5'X27'-6")(1') /27	=	12.7 cy
TYPE 22 CONC	= (0.5')[(34.5')(19.5') - (33.5'X18.5')]/27	=	4.0 cy
	+ [(3'X3'X0.67') + (2X0.5'X3'+2'X1.5')]/27	=	0.4 cy
		=	4.4 cy
CEMENT GRAUT	= (12.5')(27.5')(3/12')	=	58 cf
3/4" ϕ ANCHOR BOLTS		=	16 EA
1/4 x 3/16 PLAIN GRATING		=	0.1 TON

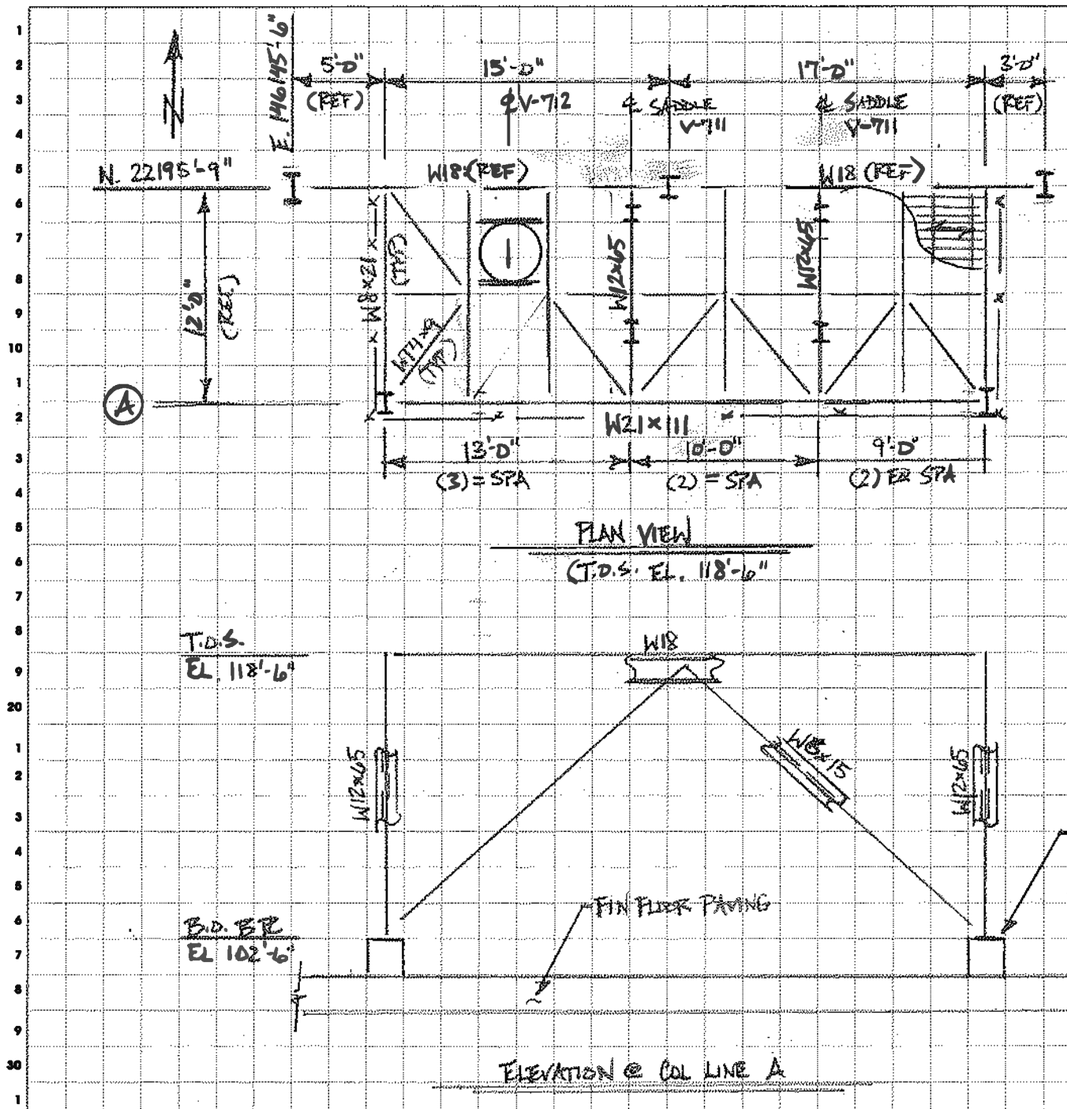
FLUOR

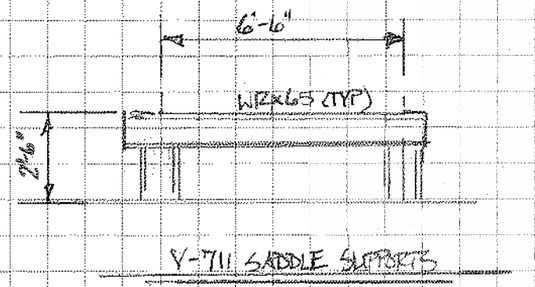
FORM E52 (Rev. 2-05)

CALCULATIONS AND SKETCHES

V-711 & V-712 STEEL SUPPORTS & PLATFORM

DATE 12-NOV-2020
CONT. NO. M1NN
BY CTR CHK'D
SHEET NO. EC-CCS-215-0003-31





MTO QUANTITIES

EX LIGHT STEEL	= (7)(7.8')(9 plf)	= 0.3	TONS
LIGHT STEEL	= (2)(22.5')(15 plf)	= 0.4	TONS
MEDIUM STEEL	= (6)(21 plf)(12') + (2)(4.33')(21 plf)	= 0.9	TONS
X-HEAVY STEEL	= (2)(65 plf)(12') + (2)(65 plf)(16')	= 1.8	TONS
	+ (2)(16.75')(65 plf)	= 0.7	TONS
		Σ = 2.5	TONS
XX HEAVY STEEL	= (111 plf)(32')	= 1.8	TONS
1¼" x 3/16" PLAIN GRATING	= (32')(12')(9.2 psf)	= 1.8	TONS
HANDRAIL	= [(2)(12') + 32'](15 plf)	= 0.4	TONS
LADDER	= (21 plf)(16')	= 0.2	TONS
SAFETY GATE	=	= 1	EA
TYPE 27 CONC	= (2)(2')³/27	= 0.6	cy
CEMENT GROUT	= (2)(2')²(1/12')	= 0.7	cf
1" ⌀ ANCHOR BOLTS	= (2)(4)	= 8	EA

EC-CCS-215-0003-02

ELECTRICAL ROOM
(20' X 30')

DRAINAGE TRENCH

AIR INTAKE DOOR

DOOR

PREHEAT COIL PULL

FILTER PULL

FD FAN

APCU Skid

FUEL GAS

STEAM DRUM TUBES

BURNERS

ECONOMIZER

AIG / SCR

2' THK PAD (TYP)

1' THK PAD (TYP)

8'

PK-702

CCS-RIO-751 CCS-AH-0003

VACUUM TRUCK

BLDG. SUMP

DEAERATOR / BFW PUMPS (BELOW)

chemical tote path

Chem Feed

PMS CHN

15'x7' SKID 1' THK PAD

11'x5' SKID 1' THK PAD

CHEMICAL UNLOADING

NH3 unloading

NH3 Storage Tank (37,800 gallons)

AHU

CCS-B0E-001

4' THK BLOCK

22'-2" (TYP.)

DUCT AND PIPE RACK

2'-0" THICK FLOOR SLAB

3'-0" THICK FLOOR SLAB

1'-0" THICK FLOOR SLAB

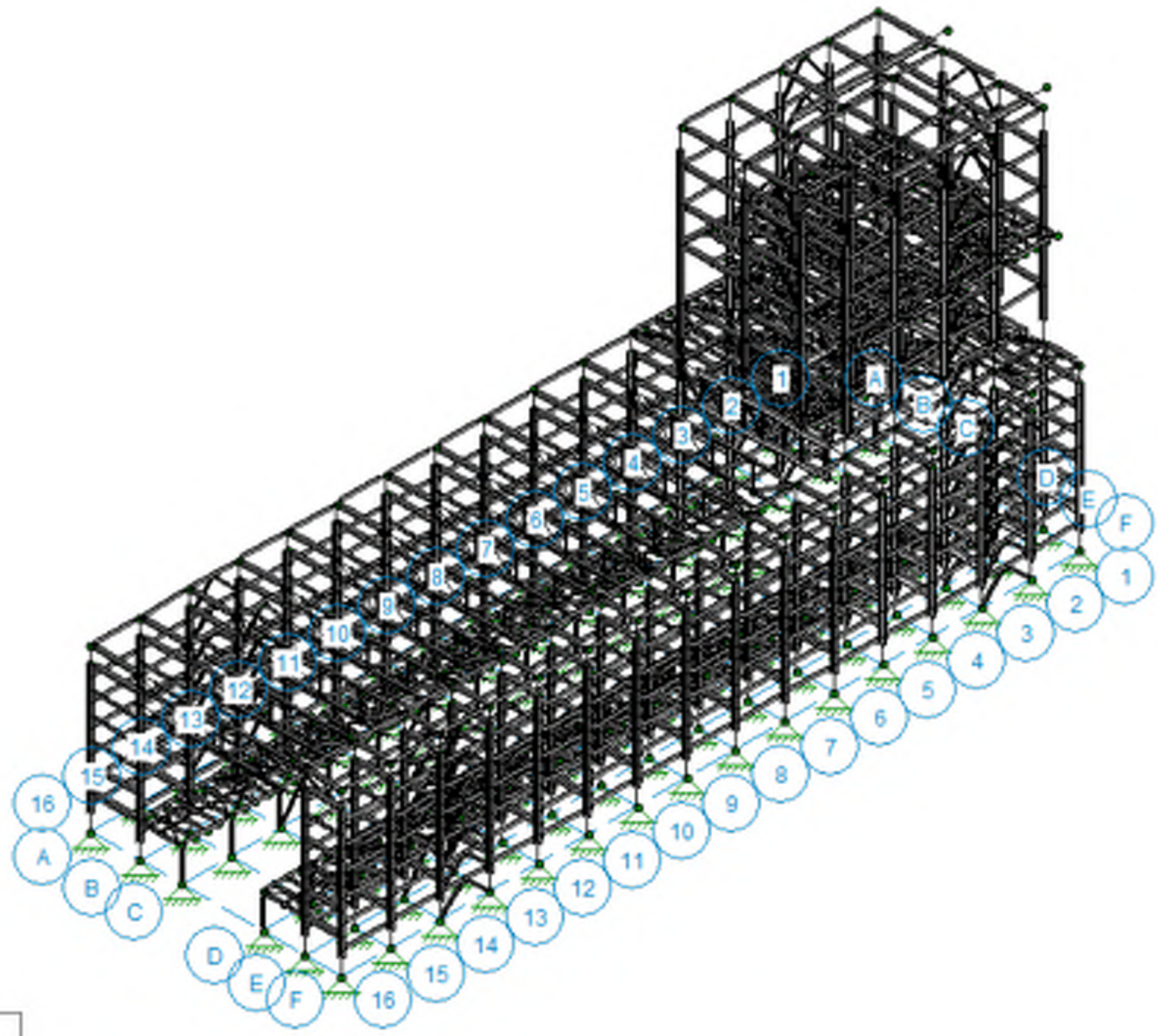
FLUOR®

CALCULATIONS AND SKETCHES

DATE	07-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0002-01 SK-001

FORM E52 (Rev. 2-05)

PROCESS ENCLOSURE EQUIPMENT STRUCTURE AND PIPERACK - ISOMETRIC



ISOMETRIC VIEW
LOOKING SOUTHWEST

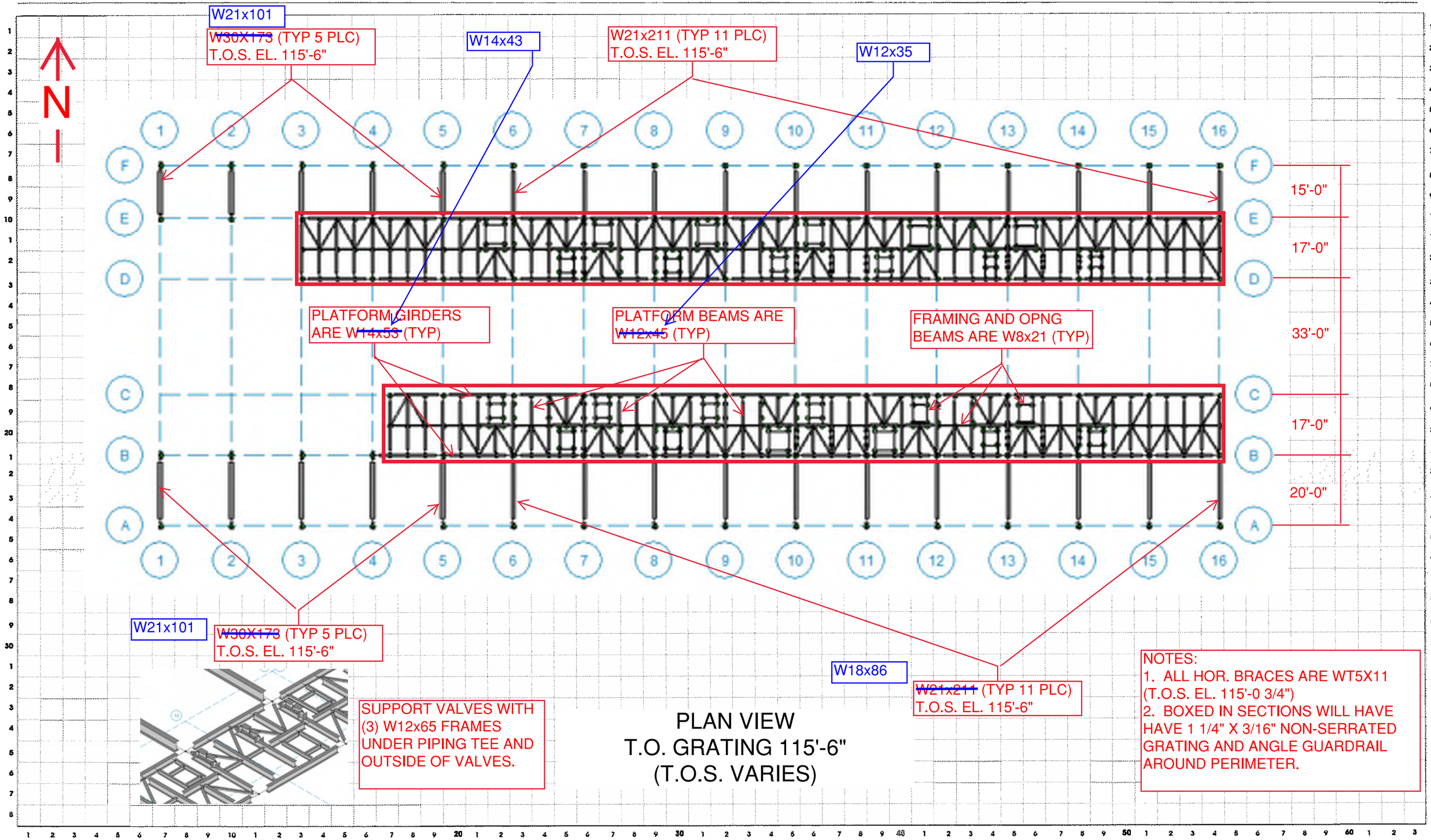
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CALCULATIONS AND SKETCHES

DATE	07-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0002-01 SK-002

FORM E52 (Rev. 2-05)

PROCESS ENCLOSURE EQUIPMENT STRUCTURE AND PIPERACK - PLAN VIEW



SUPPORT VALVES WITH (3) W12x65 FRAMES UNDER PIPING TEE AND OUTSIDE OF VALVES.

PLAN VIEW
T.O. GRATING 115'-6"
(T.O.S. VARIES)

NOTES:
1. ALL HOR. BRACES ARE WT5X11 (T.O.S. EL. 115'-0 3/4")
2. BOXED IN SECTIONS WILL HAVE HAVE 1 1/4" X 3/16" NON-SERRATED GRATING AND ANGLE GUARDRAIL AROUND PERIMETER.

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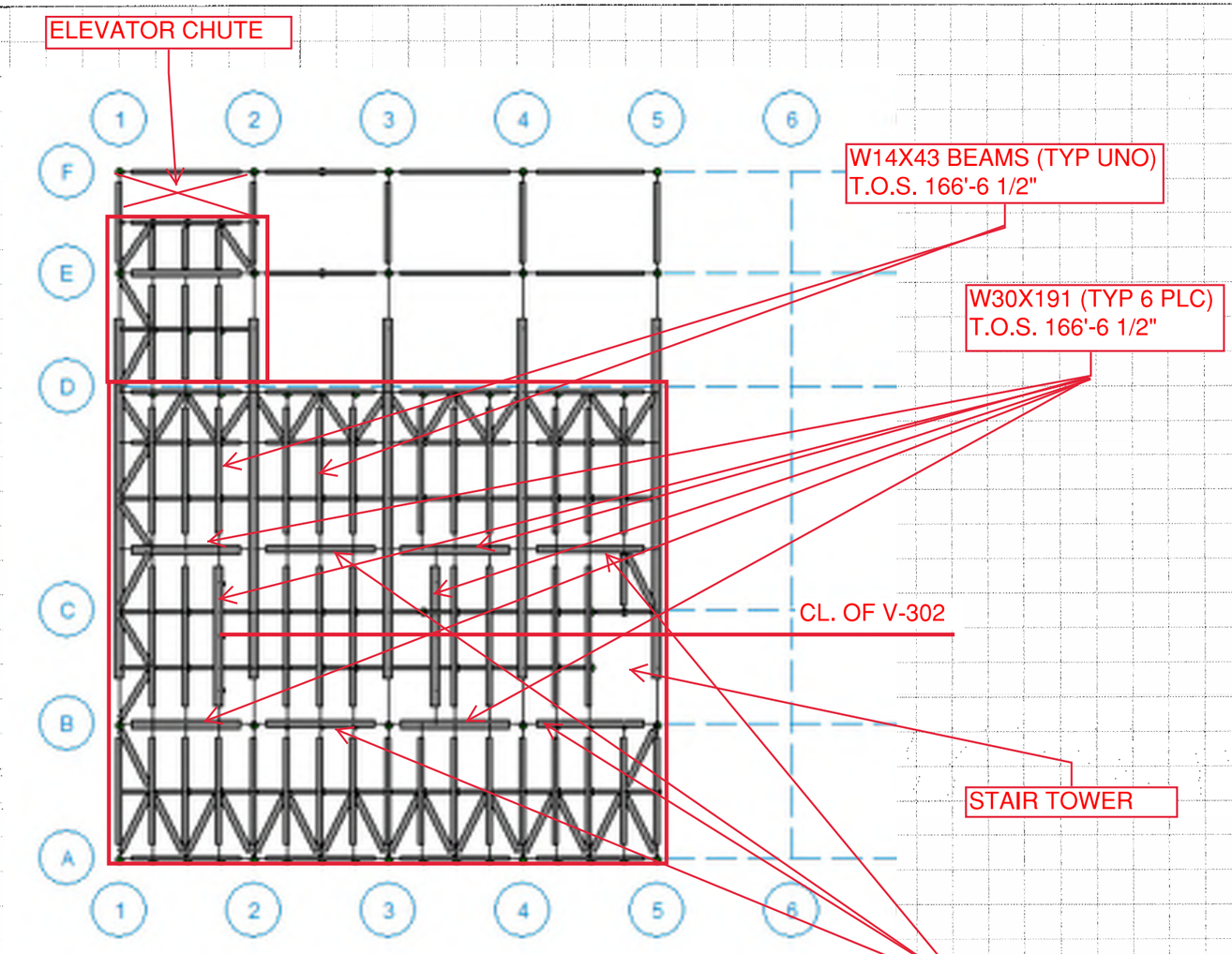
CALCULATIONS AND SKETCHES

DATE	07-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0002-01 SK-003

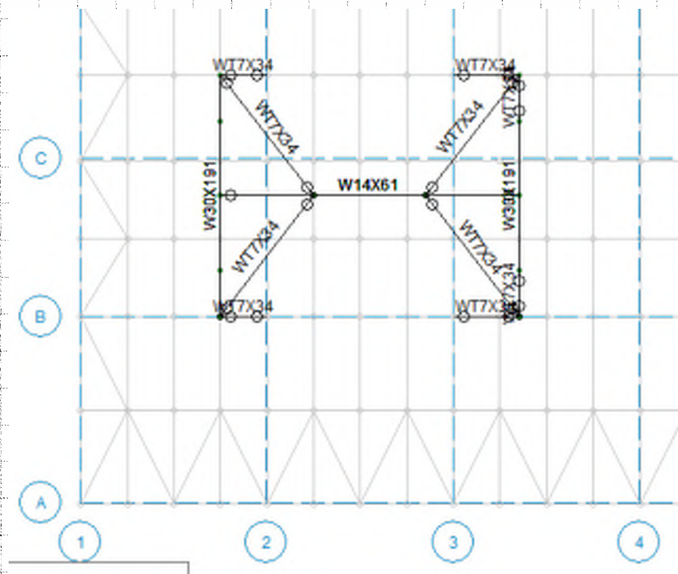
FORM E52 (Rev. 2-05)

PROCESS ENCLOSURE EQUIPMENT STRUCTURE AND PIPERACK - PLAN VIEW

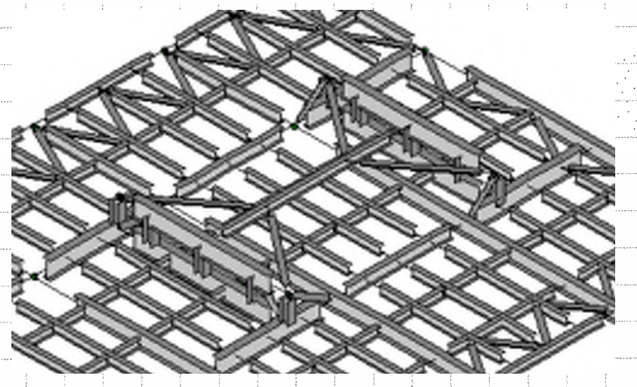
N



PLAN VIEW
T.O. CONC. DECK 167'-0"
(T.O.S. VARIES)



V-302 SUPPORT
T.O. STEEL EL. 171'-2"



VERTICAL STUB
COLUMNS ARE W14x90

NOTES:
1. ALL HOR. BRACES ARE WT5X11 (T.O.S. EL. 166'-2 1/2")
2. BOXED IN SECTIONS WILL HAVE HAVE 4" CONC. WITH 18 GA. RIBBED DECKING (5 1/2" FROM T.O. CONC TO BOT. OF RIB) AND GUARDRAIL.
3. ALL SHORT SPAN BEAMS (4' TO 6') ARE W8x21 AT T.O.S. EL. 166'-6 1/2".

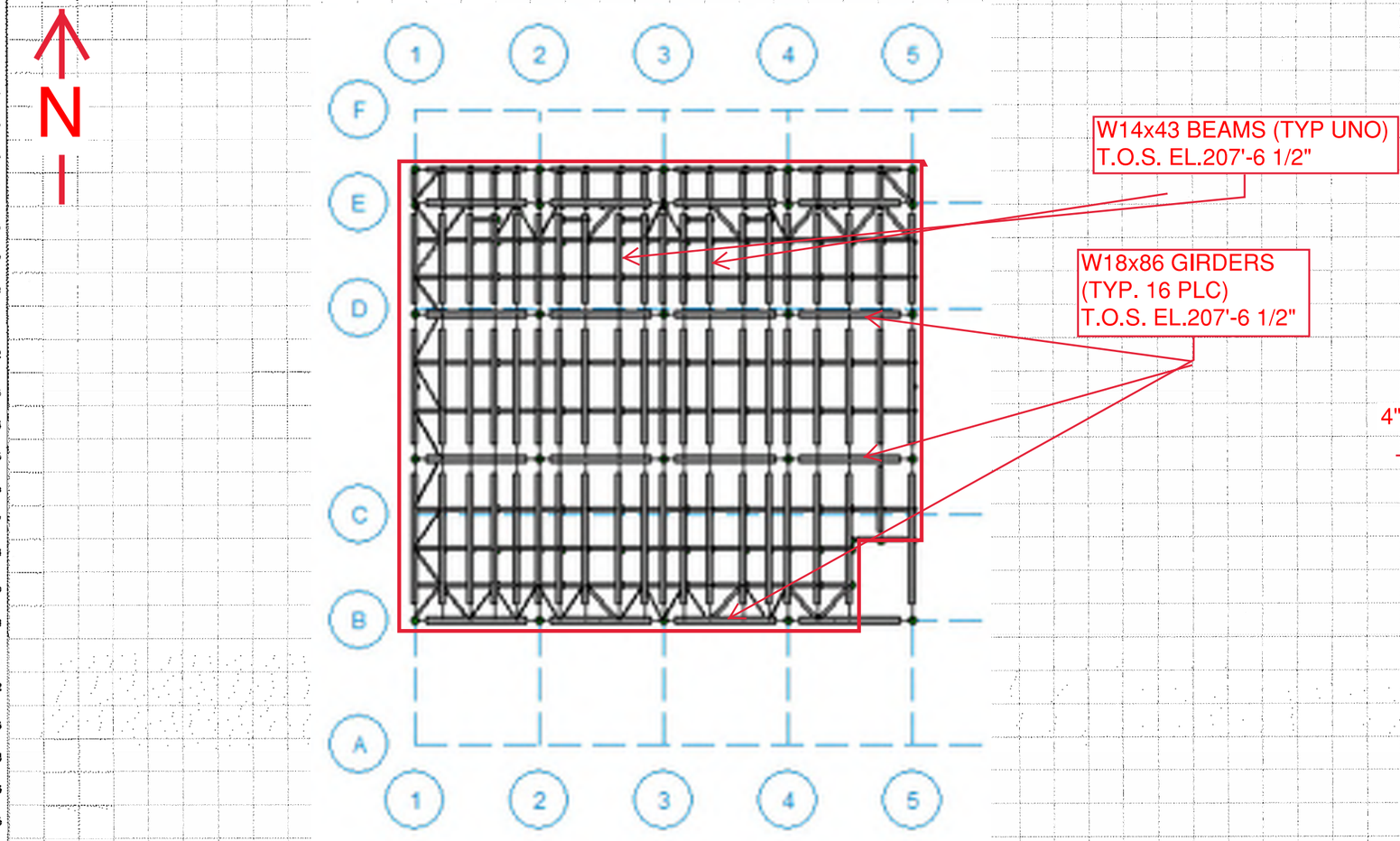
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CALCULATIONS AND SKETCHES

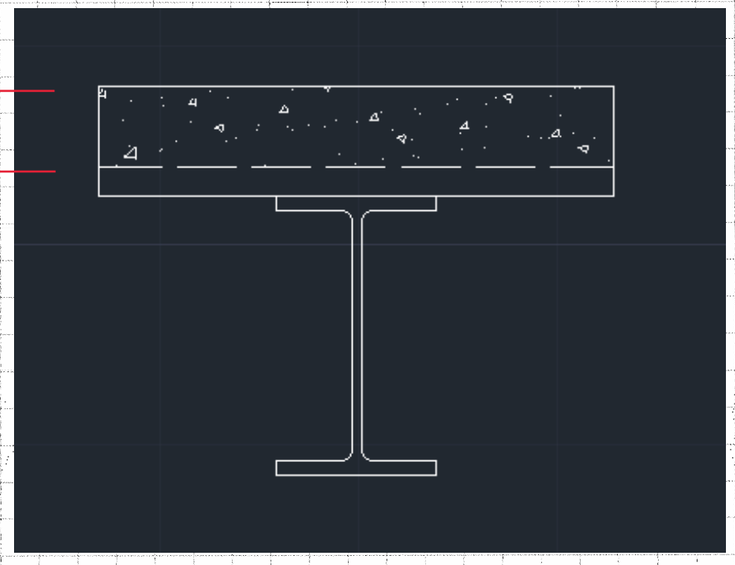
DATE	07-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0002-01 SK-004

FORM E52 (Rev. 2-05)

PROCESS ENCLOSURE EQUIPMENT STRUCTURE AND PIPERACK - PLAN VIEW



PLAN VIEW
T.O. CONC. DECK 208'-0"
(T.O.S. VARIES)



TYPICAL CONC. DECK SECTION

NOTES:
1. ALL HOR. BRACES ARE WT5X11 (T.O.S. EL. 207'-2 1/2")
2. BOXED IN SECTIONS WILL HAVE HAVE 4" CONC. WITH 18 GA. RIBBED DECKING (5 1/2" FROM T.O. CONC TO BOT. OF RIB) AND GUARDRAIL.
3. ALL SHORT SPAN BEAMS (4' TO 6') ARE W8x21 AT T.O.S. EL. 207'-6 1/2".
4. SPACE W14x43 FRAMING BEAMS TO LAY UNDER PLATE/FRAME EXCHANGER SUPPORTS.

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CALCULATIONS AND SKETCHES

DATE	07-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0002-01 SK-005

FORM E52 (Rev. 2-05)

PROCESS ENCLOSURE EQUIPMENT STRUCTURE AND PIPERACK - ELEVATION VIEW

T.O.S. EL. 249'-10"

T.O.S. EL. 236'-0"

T.O.S. EL. 222'-0"

T.O.S. EL. 207'-6 1/2"

T.O.S. EL. 187'-6"

T.O.S. EL. 166'-6 1/2"

T.O.S. EL. 160'-6"

T.O.S. EL. 151'-6"

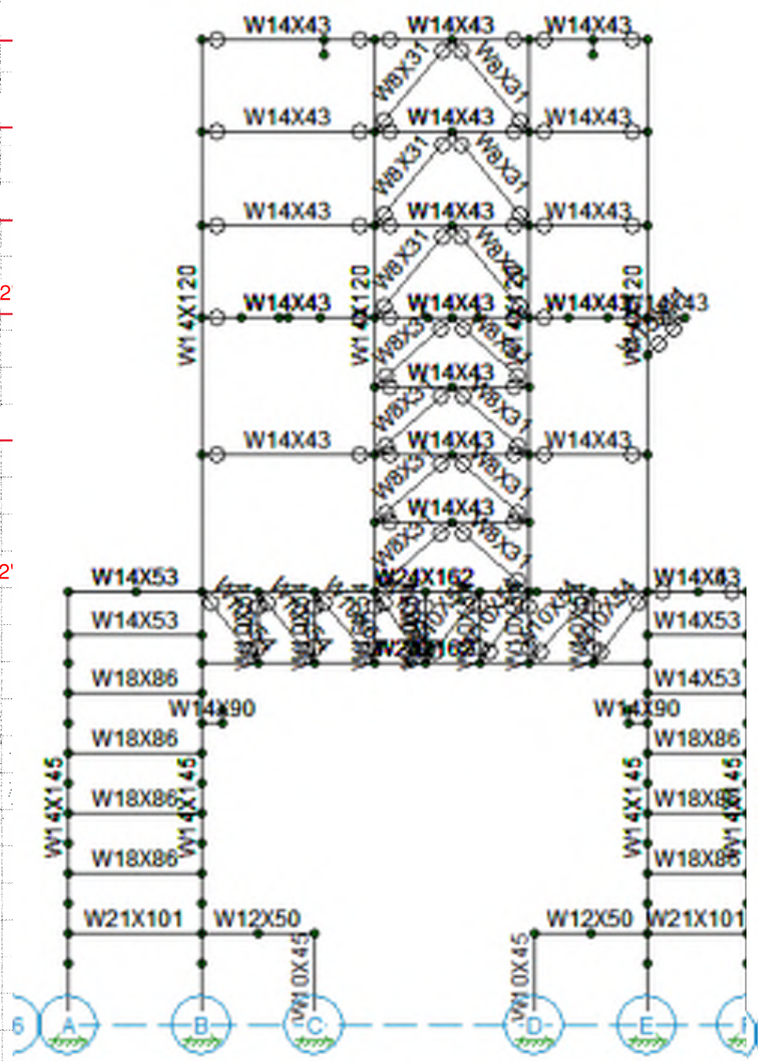
T.O.S. EL. 142'-6"

T.O.S. EL. 133'-6"

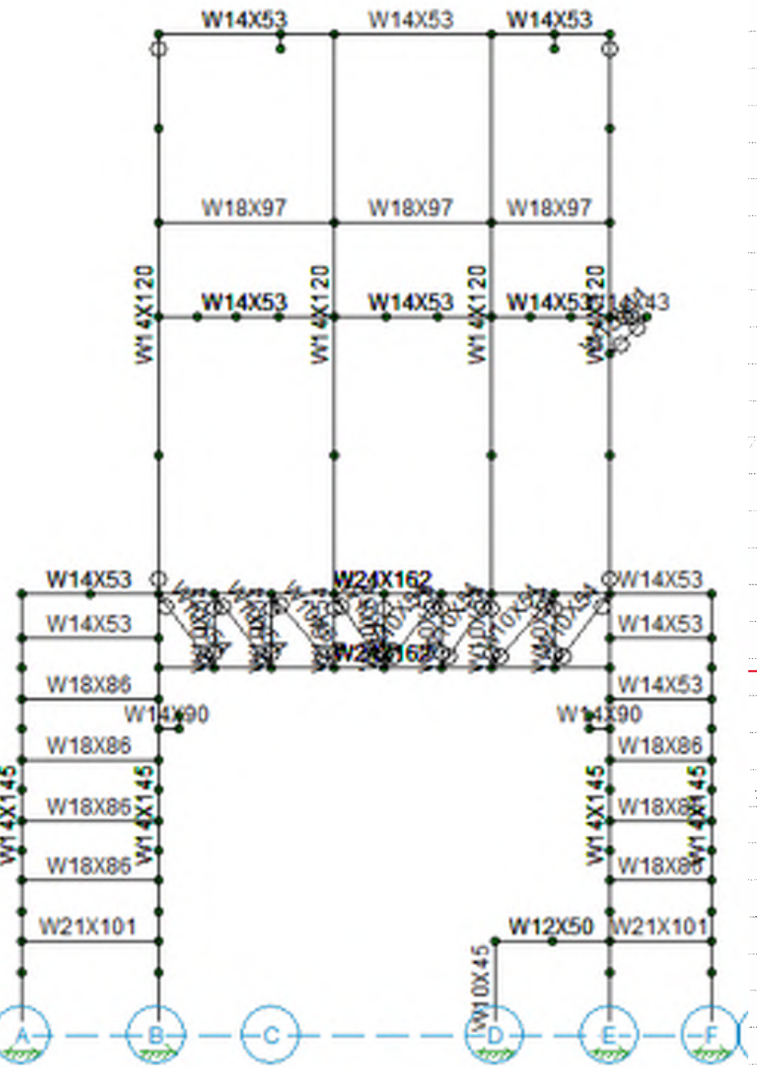
T.O.S. EL. 124'-6"

T.O.S. EL. 115'-6"

B.O. BPL EL. 101'-6"

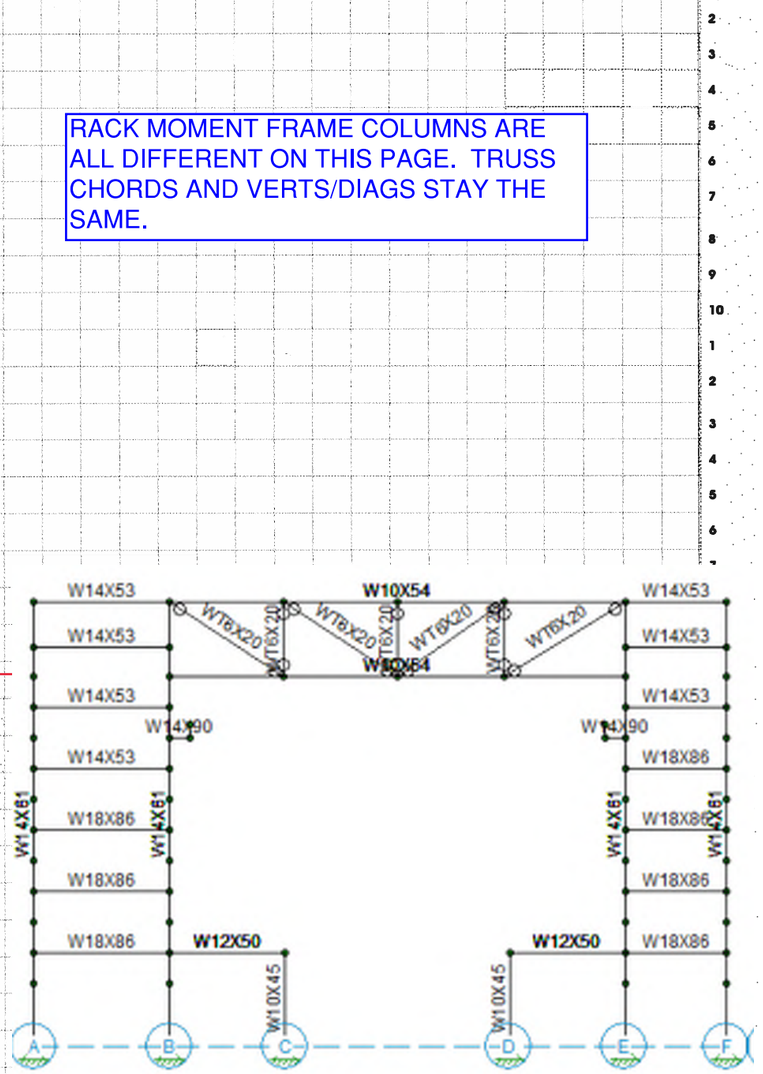


ELEVATION VIEW
LOOKING WEST
BENTS 1 AND 5



ELEVATION VIEW
LOOKING WEST
BENTS 2 THRU 4

RACK MOMENT FRAME COLUMNS ARE ALL DIFFERENT ON THIS PAGE. TRUSS CHORDS AND VERTS/DIAGS STAY THE SAME.



ELEVATION VIEW
LOOKING WEST
BENTS 6 THRU 16

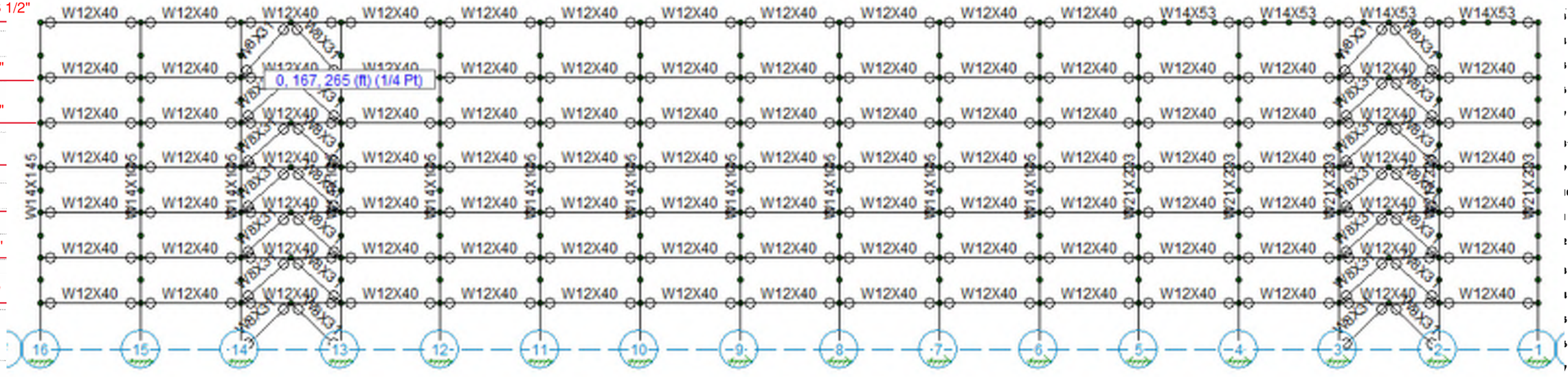
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CALCULATIONS AND SKETCHES

FORM E52 (Rev. 2-05)

PROCESS ENCLOSURE EQUIPMENT STRUCTURE AND PIPERACK - ELEVATION VIEW

DATE	07-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0002-01 SK-006



ELEVATION VIEW
LOOKING SOUTH
BENTS A AND F

REDUCE W21X233 COLUMNS TO W14X145.
REDUCE W14X145 COLUMNS TO W14X61

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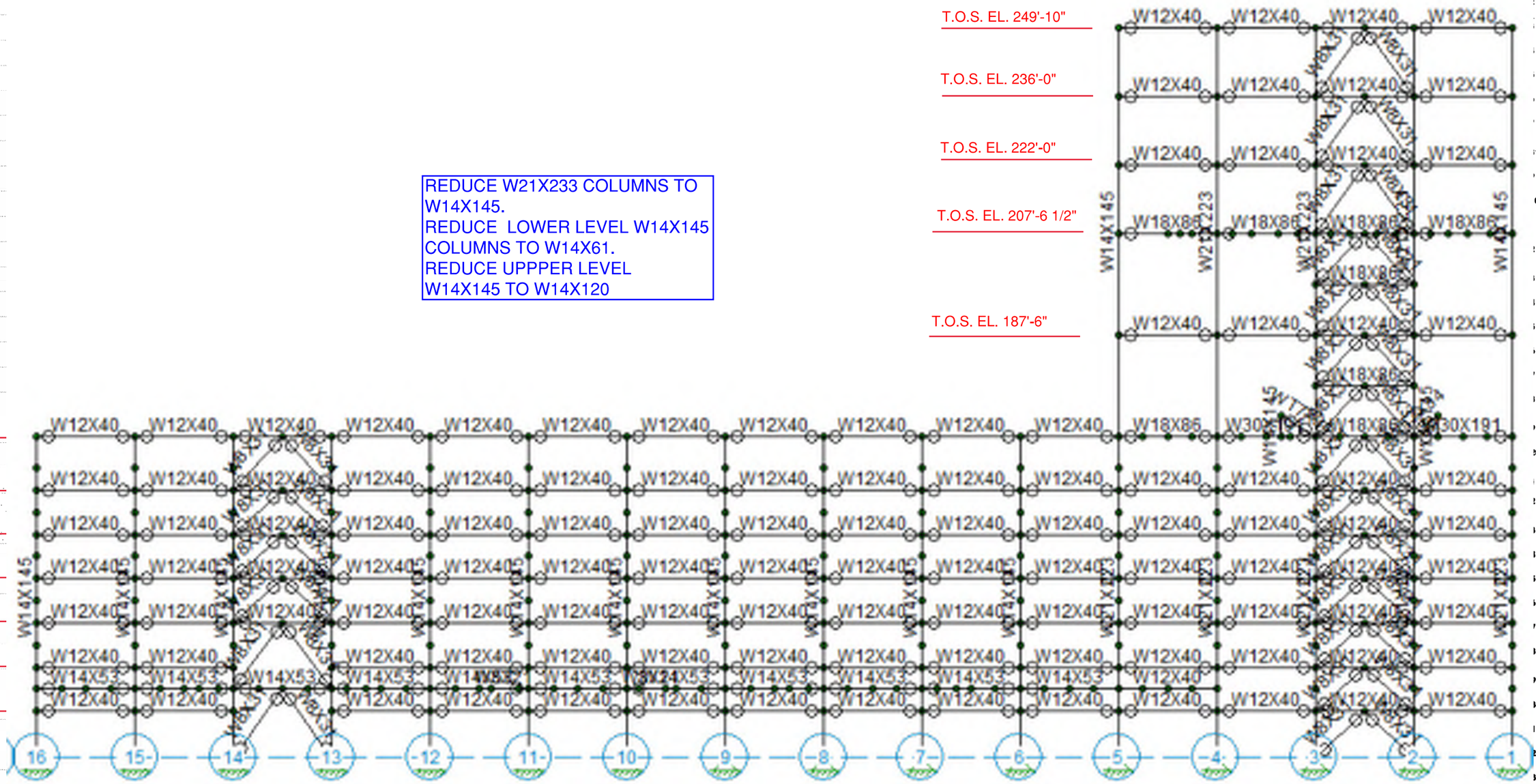
CALCULATIONS AND SKETCHES

DATE	07-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0002-01 SK-007

FORM E52 (Rev. 2-05)

PROCESS ENCLOSURE EQUIPMENT STRUCTURE AND PIPERACK - ELEVATION VIEW

REDUCE W21X233 COLUMNS TO W14X145.
REDUCE LOWER LEVEL W14X145 COLUMNS TO W14X61.
REDUCE UPPPER LEVEL W14X145 TO W14X120



ELEVATION VIEW
LOOKING SOUTH
BENTS B AND E

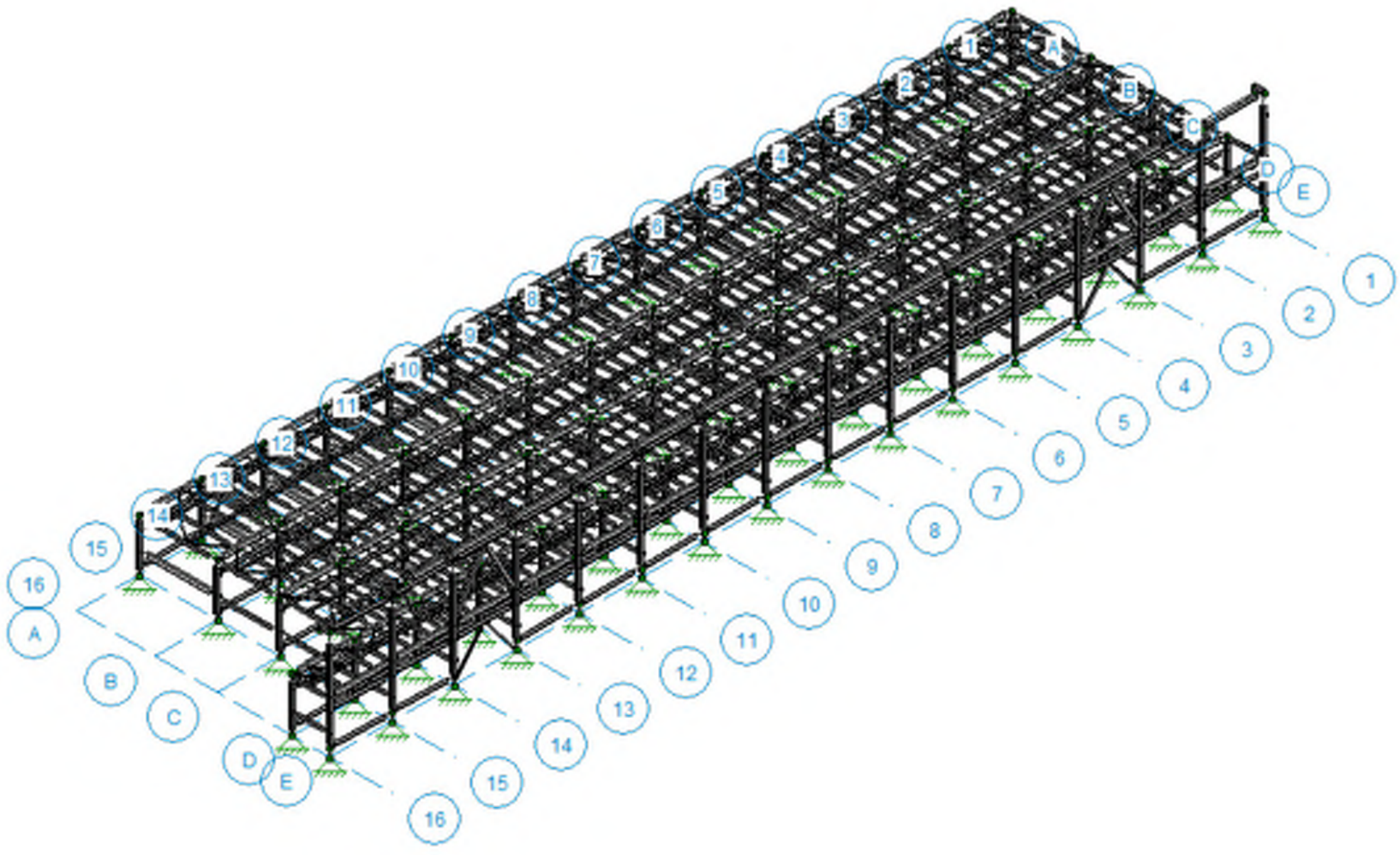
FLUOR®

CALCULATIONS AND SKETCHES

DATE	13-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0002-02 SK-001

FORM E52 (Rev. 2-05)

PROCESS ENCLOSURE PLATE EXCHANGER PLATFORM - ISOMETRIC



ISOMETRIC VIEW
LOOKING SOUTHWEST

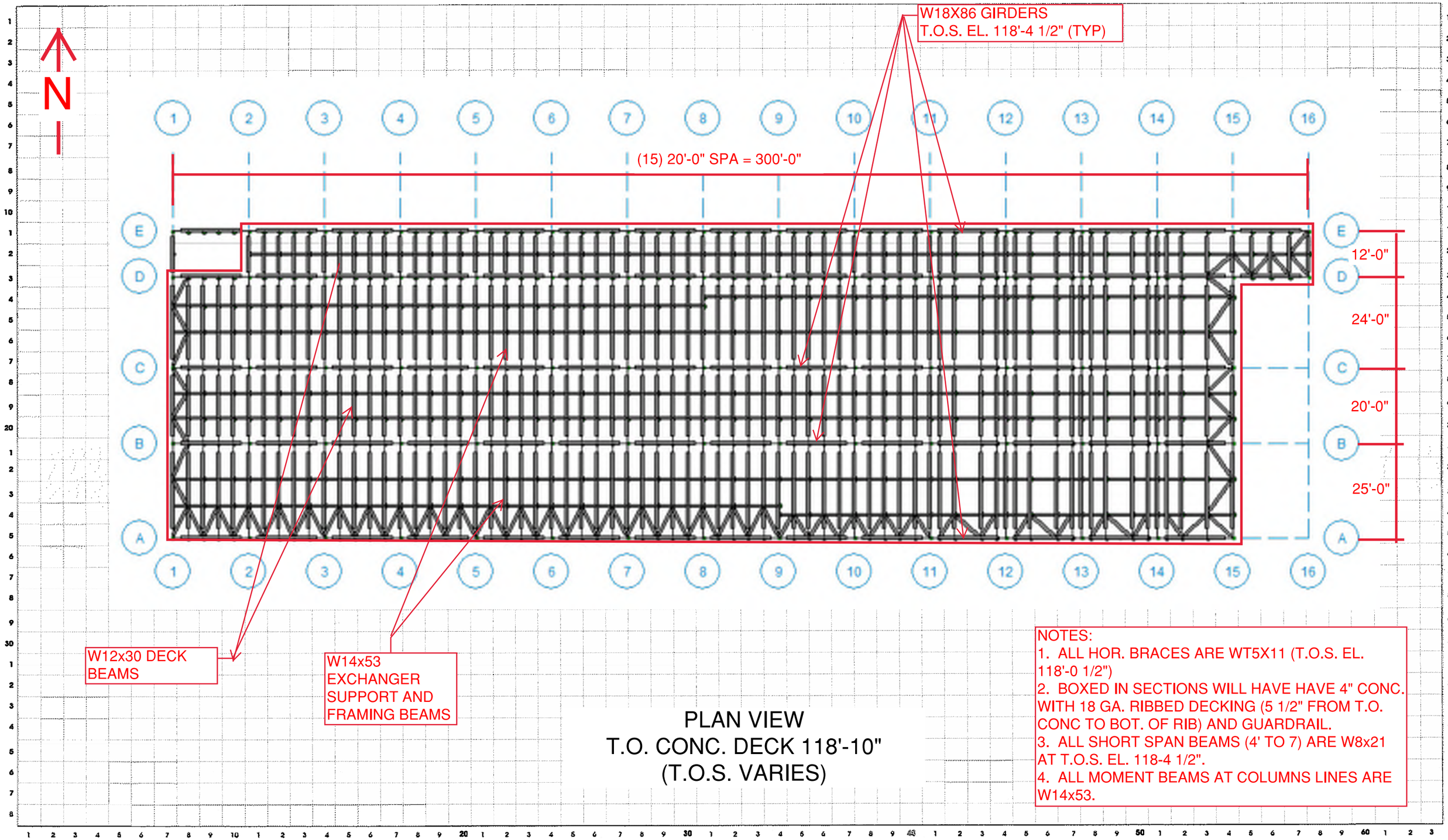
FLUOR®

CALCULATIONS AND SKETCHES

DATE	13-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0002-02 SK-002

FORM E52 (Rev. 2-05)

PROCESS ENCLOSURE PLATE EXCHANGER PLATFORM - PLAN VIEW



PLAN VIEW
T.O. CONC. DECK 118'-10"
(T.O.S. VARIES)

NOTES:
1. ALL HOR. BRACES ARE WT5X11 (T.O.S. EL. 118'-0 1/2")
2. BOXED IN SECTIONS WILL HAVE HAVE 4" CONC. WITH 18 GA. RIBBED DECKING (5 1/2" FROM T.O. CONC TO BOT. OF RIB) AND GUARDRAIL.
3. ALL SHORT SPAN BEAMS (4' TO 7) ARE W8x21 AT T.O.S. EL. 118-4 1/2".
4. ALL MOMENT BEAMS AT COLUMNS LINES ARE W14x53.

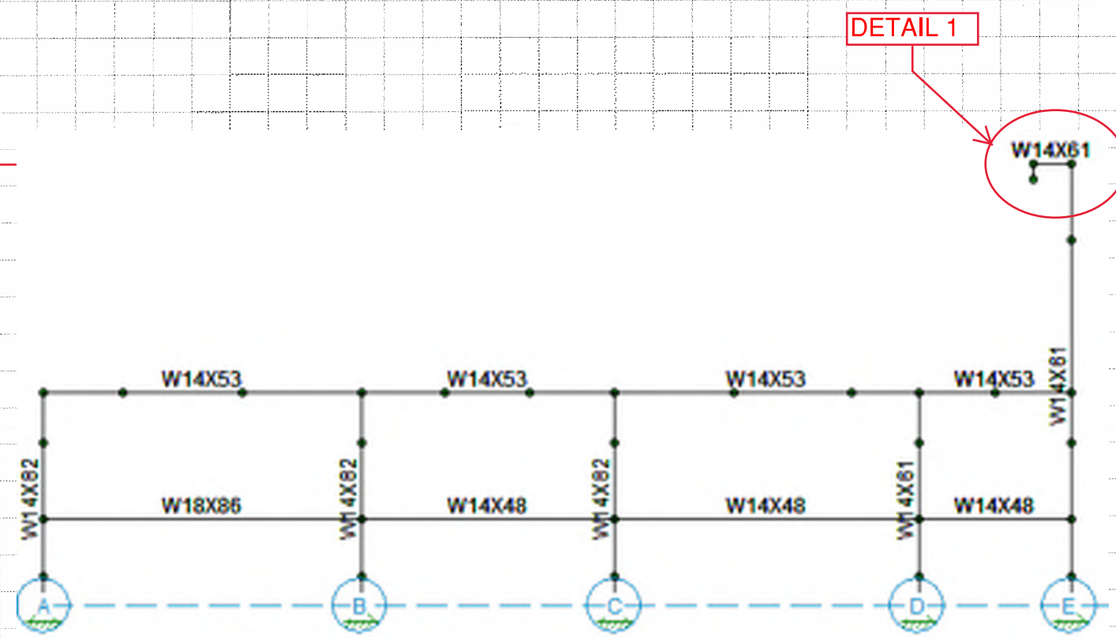
FLUOR®

CALCULATIONS AND SKETCHES

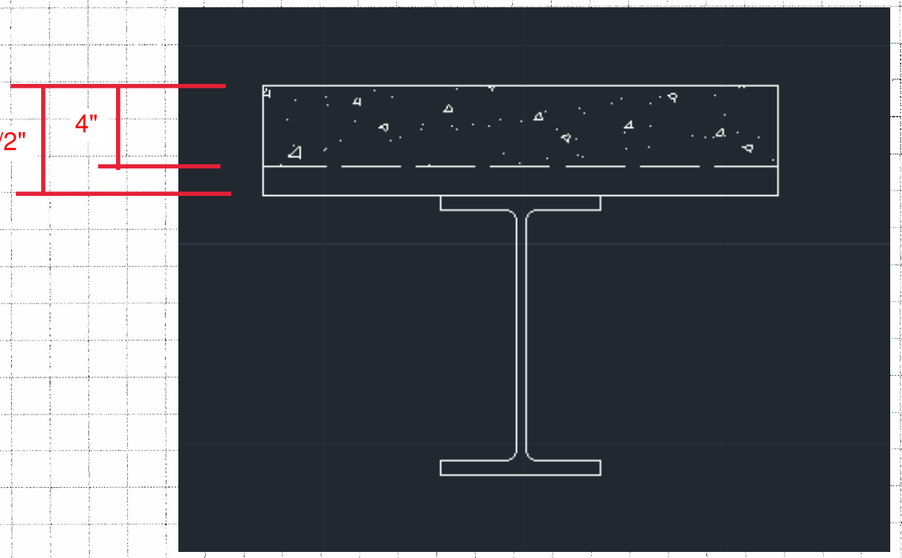
FORM E52 (Rev. 2-05)

PROCESS ENCLOSURE PLATE EXCHANGER PLATFORM - ELEVATION VIEW AND SECTIONS

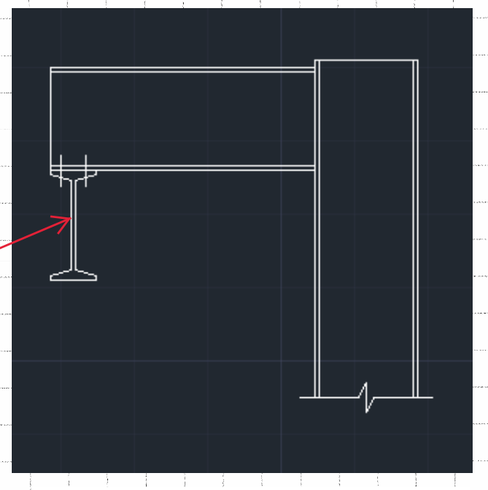
DATE	13-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0002-02 SK-003



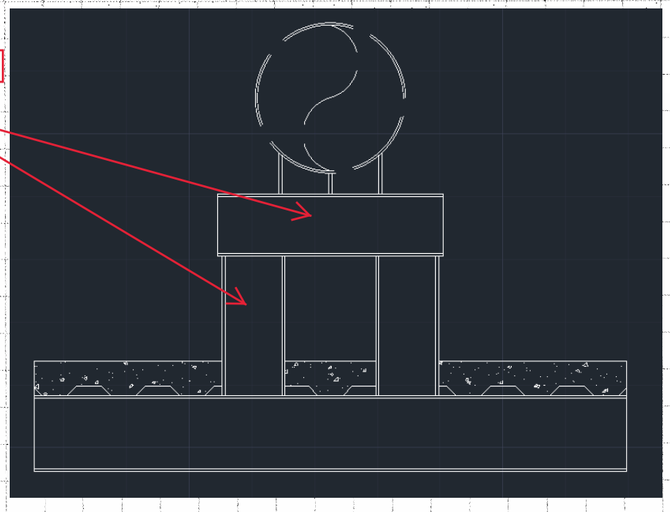
ELEVATION VIEW
LOOKING WEST
BENTS 1 THRU 15



TYPICAL CONC. DECK SECTION



DETAIL 1



TYPICAL VALVE SUPPORTS

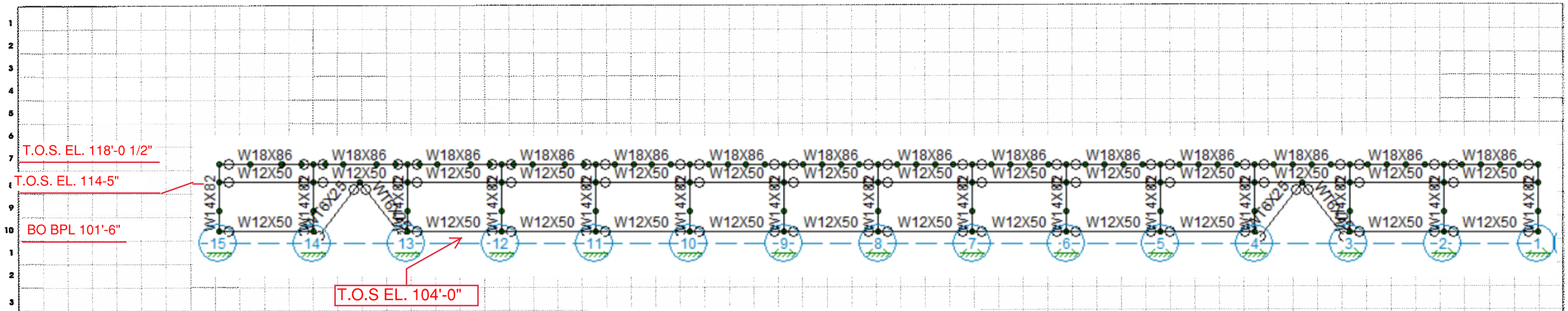
FLUOR®

CALCULATIONS AND SKETCHES

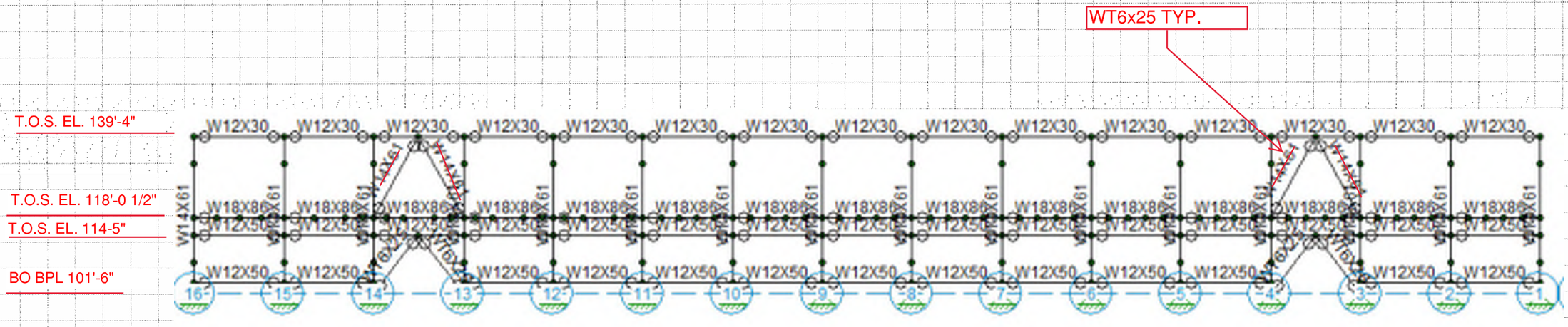
DATE	13-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0002-02 SK-005

FORM E52 (Rev. 2-05)

PROCESS ENCLOSURE PLATE EXCHANGER PLATFORM - ELEVATION VIEW



ELEVATION VIEW
LOOKING SOUTH
BENTS A



ELEVATION VIEW
LOOKING SOUTH
BENTS E

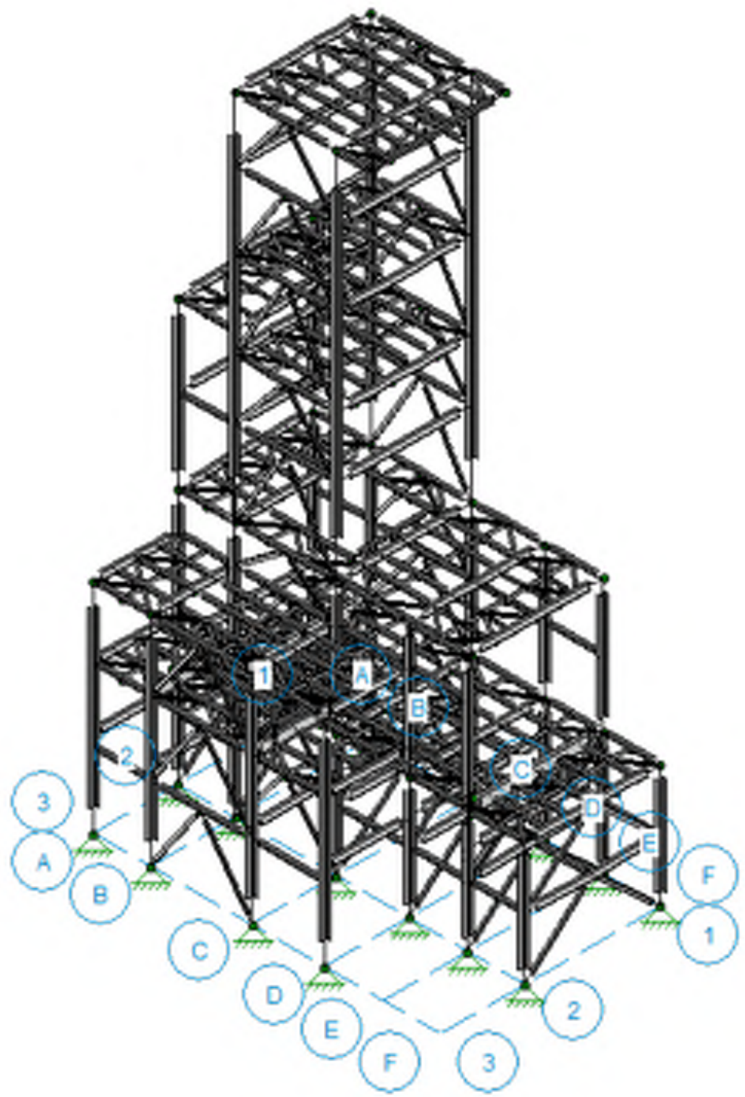
FLUOR®

CALCULATIONS AND SKETCHES

FORM E52 (Rev. 2-05)

EQUIPMENT STRUCTURE - ISOMETRIC

DATE	19-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0003-20 SK-001



ISOMETRIC VIEW
LOOKING SOUTHWEST

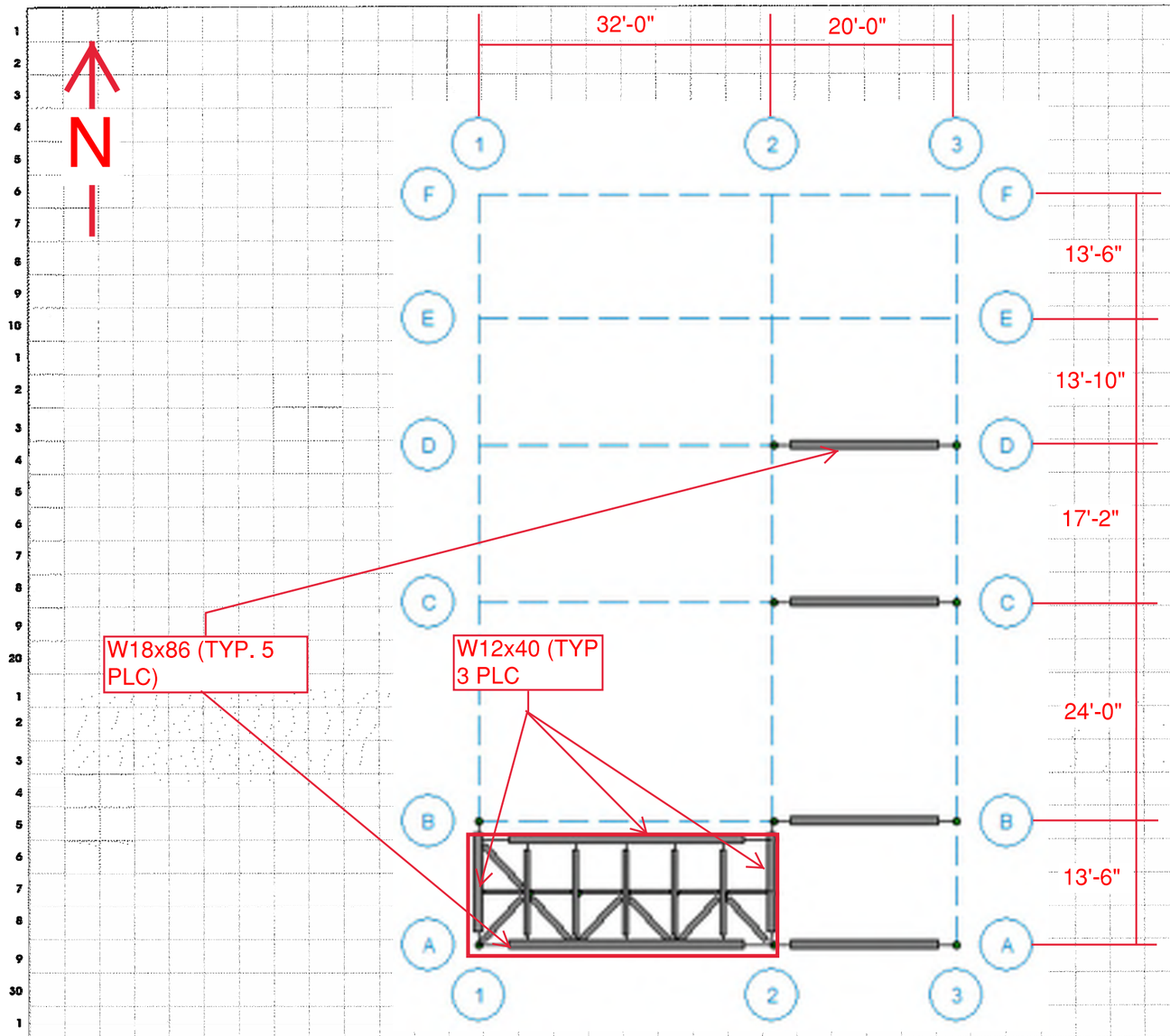
FLUOR®

CALCULATIONS AND SKETCHES

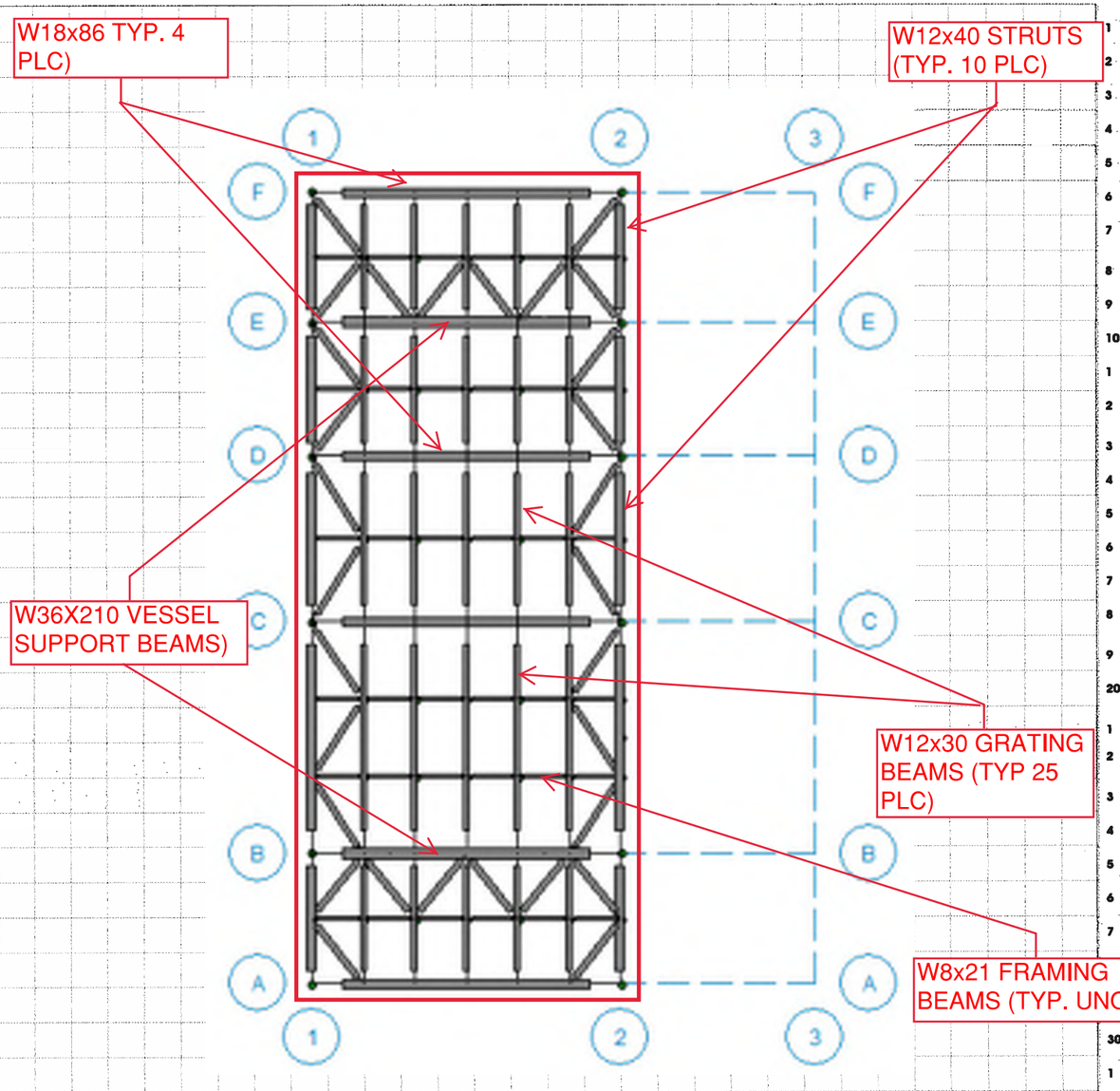
DATE	19-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0003-20 SK-002

FORM E52 (Rev. 2-05)

EQUIPMENT STRUCTURE - PLAN VIEW



PLAN VIEW
T.O. GRATING 121'-3"
(T.O.S. VARIES)



PLAN VIEW
T.O. GRATING 130'-0"
(T.O.S. VARIES)

NOTES:
1. ALL HOR. BRACES ARE WT5X11 (-5 1/4" FROM T.O. GRATING)
2. BOXED IN SECTIONS WILL HAVE HAVE 1 1/4" X 3/16" SERRATED GRATING AND GUARDRAIL.
3. ALL BEAMS NOT NOTED ARE W8x21 AT T.O.S. EL. 121'-1 3/4" AND 129'-10 3/4", RESPECTIVELY.

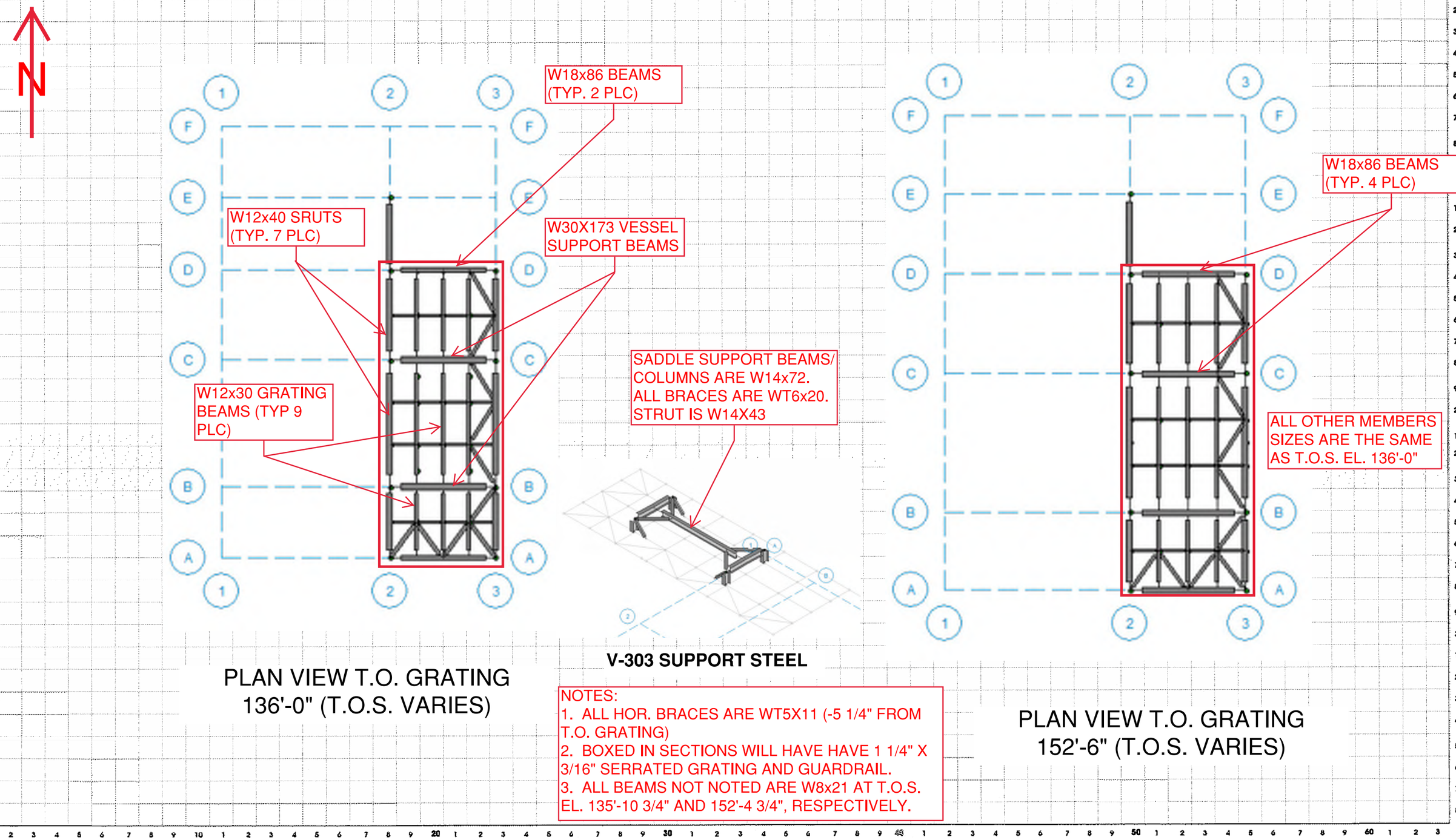
FLUOR®

CALCULATIONS AND SKETCHES

FORM E52 (Rev. 2-05)

EQUIPMENT STRUCTURE - PLAN VIEW AND V303 SADDLE SUPPORT DETAIL

DATE	19-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0003-20 SK-003



PLAN VIEW T.O. GRATING
136'-0" (T.O.S. VARIES)

V-303 SUPPORT STEEL

PLAN VIEW T.O. GRATING
152'-6" (T.O.S. VARIES)

NOTES:
1. ALL HOR. BRACES ARE WT5X11 (-5 1/4" FROM T.O. GRATING)
2. BOXED IN SECTIONS WILL HAVE HAVE 1 1/4" X 3/16" SERRATED GRATING AND GUARDRAIL.
3. ALL BEAMS NOT NOTED ARE W8x21 AT T.O.S. EL. 135'-10 3/4" AND 152'-4 3/4", RESPECTIVELY.

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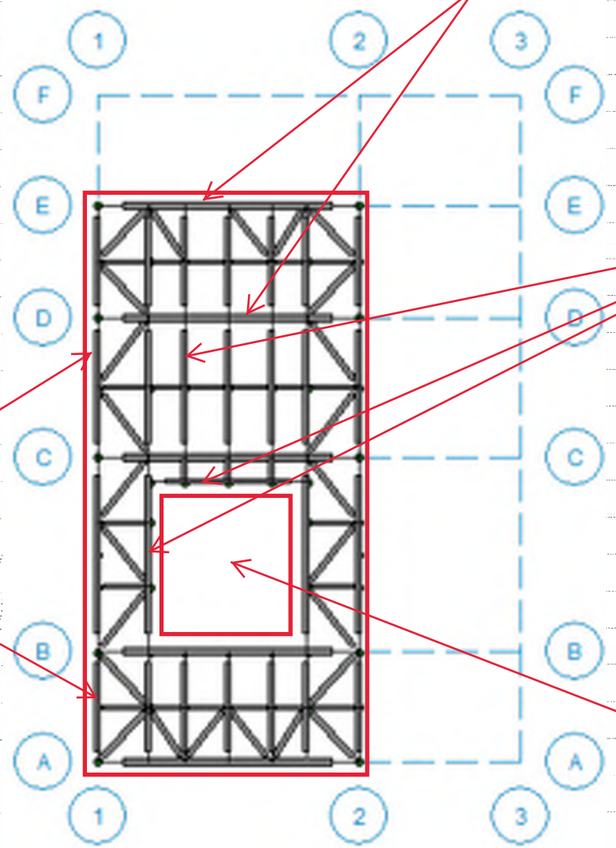
CALCULATIONS AND SKETCHES

FORM E52 (Rev. 2-05)

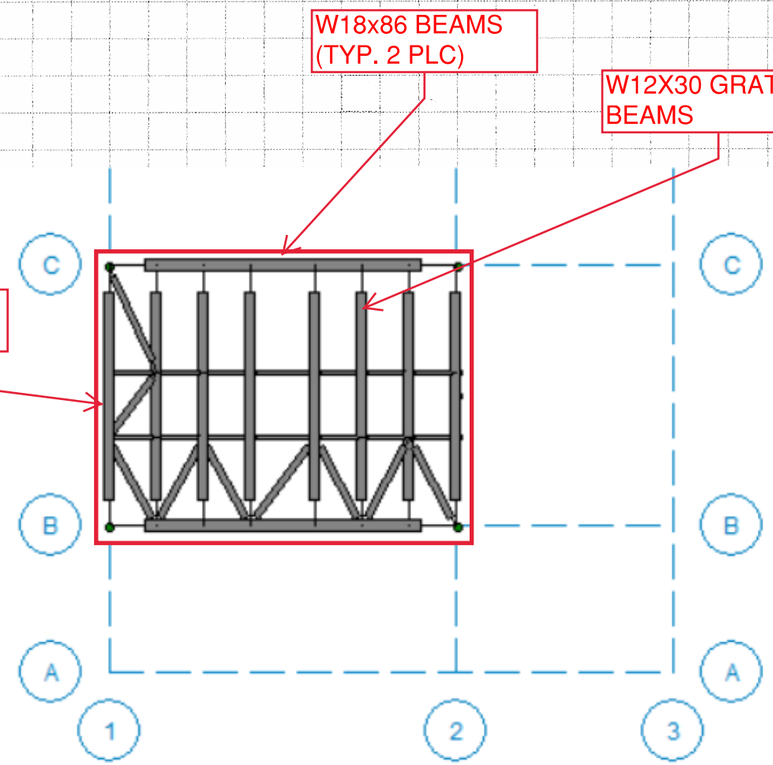
EQUIPMENT STRUCTURE - PLAN VIEW

DATE	19-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0003-20 SK-004

N



PLAN VIEW T.O. GRATING
161'-6" (T.O.S. VARIES)



PLAN VIEW T.O. GRATING
196'-0" (T.O.S. VARIES)

NOTES:
1. ALL HOR. BRACES ARE WT5X11 (-5 1/4" FROM T.O. GRATING)
2. BOXED IN SECTIONS WILL HAVE HAVE 1 1/4" X 3/16" SERRATED GRATING AND GUARDRAIL.
3. ALL BEAMS NOT NOTED ARE W8x21 AT T.O.S. EL. 161'-4 3/4" AND 195'-10 3/4", RESPECTIVELY.

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CALCULATIONS AND SKETCHES

DATE	19-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0003-20 SK-005

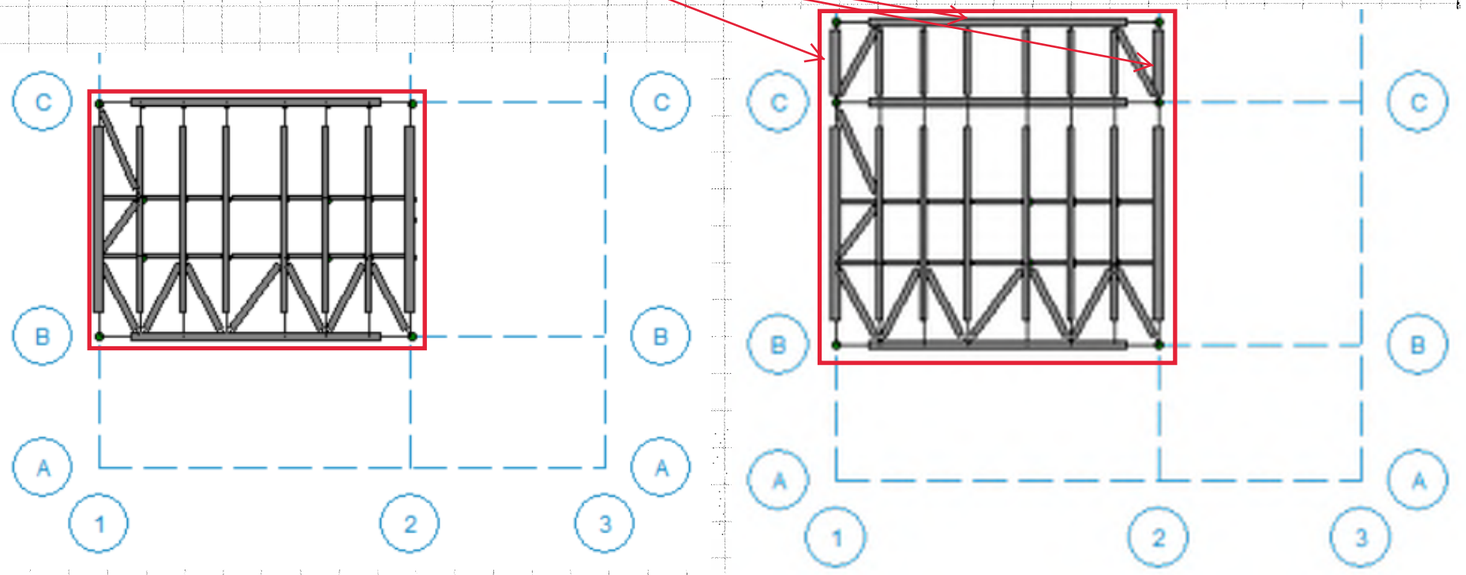
FORM E52 (Rev. 2-05)

EQUIPMENT STRUCTURE - PLAN VIEW

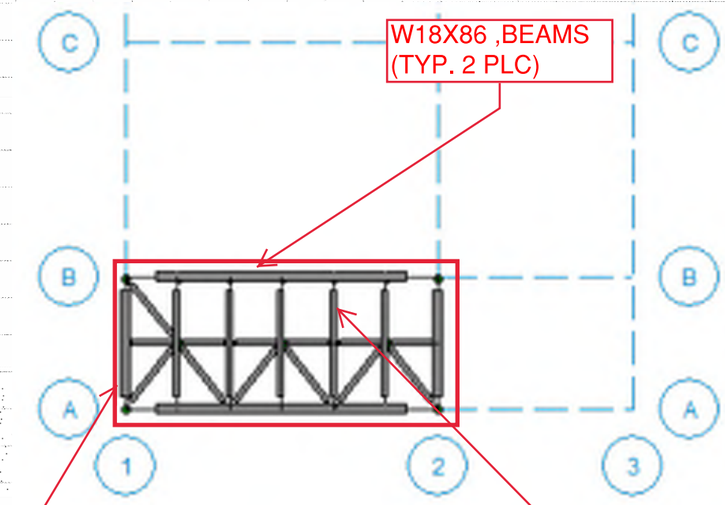
N

NOTES:
1. ALL HOR. BRACES ARE WT5X11 (-5 1/4" FROM T.O. GRATING)
2. BOXED IN SECTIONS WILL HAVE HAVE 1 1/4" X 3/16" SERRATED GRATING AND GUARDRAIL.
3. ALL BEAMS NOT NOTED ARE W8x21 AT T.O.S. EL. 200'-7 3/4", 216'-4 3/4", AND 249'-7 3/4", RESPECTIVELY.

W14x43 BEAMS



W18X86 ,BEAMS (TYP. 2 PLC)



W12x40 STRUTS (TYP. 2 PLC)

W12x30 GRATING BEAMS

MEMBER SIZES ARE COMMON TO ALL ELEVATIONS

PLAN VIEW T.O. GRATING
200'-9" (T.O.S. VARIES)

PLAN VIEW T.O. GRATING
216'-6" (T.O.S. VARIES)

PLAN VIEW T.O. GRATING
249'-9" (T.O.S. VARIES)

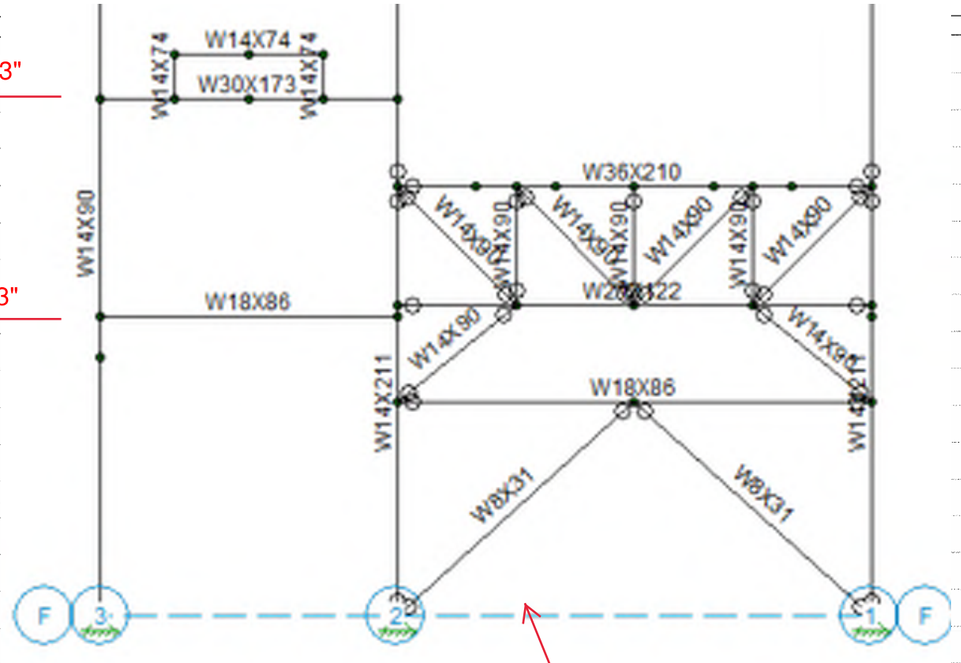
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CALCULATIONS AND SKETCHES

FORM E52 (Rev. 2-05)

EQUIPMENT STRUCTURE - ELEVATION VIEWS

DATE	19-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0003-20 SK-006



T.O.S EL. 121'-3"

T.O.S EL. 121'-3"

T.O.S EL. 130'-0"

T.O.S EL. 122'-0"

T.O.S EL. 115'-6"

T.O.S EL. 200'-9"

T.O.S EL. 181'-6"

T.O.S EL. 161-6"

T.O.S EL. 152'-6"

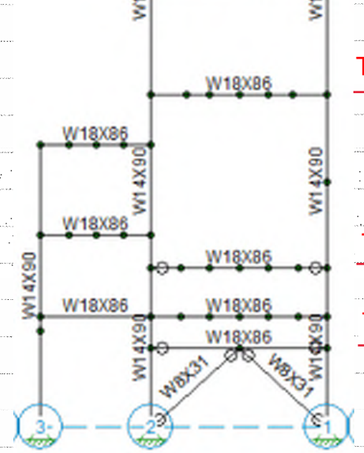
T.O.S EL. 136'-0"

T.O.S EL. 130'-0"

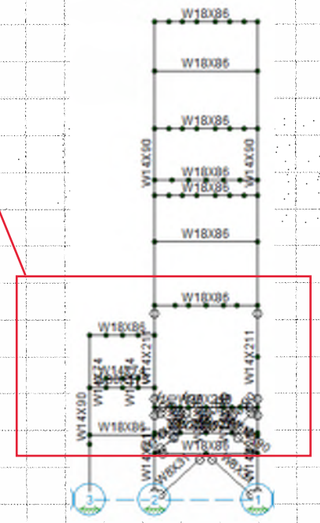
T.O.S EL. 121'-3"

T.O.S EL. 115'-6"

B.O. BPL EL. 101'-0"



ELEVATION VIEW
COLUMN LINE A
(LOOKING SOUTH)



ELEVATION VIEW
COLUMN LINE B
(LOOKING SOUTH)

FLUOR®

CALCULATIONS AND SKETCHES

DATE	19-OCT-2020
CONT. NO.	M1NN
BY	CTK
CHK'D	
SHEET NO.	EC-CCS-215-0003-20 SK-007

FORM E52 (Rev. 2-05)

EQUIPMENT STRUCTURE - ELEVATION VIEWS

ELEVATION VIEW
COLUMN LINE C
(LOOKING SOUTH

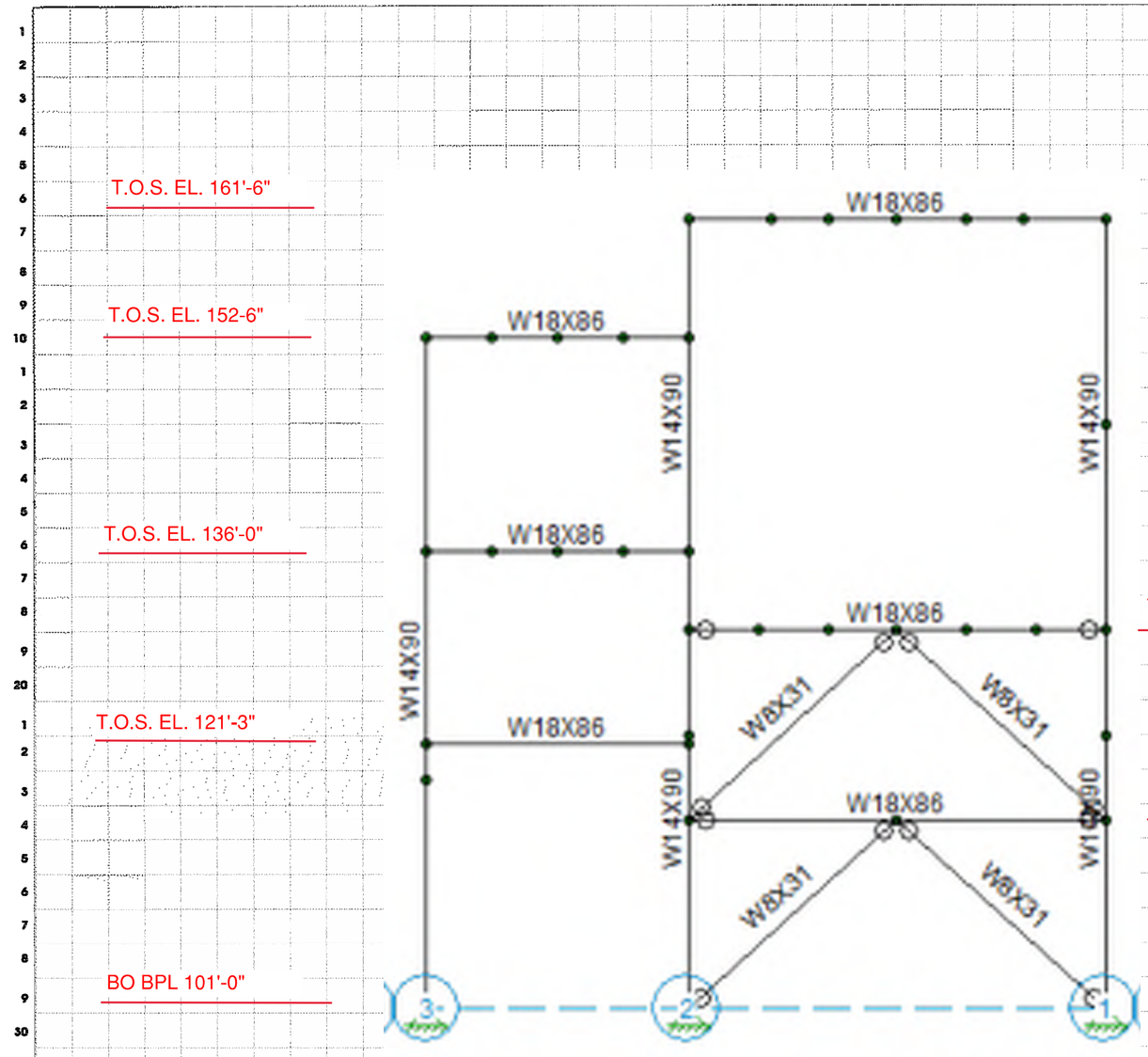
FLUOR®

CALCULATIONS AND SKETCHES

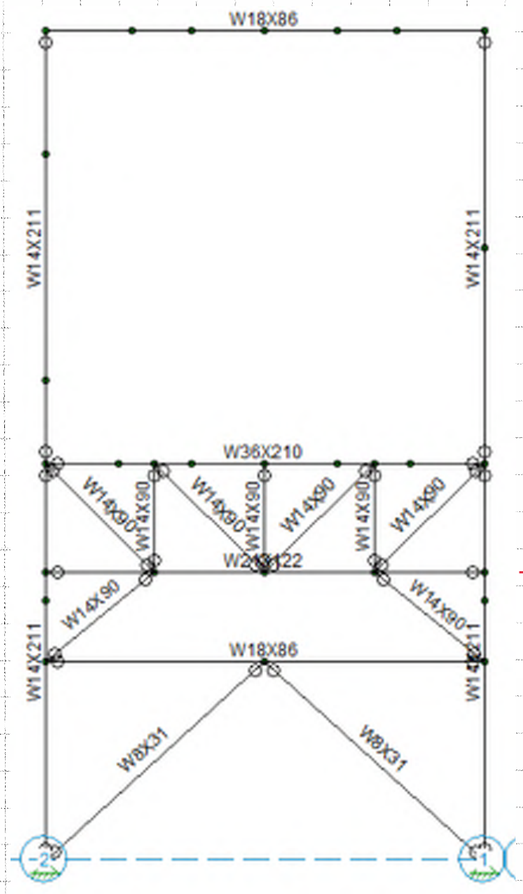
FORM E52 (Rev. 2-05)

EQUIPMENT STRUCTURE - ELEVATION VIEWS

DATE	19-OCT-2020
CONT. NO.	M1NN
BY	CTK
CHK'D	
SHEET NO.	EC-CCS-215-0003-20 SK-008



ELEVATION VIEW
COLUMN LINE D
(LOOKING SOUTH)



ELEVATION VIEW
COLUMN LINE E
(LOOKING SOUTH)

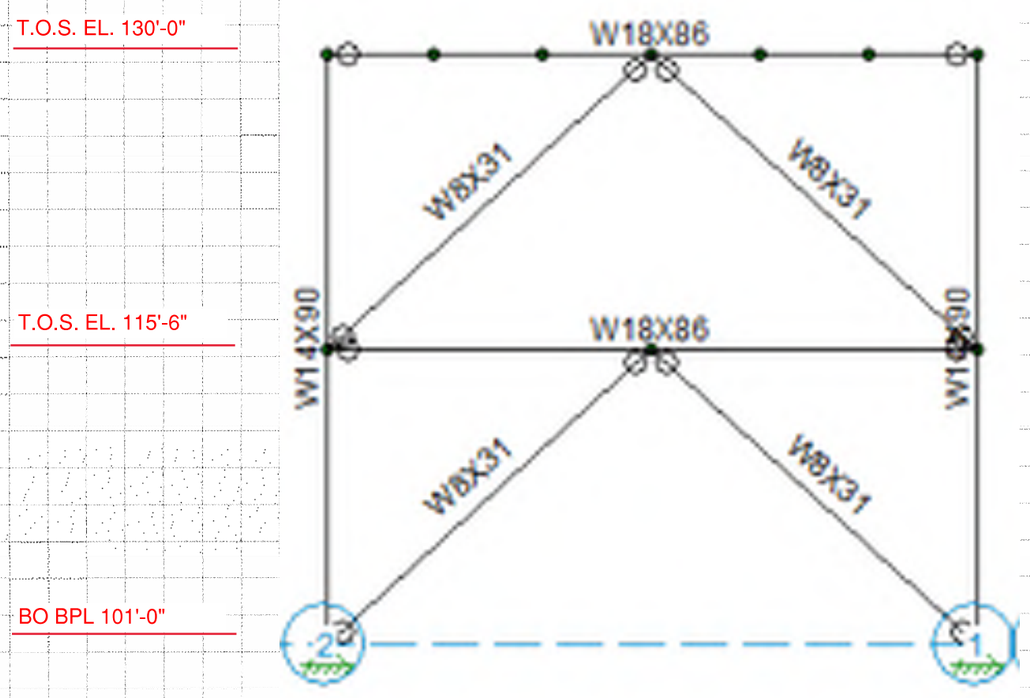
FLUOR®

CALCULATIONS AND SKETCHES

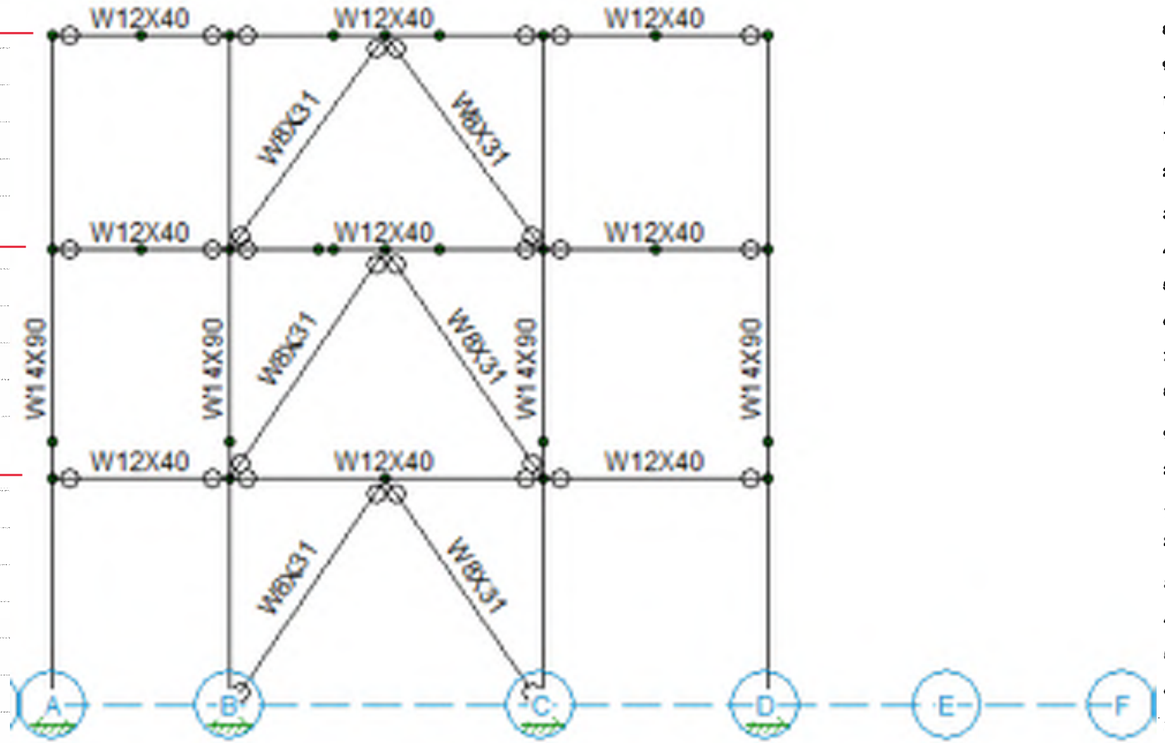
FORM E52 (Rev. 2-05)

EQUIPMENT STRUCTURE - ELEVATION VIEWS

DATE	19-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0003-20 SK-009



ELEVATION VIEW
COLUMN LINE D
(LOOKING SOUTH)



ELEVATION VIEW
COLUMN LINE 3
(LOOKING WEST)

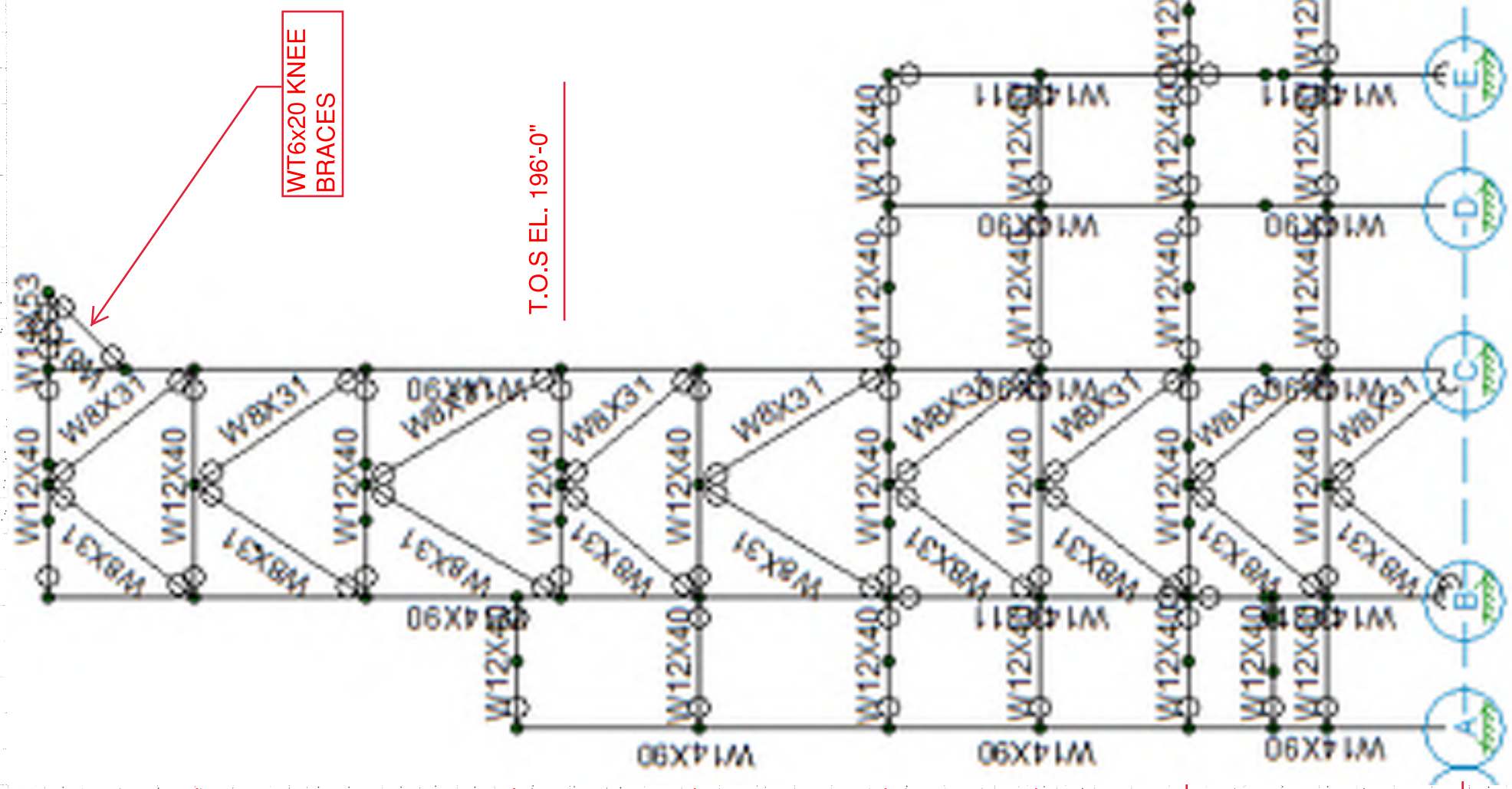
FLUOR®

CALCULATIONS AND SKETCHES

DATE	19-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0003-20 SK-010

FORM E52 (Rev. 2-05)

EQUIPMENT STRUCTURE - ELEVATION VIEWS



ELEVATION VIEW
COLUMN LINE 1
(LOOKING SOUTH

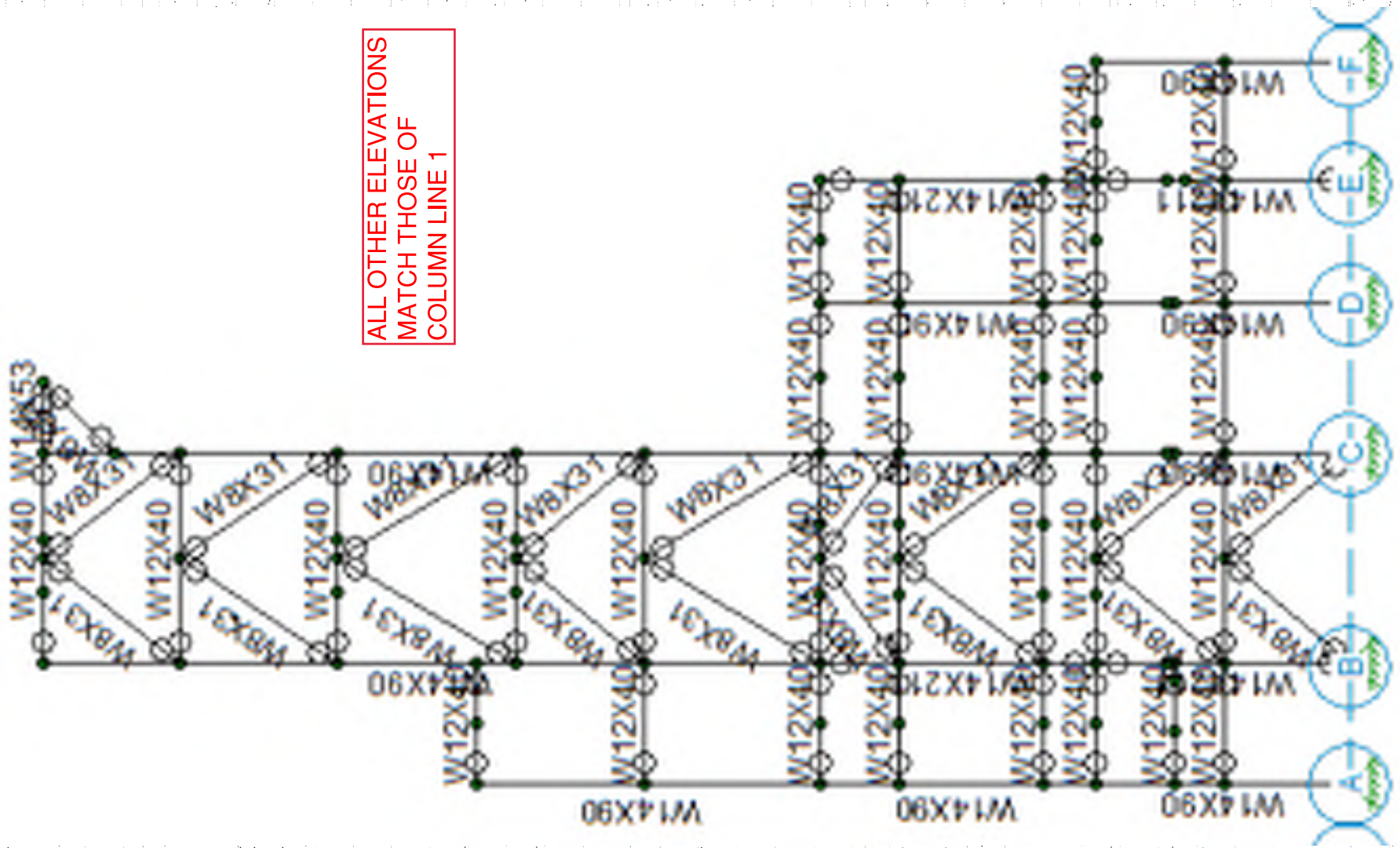
FLUOR®

CALCULATIONS AND SKETCHES

FORM E52 (Rev. 2-05)

EQUIPMENT STRUCTURE - ELEVATION VIEWS

DATE	19-OCT-2020
CONT. NO.	M1NN
BY	CTK CHK'D
SHEET NO.	EC-CCS-215-0003-20 SK-011



ELEVATION VIEW
COLUMN LINE 2
(LOOKING SOUTH)

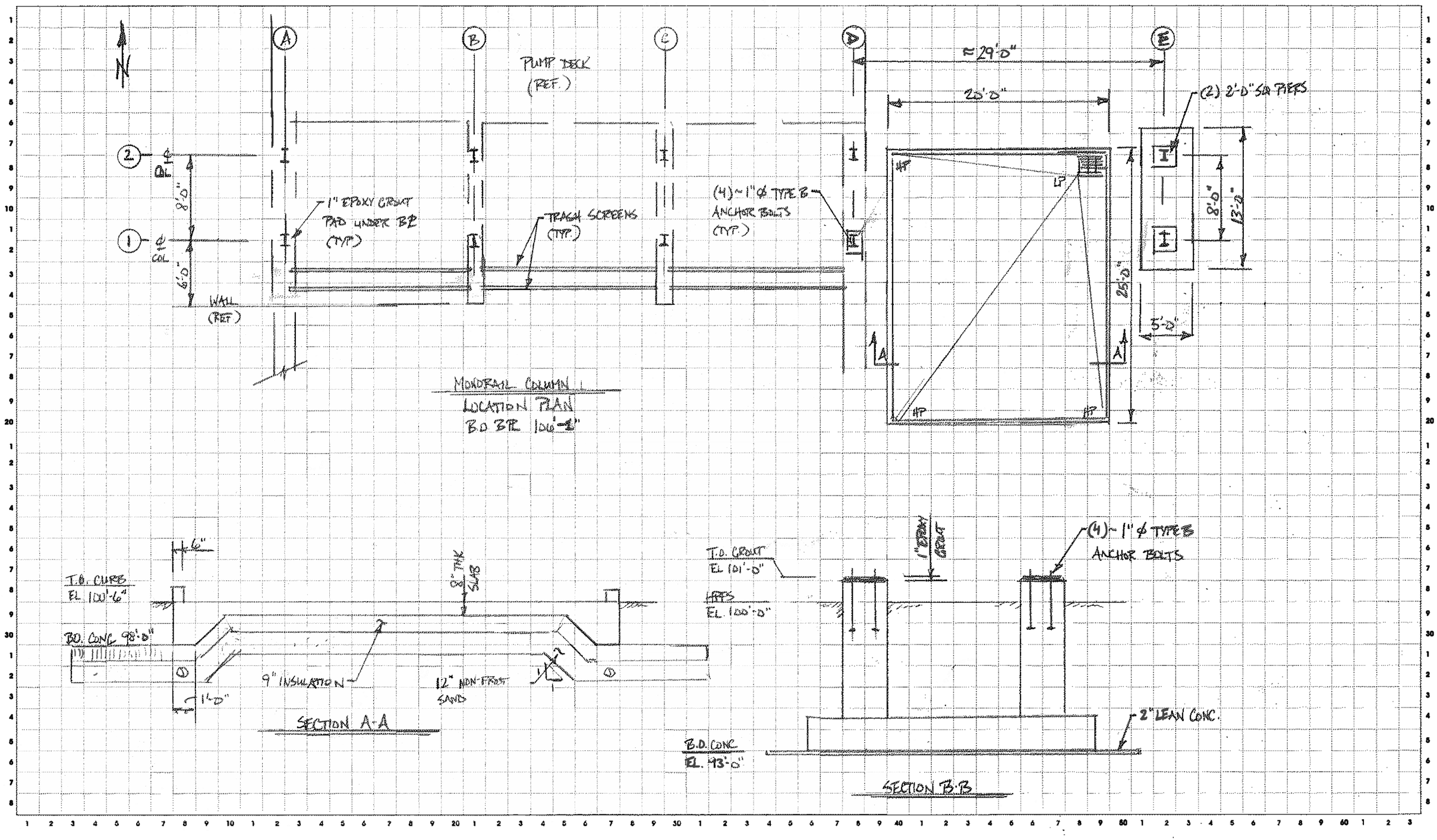
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CALCULATIONS AND SKETCHES

FORM E52 (Rev. 2-05)

CCS-X-701 COOLING TOWER MONORAIL STEEL, TRASH SCREENS, LAYDOWN SLABS, & FDN'S

DATE 21-OCT-2020
CONT. NO. M1NN
BY CTK CHK'D
SHEET NO. EC-CCS-0005-01

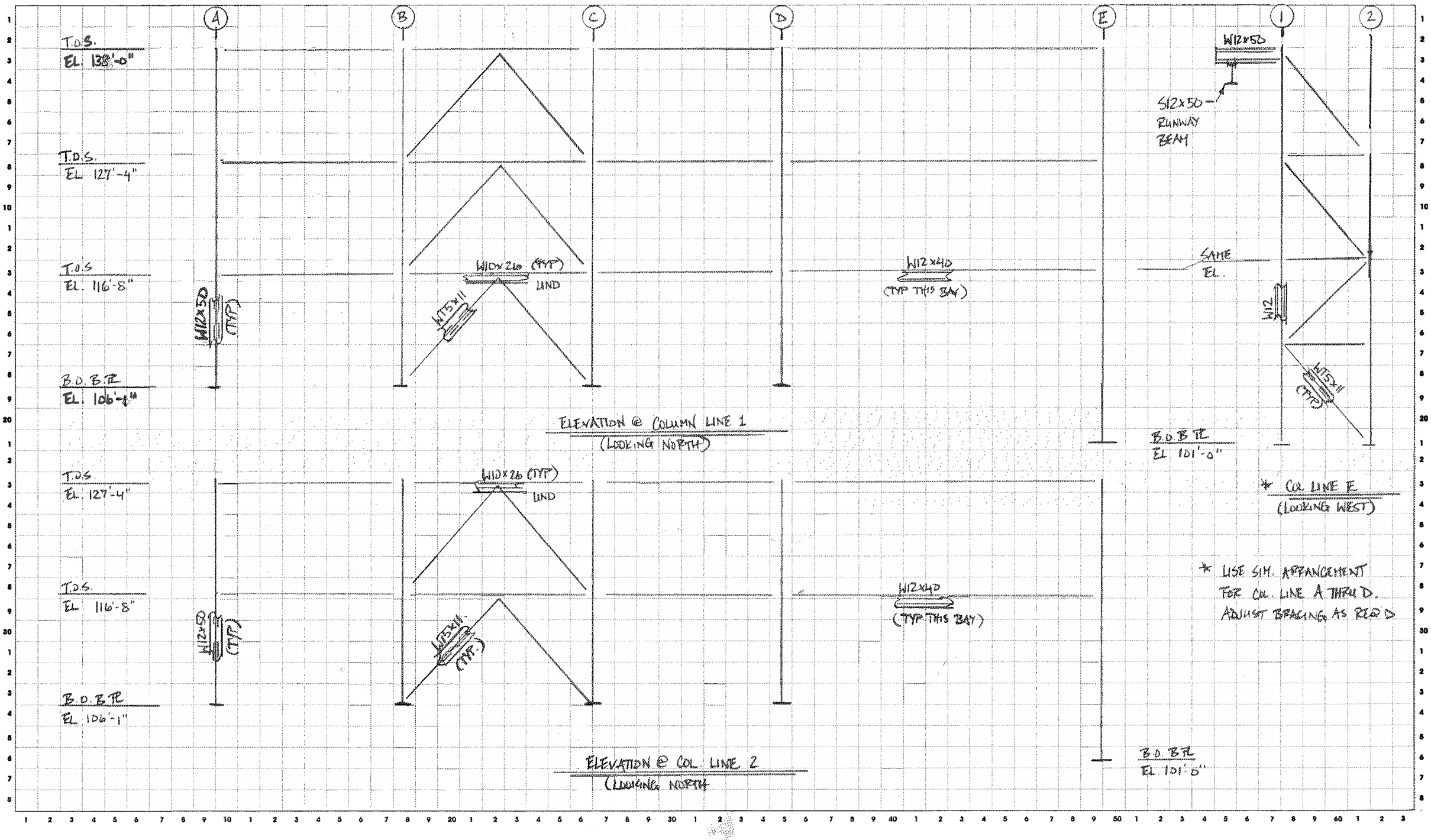


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CALCULATIONS AND SKETCHES

DATE 21-OCT-2020
CONT. NO. MINN
BY DK CHK'D
SHEET NO. EC-CCS-0005-01

FORM E52 (Rev. 2-05) CCS-X-701 COOLING TOWER MONORAIL FRAMING



ATTACHMENT 8 – ARCHITECTURAL DESIGN DRAWINGS

DRAWING NUMBER	DRAWING DESCRIPTION	REVISION	REVISION DATE
M1NN-CCS-DWG-220-00010	DRAWING INDEX LIST	C	11DEC2020
M1NN-CCS-DWG-220-00011	CONCEPTUAL FLOOR PLAN	C	11DEC2020
M1NN-CCS-DWG-220-00012	EXTERIOR ELEVATIONS	C	11DEC2020

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
A	09SEP20	ISSUED FOR INTERNAL REVIEW	VA	RM	JP
B	29SEP20	ISSUED FOR CLIENT REVIEW	RM	TR	JP
C	11DEC20	ISSUED FOR FEED	RM	TR	JP

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV

REFERENCE DWG NUMBER	REFERENCE DRAWINGS

FLUOR®

CONTRACT M1NN

CONTRACT	M1NN
DESIGNED BY	V. AU
CHECKED BY	R. MARTINEZ
SUPERVISOR	T. RISHFORTH
LEAD ENGR/SPEC.	J. PATEL
FLUOR	
CLIENT	

APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA

CARBON CAPTURE AND SEQUESTRATION

PROCESS ENCLOSURE CCS-PRE-001

DRAWING INDEX LIST

SCALE: 1"=1"

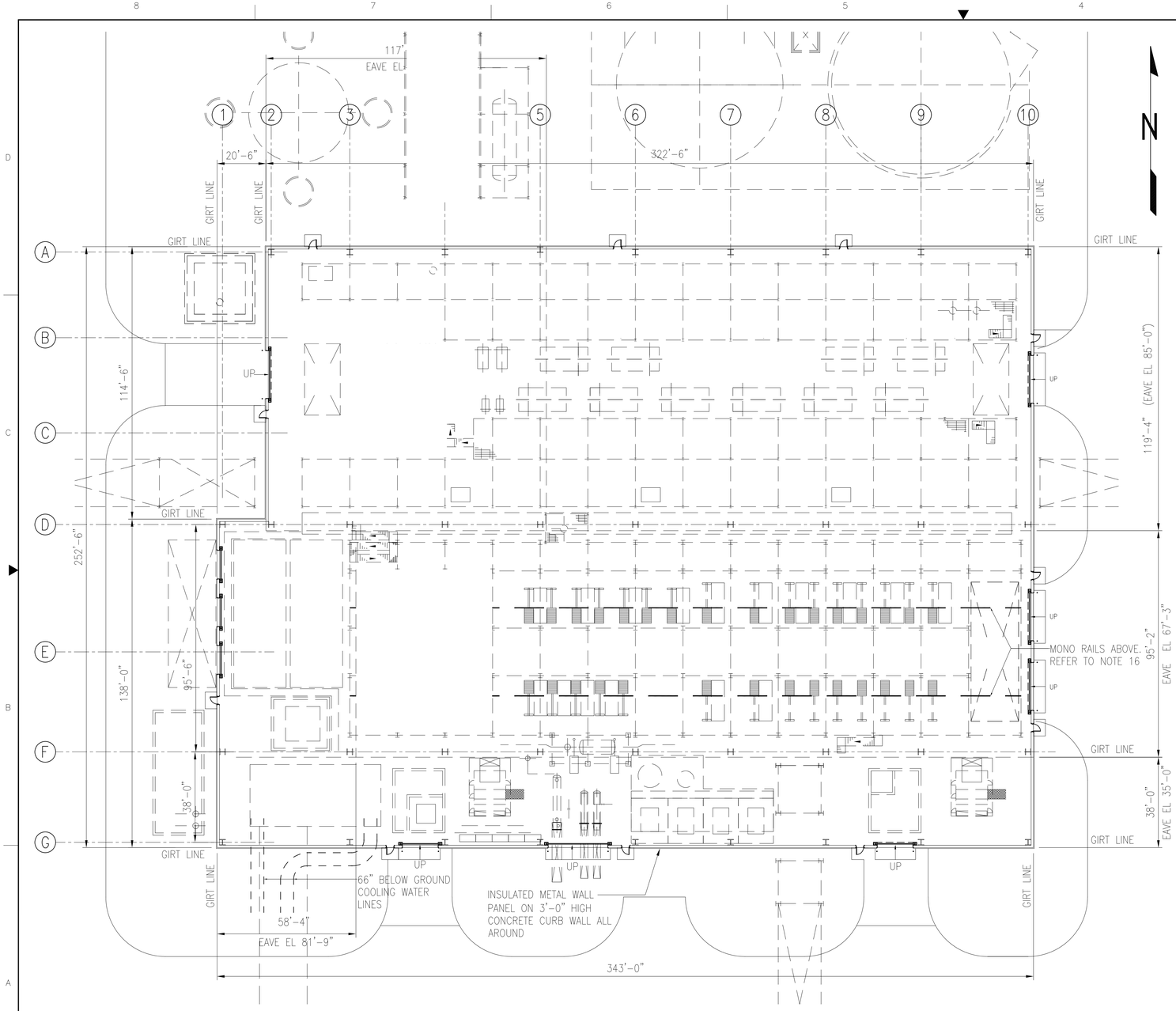
DRAWING NUMBER: M1NN-CCS-DWG-220-00010

REV: C

CAD FILE NAME: M1NN-CCS-DWG-220-00010_C.dwg

F-D22.DWG 01JUL09

PLOT DATE: Z:\CAD\220_ARCHITECTURAL\01 Process Enclosure\03 IFF\M1NN-CCS-DWG-220-00010_C.dwg 12-10-20 5:16 pm Printed By: mar1144G



GENERAL NOTES:

1. THIS DRAWING IS NOT FOR CONSTRUCTION PURPOSES. DESIGN BUILD CONTRACTOR WILL BE RESPONSIBLE FOR THE ISSUED FOR CONSTRUCTION (IFC) DRAWING.
2. ISSUED FOR FEED (IFF) DRAWINGS ARE CONCEPTUAL DESIGN DRAWING ONLY. DETAILED DESIGN TO BE DONE BY THE IFC ARCHITECT OF RECORD.
3. THE INFORMATION CONTAINED IN "GENERAL CODE DATA" WAS COMPLIED BY AND FOR THE EXCLUSIVE USE OF THE ARCHITECT IN THE DESIGN OF HIS PORTION OF THE WORK. IT IS ALSO INTENDED TO IDENTIFY TO THE AUTHORITIES HAVING JURISDICTION THE ARCHITECTS INTERPRETATION OF THE CODE. THE INFORMATION IS EXCERPTED FROM THE CODE UNLESS INDICATED OTHERWISE. IT IS INTENDED TO IDENTIFY REQUIREMENTS FOR THIS STRUCTURE PRIMARILY IN TERMS OF OCCUPANCY, CONSTRUCTION TYPE, EGRESS AND OTHER MISC ISSUES.
4. THIS INFORMATION IS NOT INTENDED TO INCLUDE ALL APPLICABLE PORTIONS OF THE CODE OR OTHER APPLICABLE CODES AND GOVERNING REGULATIONS. IT IS ALSO NOT INTENDED TO DIMINISH THE IMPORTANCE OR RELEVANCE OF OTHER PORTIONS OF CODES AND REGULATIONS THAT ARE APPLICABLE TO THE WORK CONTAINED IN THE DRAWING AND SPECIFICATIONS.
5. THE CODE DATA PROVIDED IS CONCEPTUAL AND CONSULTANTS, CONTRACTORS, MANUFACTURERS AND OTHER PARTIES THAT HAVE OR WILL PERFORM DESIGN OR CONSTRUCTION SERVICES ON THIS STRUCTURE SHALL NOT RELY ON THE INFORMATION IN THE PERFORMANCE OF THEIR WORK. EACH SUCH PARTY SHALL BE RESPONSIBLE FOR THEIR OWN REVIEW AND COMPLIANCE OF CODES AND REGULATIONS.
6. THE DETAILED ENGINEERING CONTRACTOR SHALL PERFORM CODE REVIEW INCLUDING (BUT NOT LIMITED TO) IBC, IPC AND OTHER APPLICABLE LOCAL REGULATIONS.
7. ALL DIMENSIONS ARE IN FEET AND INCHES UNLESS OTHERWISE STATED.
8. ALL ELEVATIONS ARE BASED ON HPFS EL. 1988 FT.
9. THIS DRAWING SET SHALL BE READ IN CONJUNCTION WITH PROJECT SPECIFICATIONS, BUILDING DESIGN NARRATIVE AND ALL RELEVANT DRAWINGS.
10. ALL DIMENSIONS AND DETAILS SHOWN ARE INDICATIVE AND FOR INFORMATION ONLY. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE DETAILED DESIGN OF ALL ARCHITECTURAL AND BUILDING SUPERSTUCTURE STRUCTURAL WORKS.
11. FINAL REQUIREMENTS FOR ELECTRICAL, HVAC, FIRE PROTECTION, PLUMBING, SECURITY AND CONTROL SYSTEM SHALL BE CONFIRMED DURING DETAILED DESIGN PHASE.
12. FOR BUILDING PHILOSOPHY, REFER TO DOCUMENT NUMBER M1NN-CCS-PHL-220-00001.
13. FOR PROJECT SPECIFICATIONS, REFER TO DOCUMENT NUMBER M1NN-CCS-SPC-220-00001 TO 00005.
14. ADDITIONAL ITEMS TO BE FINALIZED DURING DETAILED PHASE:
    - -BUILDING HEIGHT
    - -WALL HEIGHT
    - -HAZARD CLASSIFICATION
    - -FINISH FLOOR AND STAIR LANDING ELEVATION
    - -TYPE OF FIRE PROTECTION/SUPPRESSION SYSTEM
    - -DOOR WIDTH AND HEIGHT
    - -LOUVERS AND WALL PENETRATIONS SIZES/LOCATIONS
    - -TELECOM CABINET AND ELECTRICAL PANEL & TRANSFORMER LOCATION
    - -SAFETY EYEWASH/SHOWER LOCATION AND QUANTITY
    - -FIRE BARRIER/DOOR RATINGS
    - -GUARD RAIL REQUIREMENT
15. FOR SITE INFORMATION REFER TO PLOT PLAN M1NN-CCS-PLN-250-00001.
16. BUILDING CONTRACTOR SHALL SUPPORT FOR TWO 25 TON MONORAILS FOR TROLLEY/HOIST OFF OF BUILDING ROOF FRAMING AT BOTTOM OF STEEL ELEVATION 57'-0" FROM FINISH FLOOR.

THIS DRAWING IS ISSUED AS A CONCEPTUAL DRAWING FOR PRICING PURPOSES ONLY ON THE DATE INDICATED. THIS DRAWING IS NOT TO BE USED FOR CONSTRUCTION OR AS THE BASIS FOR THE ISSUANCE OF A PERMIT. THE ARCHITECT OF RECORD FOR IFC DOCUMENTS SHALL USE THESE CONCEPTUAL DRAWINGS AS A BASIS FOR THEIR FINAL IFC DOCUMENTS DESIGN AND SHALL BE RESPONSIBLE FOR THEIR OWN REVIEW AND COMPLIANCE OF CODES AND REGULATIONS.

GENERAL CODE DATA

(BASED ON IBC 2018 AND NORTH DAKOTA STATE BUILDING CODE JANUARY 1, 2020)

MAJOR OCCUPANCY	MODERATE-HAZARD FACTORY INDUSTRIAL, F-1	
TYPE OF CONSTRUCTION	TYPE I-B	
FIRE RATED WALLS	AS REQUIRED PER DETAILED CODE ANALYSIS	
COMPLIANCE TO ADA	REQUIRED / ADA 2010	
FIRE SUPPRESSION SYSTEM	AUTOMATIC SPRINKLERS SYSTEM INSTALLED IN ACCORDANCE WITH SECTION 903.2.5	
FIRE DETECTION SYSTEM	REQUIRED FIRE DETECTION SYSTEM	
	ALLOWABLE	ACTUAL
FLOOR AREA	UNLIMITED	84,260 SQ. FT.
OCCUPANT LOAD @ 100 GROSS:	100 SQ FT/PERSON	0
HEIGHT (AVG OF HIGHEST ROOF)	180 FT	160 FT
TRAVEL DISTANCE TO EXIT	(IBC 2015 TABLE 1017.2.)	
WITH FIRE SPRINKLER	250 FT	150 FT
CORRIDOR WIDTH (2018 IBC TAB 1020.2)	36" SERVING LESS THAN 50 OCC. 24" FOR EQUIPMENT ACCESS	-

0 10' 20' 40' 60' 80'

SCALE: 1"=25'-0"

FLOOR PLAN — SCALE : 1"=25'-0" — 01

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
A	09SEP20	ISSUED FOR INTERNAL REVIEW	VA	RM	JP
B	29SEP20	ISSUED FOR CLIENT REVIEW	RM	TR	JP
C	11DEC20	ISSUED FOR FEED	RM	TR	JP

REFERENCE DWG NUMBER	REFERENCE DRAWINGS
M1NN-CCS-DWG-220-00010	PROCESS ENCLOSURE CCS-PRE-001 - DRAWING INDEX LIST
M1NN-CCS-DWG-220-00012	PROCESS ENCLOSURE CCS-PRE-001 - EXTERIOR ELEVATIONS

FLUOR

CONTRACT M1NN

CONTRACT	M1NN
DESIGNED BY	V. AU
CHECKED BY	R. MARTINEZ
SUPERVISOR	T. RISHFORTH
LEAD ENGR/SPEC.	J. PATEL
FLUOR	
CLIENT	

APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA
CARBON CAPTURE AND SEQUESTRATION

ARCHITECTURAL
PROCESS ENCLOSURE CCS-PRE-001
CONCEPTUAL FLOOR PLAN

SCALE 1"=25'-0"

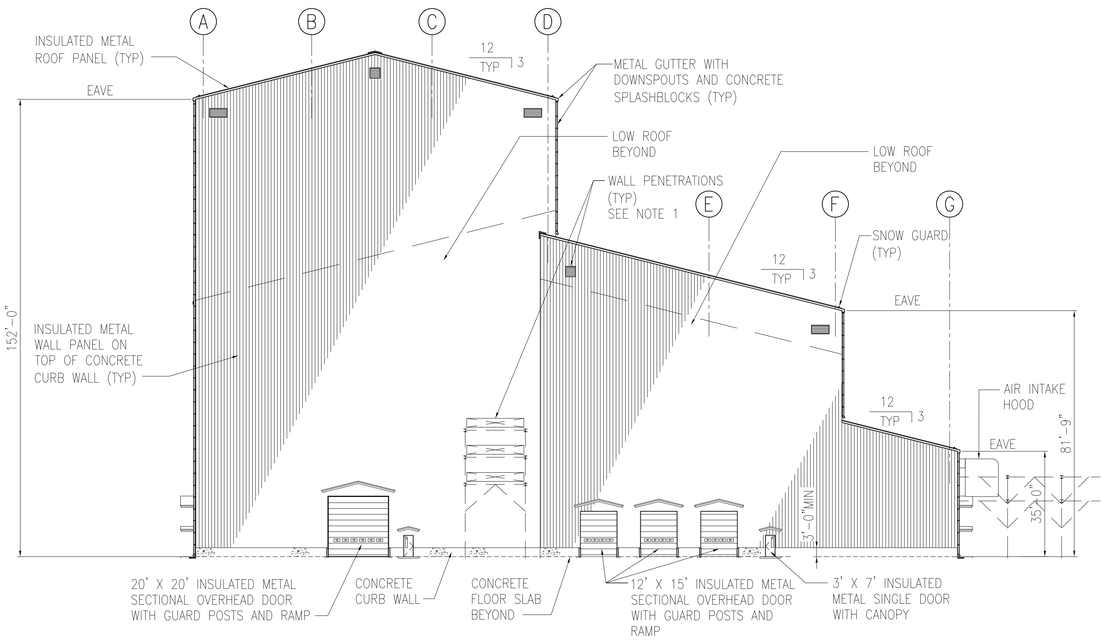
DRAWING NUMBER M1NN-CCS-DWG-220-00011

REV C

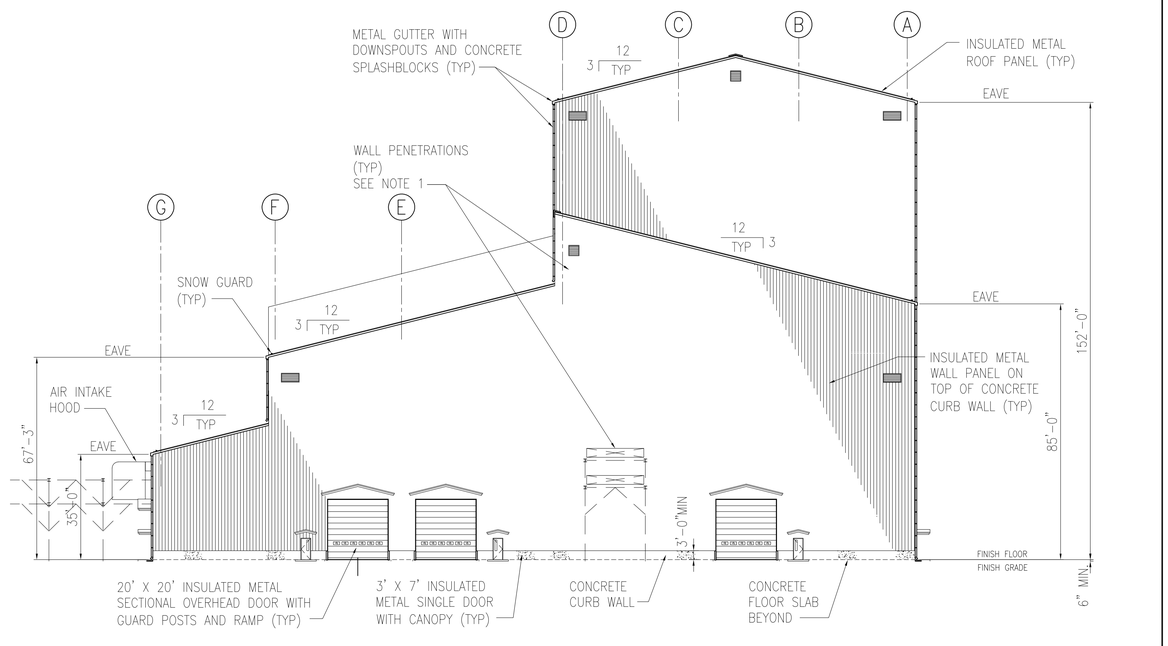
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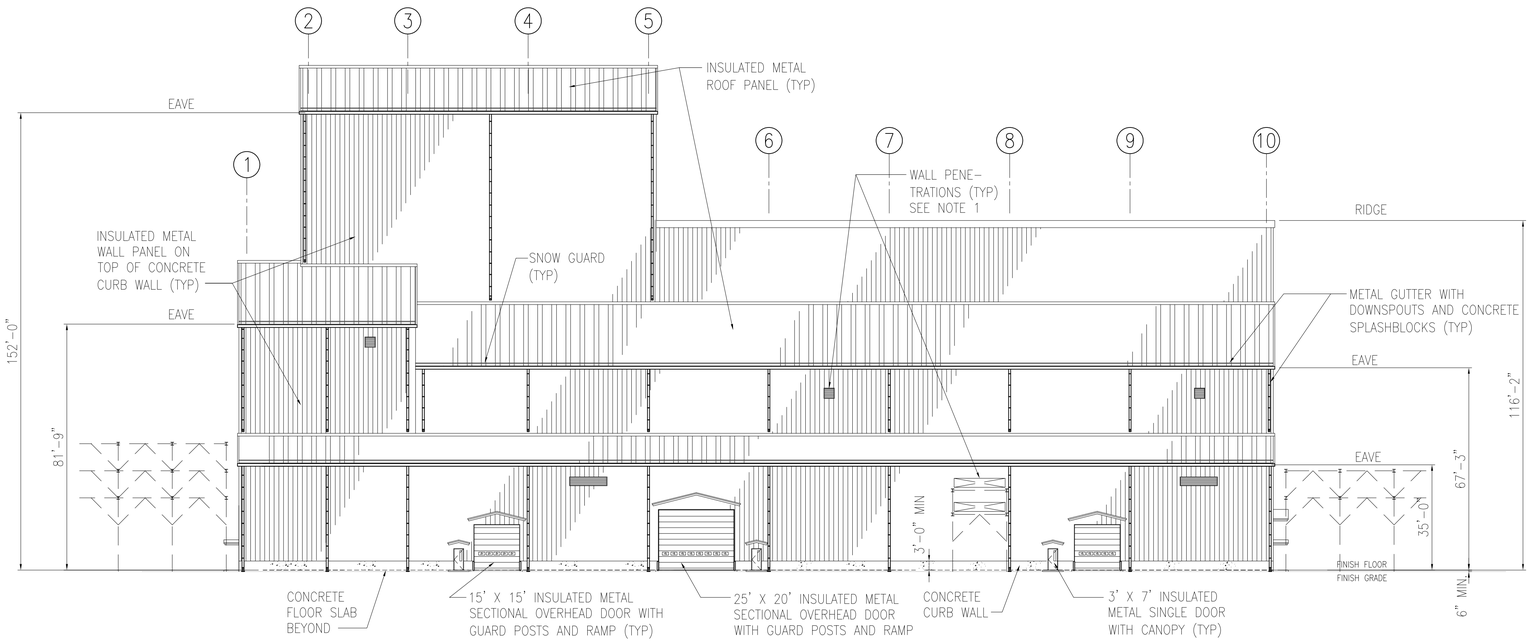
F-022.DWG 01JUL09



WEST ELEVATION | SCALE: 1"=25'-0" | 03



EAST ELEVATION | SCALE: 1"=25'-0" | 02



SOUTH ELEVATION | SCALE: 1"=25'-0" | 01

NOTES:

1. WALL OPENINGS ARE FOR CONCEPTUAL PURPOSES ONLY. WALL OPENINGS SHALL BE FINALIZED DURING DETAIL DESIGN.

0 10' 20' 40' 60' 80'
SCALE: 1"=25'-0"

THIS DRAWING IS ISSUED AS A CONCEPTUAL DRAWING FOR PRICING PURPOSES ONLY ON THE DATE INDICATED. THIS DRAWING IS NOT TO BE USED FOR CONSTRUCTION OR AS THE BASIS FOR THE ISSUANCE OF A PERMIT. THE ARCHITECT OF RECORD FOR IFC DOCUMENTS SHALL USE THESE CONCEPTUAL DRAWINGS AS A BASIS FOR THEIR FINAL IFC DOCUMENTS DESIGN AND SHALL BE RESPONSIBLE FOR THEIR OWN REVIEW AND COMPLIANCE OF CODES AND REGULATIONS.

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
A	09SEP20	ISSUED FOR INTERNAL REVIEW	VA	RM	JP
B	29SEP20	ISSUED FOR CLIENT REVIEW	RM	TR	JP
C	11DEC20	ISSUED FOR FEED	RM	TR	JP

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV

REFERENCE DWG NUMBER	REFERENCE DRAWINGS
M1NN-CCS-DWG-220-00010	PROCESS ENCLOSURE CCS-PRE-001 - DRAWING INDEX LIST
M1NN-CCS-DWG-220-00011	PROCESS ENCLOSURE CCS-PRE-001 - CONCEPTUAL FLOOR PLAN

FLUOR®
CONTRACT M1NN

CONTRACT	M1NN
DESIGNED BY	V. AU
CHECKED BY	R. MARTINEZ
SUPERVISOR	T. RISHFORTH — APP DATE
LEAD ENGR/SPEC.	J. PATEL — APP DATE
FLUOR	APP DATE
CLIENT	APP DATE

MINNKOTA POWER COOPERATIVE
PROJECT TUNDRA
CARBON CAPTURE AND SEQUESTRATION

PROCESS ENCLOSURE CCS-PRE-001 EXTERIOR ELEVATIONS

SCALE	DRAWING NUMBER	REV
1"=25'-0"	M1NN-CCS-DWG-220-00012	C

CAD FILE NAME M1NN-CCS-DWG-220-00012_C.dwg

PLOT DATE: Z:\CAD\220_ARCHITECTURAL\01 Process Enclosure\03 IFF\M1NN-CCS-DWG-220-00012_C.dwg 12-10-20 5:19 pm Printed By: mar1144G

F-022.DWG 01JUL09

DRAWING NUMBER	DRAWING DESCRIPTION	REVISION	REVISION DATE
M1NN-CCS-DWG-220-00020	DRAWING INDEX LIST	C	11DEC2020
M1NN-CCS-DWG-220-00021	CONCEPTUAL FLOOR PLAN	C	11DEC2020
M1NN-CCS-DWG-220-00022	EXTERIOR ELEVATIONS	C	11DEC2020

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
A	09SEP20	ISSUED FOR INTERNAL REVIEW	VA	RM	JP
B	29SEP20	ISSUED FOR CLIENT REVIEW	RM	TR	JP
C	11DEC20	ISSUED FOR FEED	RM	TR	JP

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV

REFERENCE DWG NUMBER	REFERENCE DRAWINGS

FLUOR®

CONTRACT M1NN

CONTRACT	M1NN
DESIGNED BY	V. AU
CHECKED BY	R. MARTINEZ
SUPERVISOR	T. RISHFORTH
LEAD ENGR/SPEC.	J. PATEL
FLUOR	
CLIENT	

APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA

CARBON CAPTURE AND SEQUESTRATION

R

COMPRESSOR ENCLOSURE CCS-COE-001

DRAWING INDEX LIST

SCALE 1"=1"

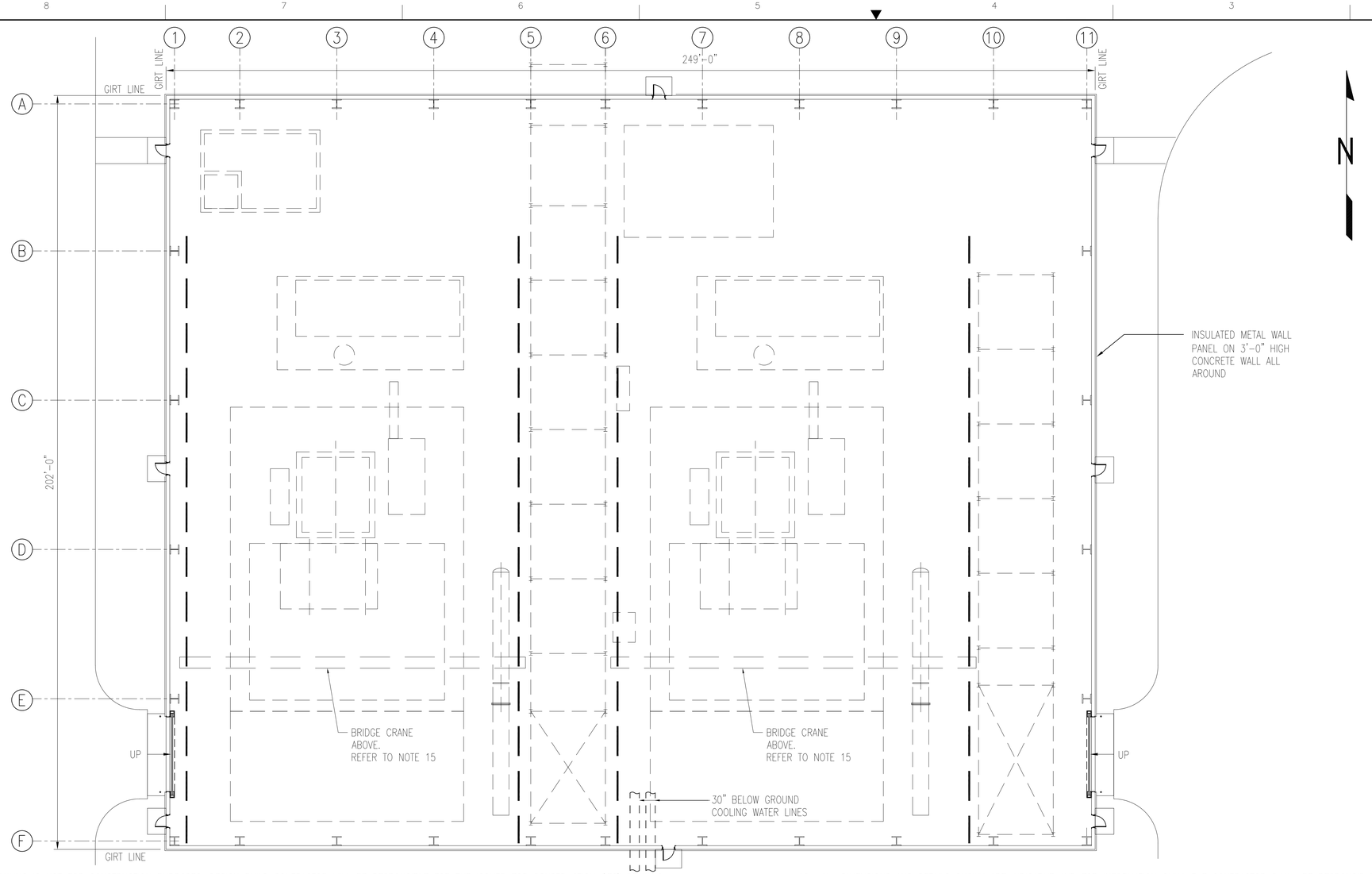
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REV C

CAD FILE NAME M1NN-CCS-DWG-220-00020_C.dwg

F-D22.DWG 01JUL09

PLOT DATE: Z:\CAD\220_ARCHITECTURAL\02 Compressor Enclosure\03 IFF\M1NN-CCS-DWG-220-00020_C.dwg 12-10-20 5:59 pm Printed By: mar1144G



1. THIS DRAWING IS NOT FOR CONSTRUCTION PURPOSES. DESIGN BUILD CONTRACTOR WILL BE RESPONSIBLE FOR THE ISSUED FOR CONSTRUCTION (IFC) DRAWING.
2. ISSUED FOR FEED (IFF) DRAWINGS ARE CONCEPTUAL DESIGN DRAWING ONLY. DETAILED DESIGN TO BE DONE BY THE IFC ARCHITECT OF RECORD.
3. THE INFORMATION CONTAINED IN "GENERAL CODE DATA" WAS COMPLIED BY AND FOR THE EXCLUSIVE USE OF THE ARCHITECT IN THE DESIGN OF HIS PORTION OF THE WORK. IT IS ALSO INTENDED TO IDENTIFY TO THE AUTHORITIES HAVING JURISDICTION THE ARCHITECTS INTERPRETATION OF THE CODE. THE INFORMATION IS EXCERPTED FROM THE CODE UNLESS INDICATED OTHERWISE. IT IS INTENDED TO IDENTIFY REQUIREMENTS FOR THIS STRUCTURE PRIMARILY IN TERMS OF OCCUPANCY, CONSTRUCTION TYPE, EGRESS AND OTHER MISC ISSUES.
4. THIS INFORMATION IS NOT INTENDED TO INCLUDE ALL APPLICABLE PORTIONS OF THE CODE OR OTHER APPLICABLE CODES AND GOVERNING REGULATIONS. IT IS ALSO NOT INTENDED TO DIMINISH THE IMPORTANCE OR RELEVANCE OF OTHER PORTIONS OF CODES AND REGULATIONS THAT ARE APPLICABLE TO THE WORK CONTAINED IN THE DRAWING AND SPECIFICATIONS.
5. THE CODE DATA PROVIDED IS CONCEPTUAL AND CONSULTANTS, CONTRACTORS, MANUFACTURERS AND OTHER PARTIES THAT HAVE OR WILL PERFORM DESIGN OR CONSTRUCTION SERVICES ON THIS STRUCTURE SHALL NOT RELY ON THE INFORMATION IN THE PERFORMANCE OF THEIR WORK. EACH SUCH PARTY SHALL BE RESPONSIBLE FOR THEIR OWN REVIEW AND COMPLIANCE OF CODES AND REGULATIONS.
6. THE DETAILED ENGINEERING CONTRACTOR SHALL PERFORM CODE REVIEW INCLUDING (BUT NOT LIMITED TO) IBC, IPC, NFPA 101 AND OTHER APPLICABLE LOCAL REGULATIONS.
7. ALL DIMENSIONS ARE IN FEET AND INCHES UNLESS OTHERWISE STATED.
8. ALL ELEVATIONS ARE BASED ON HPFS EL. 1988 FT.
9. THIS DRAWING SET SHALL BE READ IN CONJUNCTION WITH PROJECT SPECIFICATIONS, BUILDING DESIGN NARRATIVE AND ALL RELEVANT DRAWINGS.
10. ALL DIMENSIONS AND DETAILS SHOWN ARE INDICATIVE AND FOR INFORMATION ONLY. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE DETAILED DESIGN OF ALL ARCHITECTURAL AND BUILDING SUPERSTUCTURE STRUCTURAL WORKS.
11. FINAL REQUIREMENTS FOR ELECTRICAL, HVAC, FIRE PROTECTION, PLUMBING, SECURITY AND CONTROL SYSTEM SHALL BE CONFIRMED DURING DETAILED DESIGN PHASE.
12. FOR PROJECT SPECIFICATIONS, REFER TO DOCUMENT NUMBER M1NN-CCS-SPC-220-00001 TO 00005.
13. ADDITIONAL ITEMS TO BE FINALIZED DURING DETAILED PHASE:
    - -BUILDING HEIGHT
    - -WALL HEIGHT
    - -HAZARD CLASSIFICATION
    - -FINISH FLOOR AND STAIR LANDING ELEVATION
    - -TYPE OF FIRE PROTECTION/SUPPRESSION SYSTEM
    - -DOOR WIDTH AND HEIGHT
    - -LOUVERS AND WALL PENETRATIONS SIZES/LOCATIONS
    - -TELECOM CABINET AND ELECTRICAL PANEL & TRANSFORMER LOCATION
    - -SAFETY EYEWASH/SHOWER LOCATION AND QUANTITY
    - -FIRE BARRIER/DOOR RATINGS
    - -GUARD RAIL REQUIREMENT
14. FOR SITE INFORMATION REFER TO PLOT PLAN M1NN-CCS-PLN-250-00001
15. BRIDGE CRANES WILL BE PROVIDED BY COMPANY. BUILDING CONTRACTOR TO ACCOUNT FOR TWO 60 TON BRIDGE CRANES SUPPORT AT TOP OF STEEL ELEVATION 51'-6" FROM FINISH FLOOR. THE RUNWAY BEAMS WILL BE IN THE BUILDING CONTRACTOR'S SCOPE.

LEGEND :

0 10' 20' 40' 60'

SCALE: 1/16"=1'-0"

THIS DRAWING IS ISSUED AS A CONCEPTUAL DRAWING FOR PRICING PURPOSES ONLY ON THE DATE INDICATED. THIS DRAWING IS NOT TO BE USED FOR CONSTRUCTION OR AS THE BASIS FOR THE ISSUANCE OF A PERMIT. THE ARCHITECT OF RECORD FOR IFC DOCUMENTS SHALL USE THESE CONCEPTUAL DRAWINGS AS A BASIS FOR THEIR FINAL IFC DOCUMENTS DESIGN AND SHALL BE RESPONSIBLE FOR THEIR OWN REVIEW AND COMPLIANCE OF CODES AND REGULATIONS.

GENERAL CODE DATA

(BASED ON IBC 2018 AND NORTH DAKOTA STATE BUILDING CODE JANUARY 1, 2020)

MAJOR OCCUPANCY	MODERATE-HAZARD FACTORY INDUSTRIAL, F-1	
TYPE OF CONSTRUCTION	TYPE II-B	
FIRE RATED WALLS	AS REQUIRED PER DETAILED CODE ANALYSIS	
COMPLIANCE TO ADA	REQUIRED / ADA 2010	
FIRE SUPPRESSION SYSTEM	AUTOMATIC SPRINKLER SYSTEM INSTALLED IN ACCORDANCE WITH SECTION 903.2.5.	
FIRE DETECTION SYSTEM	REQUIRED FIRE DETECTION SYSTEM	
	ALLOWABLE	ACTUAL
FLOOR AREA	62,000 SQ. FT.	50,298 SQ. FT.
OCCUPANT LOAD @ 100 GROSS:	100 SQ FT/PERSON	0
HEIGHT (AVG OF HIGHEST ROOF)	75 FT	75 FT
TRAVEL DISTANCE TO EXIT	(IBC 2015 TABLE 1017.2.)	
WITH FIRE SPRINKLER	250 FT	100 FT
CORRIDOR WIDTH (2018 IBC TAB 1020.2)	36 IN SERVING < 50 OCC. 24 IN FOR EQUIPMENT ACCESS	-

FLOOR PLAN AND GENERAL NOTES

SCALE: 1/16"=1'-0" | 01

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
A	09SEP20	ISSUED FOR INTERNAL REVIEW	VA	RM	JP
B	29SEP20	ISSUED FOR CLIENT REVIEW	RM	TR	JP
C	11DEC20	ISSUED FOR FEED	RM	TR	JP

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV

REFERENCE DWG NUMBER	REFERENCE DRAWINGS
M1NN-CCS-DWG-220-00020	COMPRESSOR ENCLOSURE CCS-COE-001 - DRAWING INDEX LIST
M1NN-CCS-DWG-220-00022	COMPRESSOR ENCLOSURE CCS-COE-001 - EXTERIOR ELEVATIONS

FLUOR®

CONTRACT M1NN

CONTRACT	M1NN
DESIGNED BY	V. AU
CHECKED BY	R. MARTINEZ
SUPERVISOR	T. RISHFORTH
LEAD ENGR/SPEC.	J. PATEL
FLUOR	
CLIENT	

APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA

CARBON CAPTURE AND SEQUESTRATION

ARCHITECTURAL

COMPRESSOR ENCLOSURE CCS-COE-001

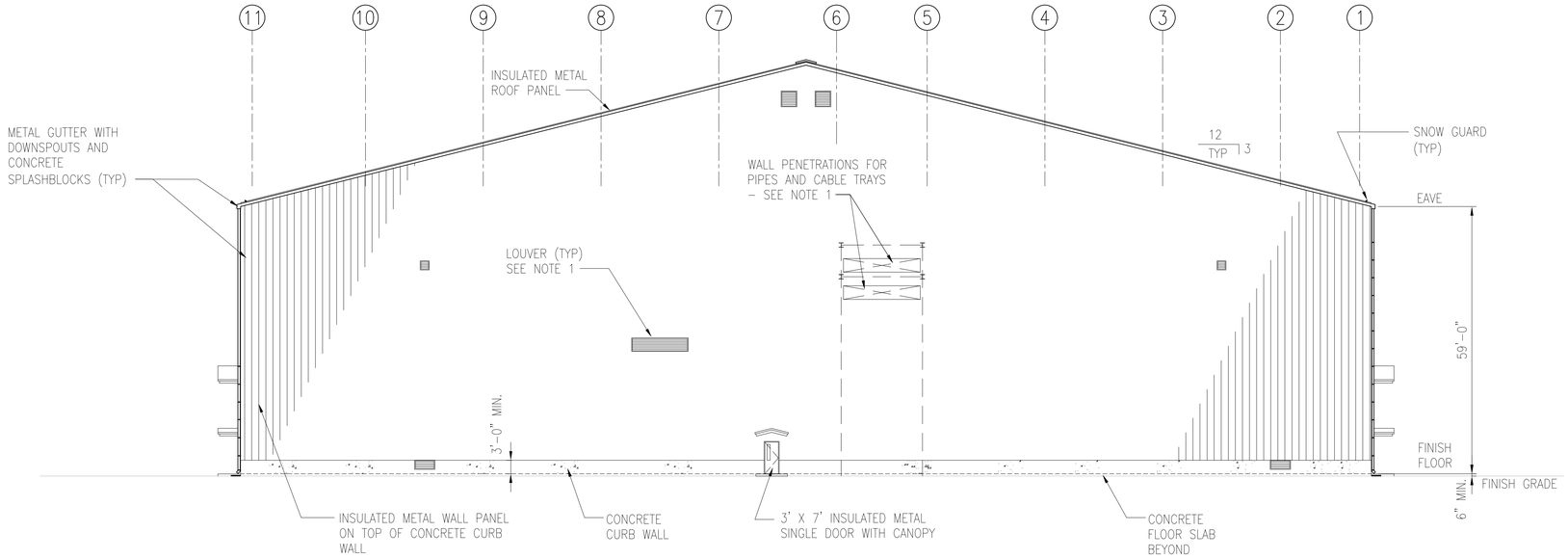
CONCEPTUAL FLOOR PLAN

SCALE	DRAWING NUMBER	REV
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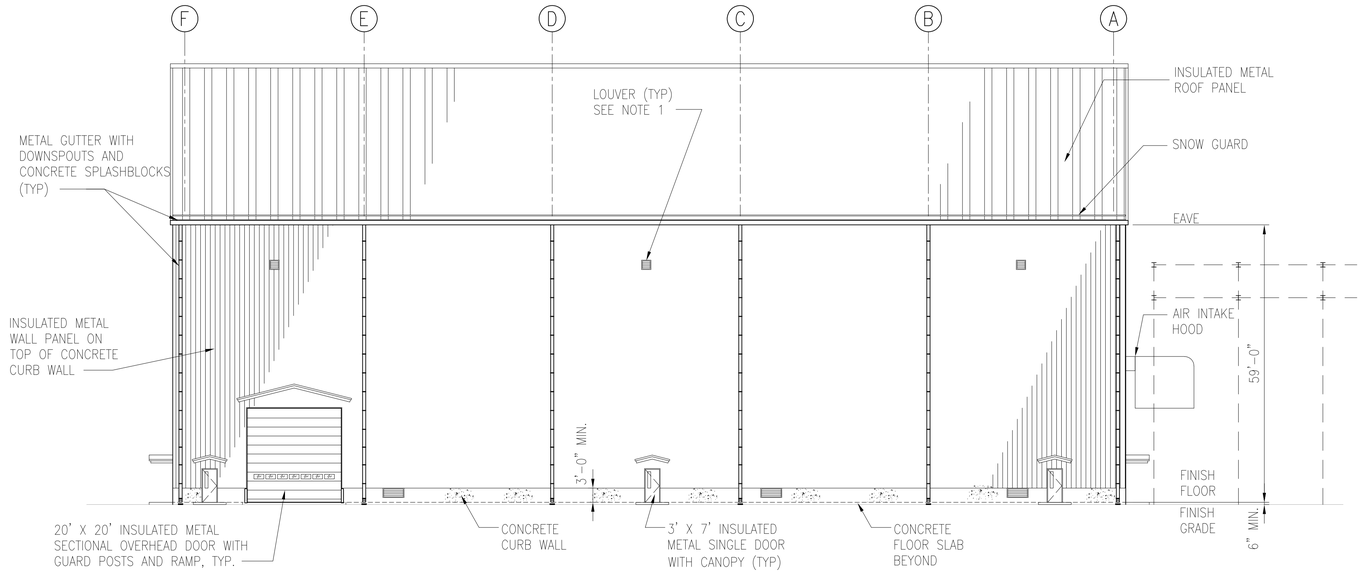
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F-R22.DWG 01JUL09



NORTH ELEVATION — SCALE: 1/16"=1'-0" — 02



EAST ELEVATION (AS SHOWN) / WEST ELEVATION (OPPOSITE HAND) — SCALE: 1/16"=1'-0" — 01

NOTES:

1. WALL AND ROOF PENETRATIONS FOR HVAC, PIPES AND CABLE TRAYS ARE FOR CONCEPTUAL PURPOSES ONLY. WALL PENETRATIONS SHALL BE FINALIZED DURING DETAIL DESIGN.

0 10' 20' 40' 60'
SCALE: 1/16"=1'-0"

THIS DRAWING IS ISSUED AS A CONCEPTUAL DRAWING FOR PRICING PURPOSES ONLY ON THE DATE INDICATED. THIS DRAWING IS NOT TO BE USED FOR CONSTRUCTION OR AS THE BASIS FOR THE ISSUANCE OF A PERMIT. THE ARCHITECT OF RECORD FOR IFC DOCUMENTS SHALL USE THESE CONCEPTUAL DRAWINGS AS A BASIS FOR THEIR FINAL IFC DOCUMENTS DESIGN AND SHALL BE RESPONSIBLE FOR THEIR OWN REVIEW AND COMPLIANCE OF CODES AND REGULATIONS.

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
A	09SEP2020	ISSUED FOR INTERNAL REVIEW	VA	RM	JP
B	29SEP20	ISSUED FOR CLIENT REVIEW	RM	TR	JP
C	11DEC20	ISSUED FOR FEED	RM	TR	JP

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV

REFERENCE DWG NUMBER	REFERENCE DRAWINGS
M1NN-CCS-DWG-220-00020	COMPRESSOR ENCLOSURE CCS-COE-001 – DRAWING INDEX LIST
M1NN-CCS-DWG-220-00021	COMPRESSOR ENCLOSURE CCS-COE-001 – CONCEPTUAL FLOOR PLAN

FLUOR®
CONTRACT M1NN

CONTRACT	M1NN
DESIGNED BY	V. AU
CHECKED BY	R. MARTINEZ
SUPERVISOR T. RISHFORTH	APP DATE
LEAD ENGR/SPEC. J. PATEL	APP DATE
FLUOR	APP DATE
CLIENT	APP DATE

MINNKOTA POWER COOPERATIVE
PROJECT TUNDRA
CARBON CAPTURE AND SEQUESTRATION
ARCHITECTURAL
COMPRESSOR ENCLOSURE CCS-COE-001
EXTERIOR ELEVATIONS

SCALE	DRAWING NUMBER	REV
1/16"=1'-0"	M1NN-CCS-DWG-220-00022	C

CAD FILE NAME: M1NN-CCS-DWG-220-00022_C.dwg

PLOT DATE: Z:\CAD\220_ARCHITECTURAL\02 Compressor Enclosure\03 IFF\M1NN-CCS-DWG-220-00022_C.dwg 12-10-20 6:04 pm Printed By: mar1144G

F-022.DWG 01AUG09

DRAWING NUMBER	DRAWING DESCRIPTION	REVISION	REVISION DATE
M1NN-CCS-DWG-220-00030	DRAWING INDEX LIST	C	11DEC2020
M1NN-CCS-DWG-220-00031	CONCEPTUAL FLOOR PLAN	C	11DEC2020
M1NN-CCS-DWG-220-00032	EXTERIOR ELEVATIONS	C	11DEC2020

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
A	09SEP20	ISSUED FOR INTERNAL REVIEW	VA	RM	JP
B	29SEP20	ISSUED FOR CLIENT REVIEW	RM	TR	JP
C	11DEC20	ISSUED FOR FEED	RM	TR	JP

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV

REFERENCE DWG NUMBER	REFERENCE DRAWINGS

FLUOR®

CONTRACT M1NN

CONTRACT	M1NN
DESIGNED BY	V. AU
CHECKED BY	R. MARTINEZ
SUPERVISOR	T. RISHFORTH
LEAD ENGR/SPEC.	J. PATEL
FLUOR	
CLIENT	

APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA

CARBON CAPTURE AND SEQUESTRATION

ARCHITECTURAL

BOILER ENCLOSURE CCS-BOE-001

DRAWING INDEX LIST

SCALE 1"=1"

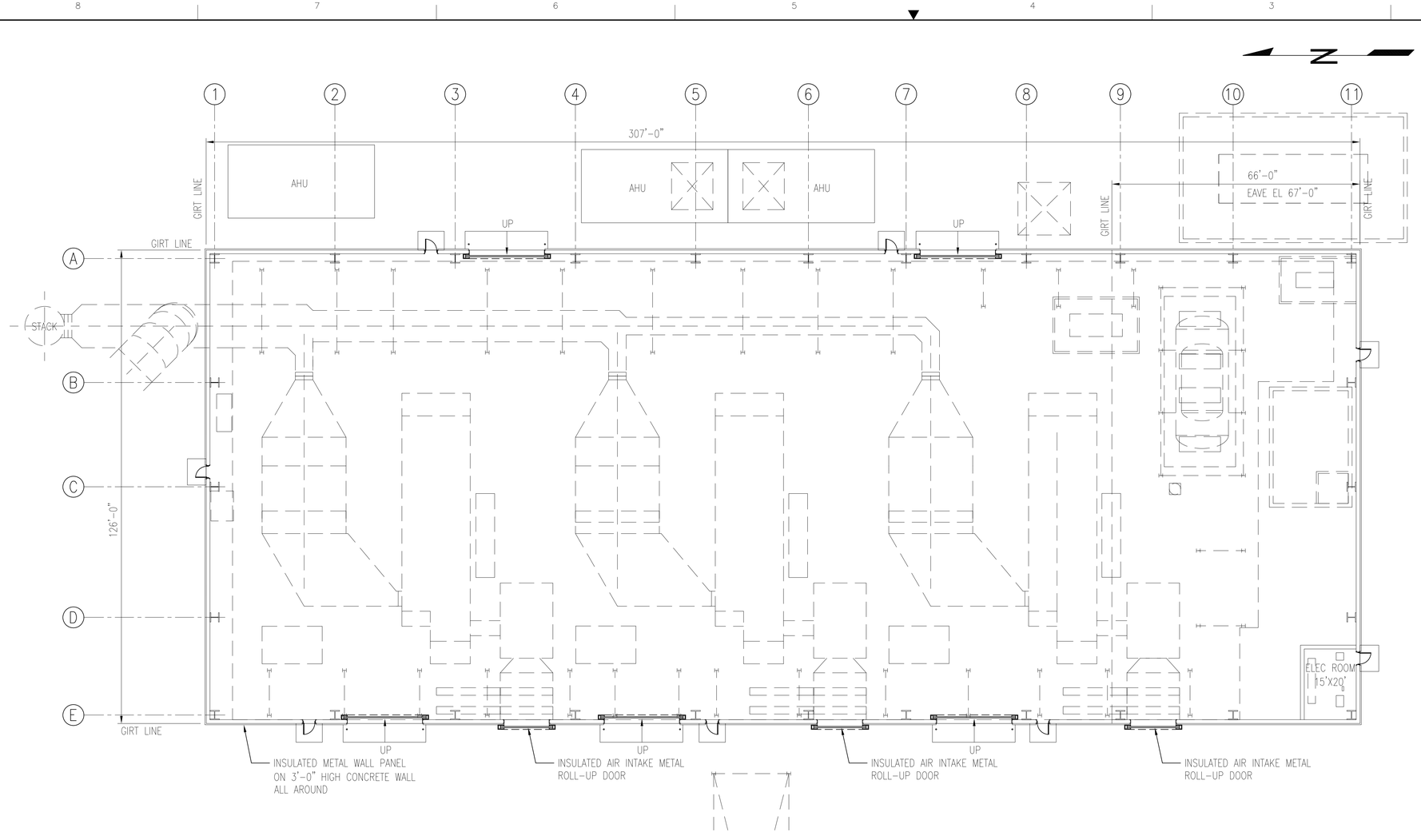
DRAWING NUMBER M1NN-CCS-DWG-220-00030

REV C

CAD FILE NAME M1NN-CCS-DWG-220-00030_C.dwg

PLOT DATE: Z:\CAD\220_ARCHITECTURAL\03 Boiler Building\03 IFF\M1NN-CCS-DWG-220-00030_C.dwg 12-10-20 8:36 pm Printed By: mar1144G

F-D22.DWG 01JUL09



FLOOR PLAN

SCALE: 1/16"=1'-0" | 01

1. THIS DRAWING IS NOT FOR CONSTRUCTION PURPOSES. DESIGN BUILD CONTRACTOR WILL BE RESPONSIBLE FOR THE ISSUED FOR CONSTRUCTION (IFC) DRAWING.
2. ISSUED FOR FEED (IFF) DRAWINGS ARE CONCEPTUAL DESIGN DRAWING ONLY. DETAILED DESIGN TO BE DONE BY THE IFC ARCHITECT OF RECORD.
3. THE INFORMATION CONTAINED IN "GENERAL CODE DATA" WAS COMPLIED BY AND FOR THE EXCLUSIVE USE OF THE ARCHITECT IN THE DESIGN OF HIS PORTION OF THE WORK. IT IS ALSO INTENDED TO IDENTIFY TO THE AUTHORITIES HAVING JURISDICTION THE ARCHITECTS INTERPRETATION OF THE CODE. THE INFORMATION IS EXCERPTED FROM THE CODE UNLESS INDICATED OTHERWISE. IT IS INTENDED TO IDENTIFY REQUIREMENTS FOR THIS STRUCTURE PRIMARILY IN TERMS OF OCCUPANCY, CONSTRUCTION TYPE, EGRESS AND OTHER MISC ISSUES.
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7. ALL DIMENSIONS ARE IN FEET AND INCHES UNLESS OTHERWISE STATED.
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11. FINAL REQUIREMENTS FOR ELECTRICAL, HVAC, FIRE PROTECTION, PLUMBING, SECURITY AND CONTROL SYSTEM SHALL BE CONFIRMED DURING DETAILED DESIGN PHASE.
12. FOR PROJECT SPECIFICATIONS, REFER TO DOCUMENT NUMBER M1NN-CCS-SPC-220-00001 TO 00005.
13. ADDITIONAL ITEMS TO BE FINALIZED DURING DETAILED PHASE:
    - -BUILDING HEIGHT
    - -WALL HEIGHT
    - -HAZARD CLASSIFICATION
    - -FINISH FLOOR AND STAIR LANDING ELEVATION
    - -TYPE OF FIRE PROTECTION/SUPPRESSION SYSTEM
    - -DOOR WIDTH AND HEIGHT
    - -LOUVERS AND WALL PENETRATIONS SIZES/LOCATIONS
    - -TELECOM CABINET AND ELECTRICAL PANEL & TRANSFORMER LOCATION
    - -SAFETY EYEWASH/SHOWER LOCATION AND QUANTITY
    - -FIRE BARRIER/DOOR RATINGS
    - -GUARD RAIL REQUIREMENT
14. FOR SITE INFORMATION REFER TO PLOT PLAN M1NN-CCS-PLN-250-00001

GENERAL NOTES

LEGEND :

0 10' 20' 40' 60'

SCALE: 1/16"=1'-0"

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GENERAL CODE DATA

(BASED ON IBC 2018 AND NORTH DAKOTA STATE BUILDING CODE JANUARY 1, 2020)

MAJOR OCCUPANCY	MODERATE-HAZARD FACTORY INDUSTRIAL, F-1	
TYPE OF CONSTRUCTION	TYPE II-B	
FIRE RATED WALLS	AS REQUIRED PER DETAILED CODE ANALYSIS	
COMPLIANCE TO ADA	REQUIRED / ADA 2010	
FIRE SUPPRESSION SYSTEM	AUTOMATIC SPRINKLER SYSTEM INSTALLED IN ACCORDANCE WITH SECTION 903.2.5.	
FIRE DETECTION SYSTEM	REQUIRED FIRE DETECTION SYSTEM	
	ALLOWABLE	ACTUAL
FLOOR AREA	62,000	37,820 SQ. FT.
OCCUPANT LOAD @ 100 GROSS:	100 SQ FT/PERSON	0
HEIGHT (AVG OF HIGHEST ROOF)	75 FT	73'-8"
TRAVEL DISTANCE TO EXIT	(IBC 2015 TABLE 1017.2.)	
WITH FIRE SPRINKLER	250 FT	60 FT
CORRIDOR WIDTH (2018 IBC TAB 1020.2)	36" SERVING < 50 OCC. 24" FOR EQUIP ACCESS	-

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
A	09SEP20	ISSUED FOR INTERNAL REVIEW	VA	RM	JP
B	29SEP20	ISSUED FOR CLIENT REVIEW	RM	TR	JP
C	11DEC20	ISSUED FOR FEED	RM	TR	JP

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV

REFERENCE DWG NUMBER	REFERENCE DRAWINGS
M1NN-CCS-DWG-220-00030	BOILER ENCLOSURE CCS-BOE-001 - DRAWING INDEX LIST
M1NN-CCS-DWG-220-00032	BOILER ENCLOSURE CCS-BOE-001 - EXTERIOR ELEVATIONS

FLUOR

CONTRACT M1NN

CONTRACT	M1NN
DESIGNED BY	V. AU
CHECKED BY	R. MARTINEZ
SUPERVISOR	T. RISHFORTH
LEAD ENGR/SPEC.	J. PATEL
FLUOR	
CLIENT	

APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA

CARBON CAPTURE AND SEQUESTRATION

ARCHITECTURAL

BOILER ENCLOSURE CCS-BOE-001

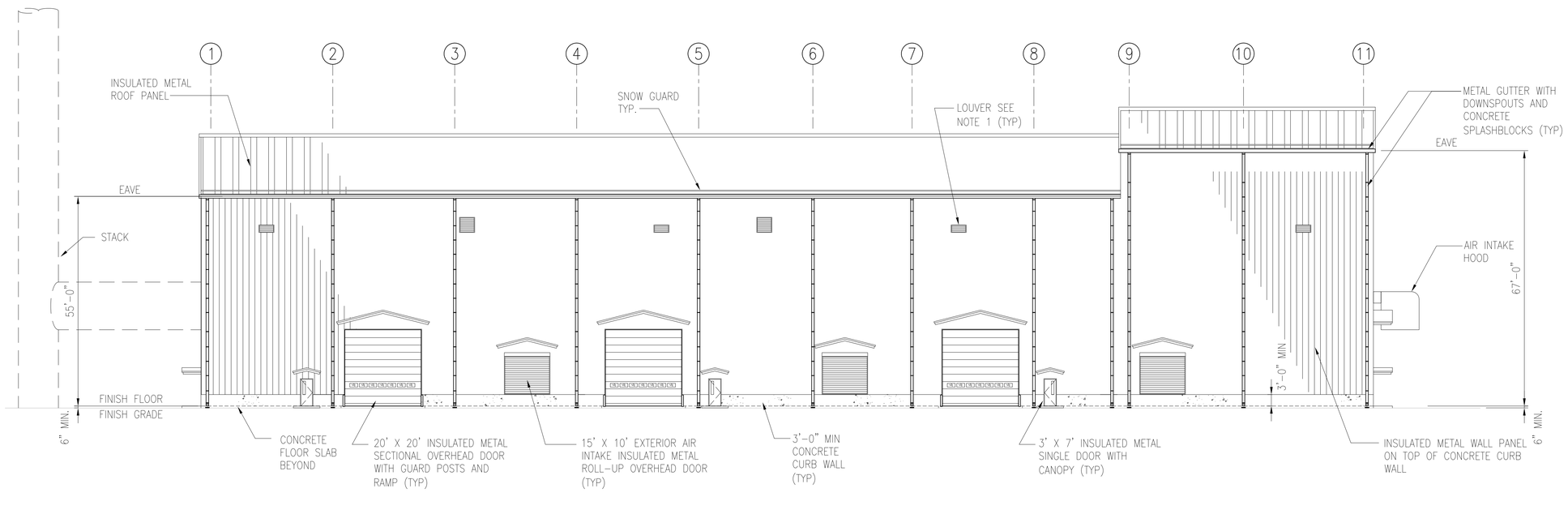
CONCEPTUAL FLOOR PLAN

SCALE	DRAWING NUMBER	REV
1/16"=1'-0"	M1NN-CCS-DWG-220-00031	C

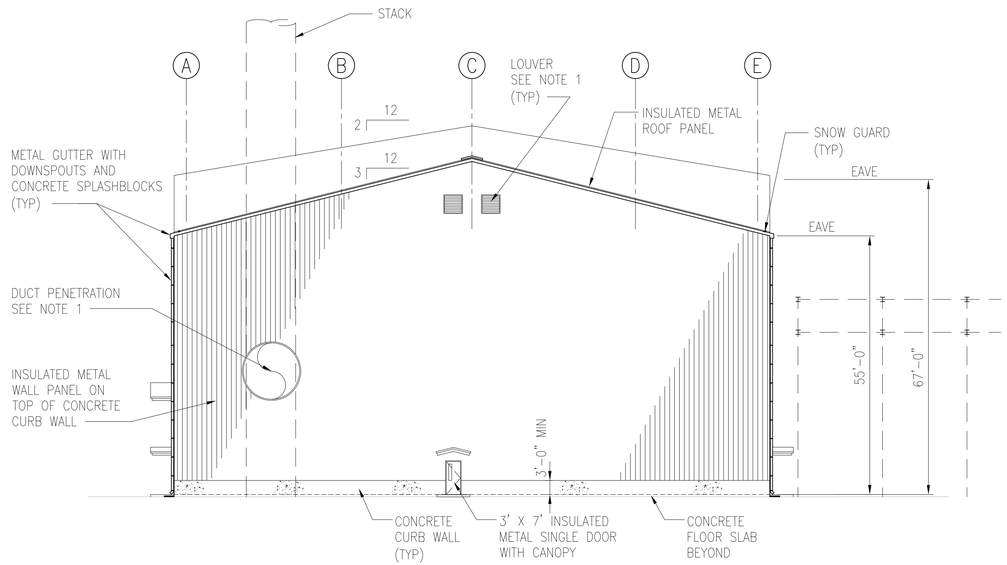
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F-0222.DWG 01JAN09

PLOT DATE: Z:\CAD\220_ARCHITECTURAL\03 Boiler Building\03 IFF\M1NN-CCS-DWG-220-00031_C.dwg 12-10-20 8:37 pm Printed By: mar1144G



WEST ELEVATION — SCALE: 1/16"=1'-0" — 02



NORTH ELEVATION — SCALE: 1/16"=1'-0" — 01

NOTES:

1. WALL AND ROOF PENETRATIONS FOR HVAC, PIPES AND CABLE TRAYS ARE FOR CONCEPTUAL PURPOSES ONLY.
   WALL PENETRATIONS SHALL BE FINALIZED DURING DETAIL DESIGN.

0 10' 20' 40' 60'

SCALE: 1/16"=1'-0"

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REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
A	09SEP20	ISSUED FOR INTERNAL REVIEW	VA	RM	JP
B	29SEP20	ISSUED FOR CLIENT REVIEW	RM	TR	JP
C	11DEC20	ISSUED FOR FEED	RM	TR	JP

REFERENCE DWG NUMBER	REFERENCE DRAWINGS
M1NN-CCS-DWG-220-00030	BOILER ENCLOSURE CCS-BOE-001 - DRAWING INDEX LIST
M1NN-CCS-DWG-220-00031	BOILER ENCLOSURE CCS-BOE-001 - CONCEPTUAL FLOOR PLAN

FLUOR®

CONTRACT M1NN

CONTRACT	M1NN
DESIGNED BY	V. AU
CHECKED BY	R. MARTINEZ
SUPERVISOR	T. RISHFORTH
LEAD ENGR/SPEC.	J. PATEL
FLUOR	
CLIENT	

APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA

CARBON CAPTURE AND SEQUESTRATION

ARCHITECTURAL

BOILER ENCLOSURE CCS-BOE-001

EXTERIOR ELEVATIONS

SCALE	DRAWING NUMBER	REV
1/16"=1'-0"	M1NN-CCS-DWG-220-00032	C

CAD FILE NAME M1NN-CCS-DWG-220-00032_C.dwg

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F-022.DWG 01JUL09

DRAWING NUMBER	DRAWING DESCRIPTION	REVISION	REVISION DATE
M1NN-CCS-DWG-220-00051	CONCEPTUAL FLOOR PLAN	C1	23FEB2021
M1NN-CCS-DWG-220-00052	EXTERIOR ELEVATIONS	C1	23FEB2021
M1NN-CCS-DWG-220-00053	WALL SECTION	C1	23FEB2021
M1NN-CCS-DWG-220-00054	COMMON BUILDING SPECIFICATIONS	C1	23FEB2021
M1NN-CCS-DWG-220-00055	HARDWARE AND ACCESSORY NOTES	C1	23FEB2021
M1NN-CCS-DWG-220-00056	WALL SECTIONS	C	23FEB2021

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV	REFERENCE DWG NUMBER	REFERENCE DRAWINGS
B	06AUG20	ISSUED FOR CLIENT REVIEW	VA	RM	JP								
C	23DEC20	ISSUED FOR FEED	RM	NS	JP								
C1	23FEB21	ISSUED FOR FEED	TR	NS	JP								

F-022.DWG 01JUL09

PLOT DATE: x:\CAD\220_ARCHITECTURAL\05 Multi-Purpose Building\M1NN-CCS-DWG-220-00050_Working.dwg 02-21-21 10:34 am Printed By: ris84116

FLUOR

CONTRACT M1NN

CONTRACT	M1NN
DESIGNED BY	V. AU
CHECKED BY	R. MARTINEZ
SUPERVISOR	T. RISHFORTH
LEAD ENGR/SPEC.	J. PATEL
FLUOR	
CLIENT	

APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA

CARBON CAPTURE AND SEQUESTRATION

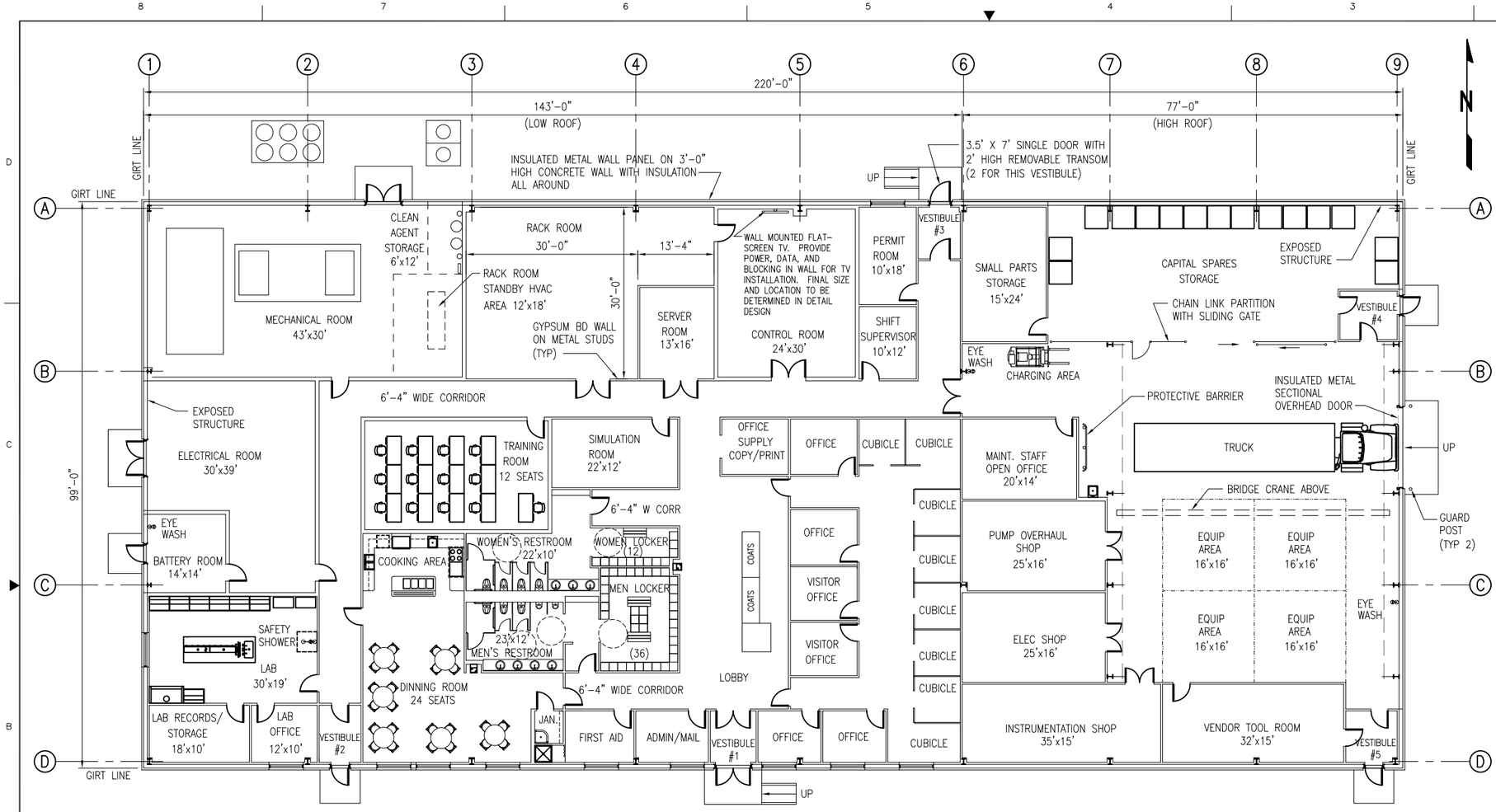
ARCHITECTURAL

MULTI-PURPOSE BUILDING CCS-MPB-001

DRAWING INDEX LIST

SCALE	DRAWING NUMBER	REV
1"=1"	M1NN-CCS-DWG-220-00050	C1

CAD FILE NAME M1NN-CCS-DWG-220-00050_Working.dwg



FLOOR PLAN

SCALE: **3/32"=1'-0"** | 02

1. THIS DRAWING IS NOT FOR CONSTRUCTION PURPOSES. DESIGN BUILD CONTRACTOR WILL BE RESPONSIBLE FOR THE ISSUED FOR CONSTRUCTION (IFC) DRAWING.
2. ISSUED FOR FEED (IFF) DRAWINGS ARE CONCEPTUAL DESIGN DRAWING ONLY. DETAILED DESIGN TO BE DONE BY THE IFC ARCHITECT OF RECORD.
3. THE INFORMATION CONTAINED IN "GENERAL CODE DATA" WAS COMPLIED BY AND FOR THE EXCLUSIVE USE OF THE ARCHITECT IN THE DESIGN OF HIS PORTION OF THE WORK. IT IS ALSO INTENDED TO IDENTIFY TO THE AUTHORITIES HAVING JURISDICTION THE ARCHITECTS INTERPRETATION OF THE CODE. THE INFORMATION IS EXCERPTED FROM THE CODE UNLESS INDICATED OTHERWISE. IT IS INTENDED TO IDENTIFY REQUIREMENTS FOR THIS STRUCTURE PRIMARILY IN TERMS OF OCCUPANCY, CONSTRUCTION TYPE, EGRESS AND OTHER MISCELLANEOUS ISSUES.
4. THIS INFORMATION IS NOT INTENDED TO INCLUDE ALL APPLICABLE PORTIONS OF THE CODE OR OTHER APPLICABLE CODES AND GOVERNING REGULATIONS. IT IS ALSO NOT INTENDED TO DIMINISH THE IMPORTANCE OR RELEVANCE OF OTHER PORTIONS OF CODES AND REGULATIONS THAT ARE APPLICABLE TO THE WORK CONTAINED IN THE DRAWING AND SPECIFICATIONS.
5. THE CODE DATA PROVIDED IS CONCEPTUAL AND CONSULTANTS, CONTRACTORS, MANUFACTURERS AND OTHER PARTIES THAT HAVE OR WILL PERFORM DESIGN OR CONSTRUCTION SERVICES ON THIS STRUCTURE SHALL NOT RELY ON THE INFORMATION IN THE PERFORMANCE OF THEIR WORK. EACH SUCH PARTY SHALL BE RESPONSIBLE FOR THEIR OWN REVIEW AND COMPLIANCE OF CODES AND REGULATIONS.
6. THE DETAILED ENGINEERING CONTRACTOR SHALL PERFORM CODE REVIEW INCLUDING (BUT NOT LIMITED TO) IBC, IPC, NFPA 101 AND OTHER APPLICABLE LOCAL REGULATIONS.
7. ALL DIMENSIONS ARE IN FEET AND INCHES UNLESS OTHERWISE STATED.
8. ALL ELEVATIONS ARE BASED ON HPFS EL. 1988 FT.
9. THIS DRAWING SET SHALL BE READ IN CONJUNCTION WITH PROJECT SPECIFICATIONS, BUILDING DESIGN NARRATIVE AND ALL RELEVANT DRAWINGS.
10. THE OPTION TO DESIGNATE THE CONTROL ROOM AND TRAINING ROOM AS STORM SHELTERS PER ICC-500 AND FEMA P-361 SHALL BE CONFIRMED IDURING THE DETAIL DESIGN PHASE.
11. ALL DIMENSIONS AND DETAILS SHOWN ARE INDICATIVE AND FOR INFORMATION ONLY. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE DETAILED DESIGN OF ALL ARCHITECTURAL AND BUILDING SUPERSTUCTURE STRUCTURAL WORKS.
12. FINAL REQUIREMENTS FOR ELECTRICAL, HVAC, FIRE PROTECTION, PLUMBING, SECURITY AND CONTROL SYSTEM SHALL BE CONFIRMED DURING DETAILED DESIGN PHASE.
13. FOR BUILDING PHILOSOPHY, REFER TO DOCUMENT NUMBER M1NN-CCS-PHL-220-00001.
14. FOR PROJECT SPECIFICATIONS, REFER TO DOCUMENT NUMBER M1NN-CCS-SPC-220-00001 TO 00008.
15. FOR BUILDING MATERIAL SPECIFICATIONS, REFER TO DRAWING NUMBER M1NN-CCS-DWG-220-00053 AND 00054.
16. ADDITIONAL ITEMS TO BE FINALIZED DURING DETAILED PHASE:
    - -BUILDING HEIGHT
    - -WALL HEIGHT
    - -HAZARD CLASSIFICATION
    - -FINISH FLOOR AND STAIR LANDING ELEVATION
    - -TYPE OF FIRE PROTECTION/SUPPRESSION SYSTEM
    - -DOOR WIDTH AND HEIGHT
    - -WINDOWS, LOUVERS AND WALL PENETRATIONS SIZES/LOCATIONS
    - -TELECOM CABINET AND ELECTRICAL PANEL & TRANSFORMER LOCATION
    - -SAFETY EYE WASH/SHOWER LOCATION AND QUANTITY
    - -FIRE BARRIER/DOOR RATINGS -GUARD RAIL REQUIREMENT
17. DESIGN BUILD CONTRACTOR TO CALCULATE AND ENSURE SUFFICIENT SOUND TRANSMISSION CLASS (STC) RATING OF WALL SHALL NOT CAUSE AUDIBLE DISTURBANCE TO THE ADJACENT ROOMS, DUE FROM HVAC EQUIPMENT NOISE.
18. DESIGN BUILD CONTRACTOR TO FINALIZE FIRE SUPPRESSION SYSTEM ON RACK ROOM AND SERVER ROOM.
19. FOR SITE INFORMATION REFER TO PLOT PLAN M1NN-CCS-PLN-250-00001

GENERAL NOTES

SCALE: **NONE** | 01

LEGEND :

SCALE: 3/32"=1'-0"

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GENERAL CODE DATA

(BASED ON IBC 2018 AND NORTH DAKOTA STATE BUILDING CODE JANUARY 1, 2020)

MAJOR OCCUPANCY	MIXED, NON-SEPARATED B, (A-2), (A-3), F-1, S-1	
TYPE OF CONSTRUCTION	TYPE II-B	
FIRE RATED WALLS	AS REQUIRED PER DETAILED CODE ANALYSIS	
COMPLIANCE TO ADA	REQUIRED / ADA 2010	
FIRE SUPPRESSION SYSTEM	CLEAN AGENT SYSTEM FOR DCS RACK ROOM AND SERVER ROOM	
FIRE DETECTION SYSTEM	REQUIRED FIRE DETECTION SYSTEM	
	ALLOWABLE	ACTUAL
FLOOR AREA	26040 SQ. FT.	21,780 SQ. FT.
OCCUPANT LOAD A-2 @ 707 SF NET: A-3 @ 643 SF NET: B @ 8677 SF GROSS: F-1 @ 5279 SF GROSS: S-1 @ 1814 SF GROSS: ACCESSORY @ 4081 SF GROSS:	 15 SQ FT/PERSON = 48 PEOPLE 15 SQ FT/PERSON = 43 PEOPLE 150 SQ FT/PERSON = 58 PEOPLE 100 SQ FT/PERSON = 53 PEOPLE 500 SQ FT/PERSON = 4 PEOPLE 300 SQ FT/PERSON = 14 PEOPLE	220 PEOPLE
HEIGHT (EAVE)	NON-SPRINKLERED: 55'	LOW AREA 15 FT HIGH AREA 25 FT
TRAVEL DISTANCE TO EXIT A. WITHOUT FIRE SPRINKLER B. WITH FIRE SPRINKLER	(IBC 2018 TABLE 1017.2.) 200 FT N/A	 123 FT -
CORRIDOR WIDTH	44 IN	76 IN

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
A	27JUL2020	ISSUED FOR INTERNAL REVIEW	VA	RM	JP
B	06AUG20	ISSUED FOR CLIENT REVIEW	VA	RM	JP
C	23DEC20	ISSUED FOR FEED	RM	NS	JP
C1	23FEB21	ISSUED FOR FEED	TR	NS	JP

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV

REFERENCE DWG NUMBER	REFERENCE DRAWINGS
M1NN-CCS-DWG-220-00050	MULTI-PURPOSE BUILDING CCS-MPB-001 - DRAWING INDEX LIST
M1NN-CCS-DWG-220-00052	MULTI-PURPOSE BUILDING CCS-MPB-001 - EXTERIOR ELEVATIONS
M1NN-CCS-DWG-220-00053	MULTI-PURPOSE BUILDING CCS-MPB-001 - WALL SECTION
M1NN-CCS-DWG-220-00054	MULTI-PURPOSE BUILDING CCS-MPB-001 - COMMON BUILDING SPECIFICATIONS
M1NN-CCS-DWG-220-00055	MULTI-PURPOSE BUILDING CCS-MPB-001 - HARDWARE AND ACCESSORY NOTES
M1NN-CCS-DWG-220-00056	MULTI-PURPOSE BUILDING CCS-MPB-001 - WALL SECTIONS

FLUOR

CONTRACT M1NN

CONTRACT	M1NN
DESIGNED BY	V. AU
CHECKED BY	R. MARTINEZ
SUPERVISOR	T. RISHFORTH
APP DATE	
LEAD ENGR/SPEC.	J. PATEL
APP DATE	
FLUOR	
APP DATE	
CLIENT	
APP DATE	

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA

CARBON CAPTURE AND SEQUESTRATION

ARCHITECTURAL

MULTI-PURPOSE BUILDING CCS-MPB-001

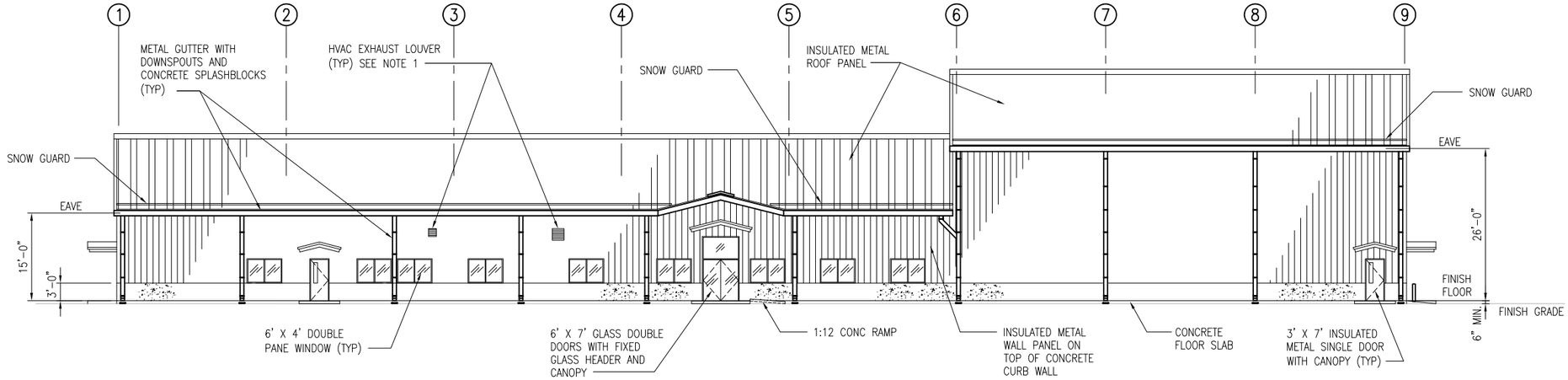
CONCEPTUAL FLOOR PLAN

SCALE	DRAWING NUMBER	REV
3/32"=1'-0"	M1NN-CCS-DWG-220-00051	C1

CAD FILE NAME M1NN-CCS-DWG-220-00051_Working.dwg

F-022DWG 013JL09

PLOT DATE: X:\CAD\220_ARCHITECTURAL\05 Multi-Purpose Building\M1NN-CCS-DWG-220-00051_Working.dwg 02-21-21 10:45 am Printed By: ris84116



SOUTH ELEVATION — SCALE: **3/32"=1'-0"** — 02

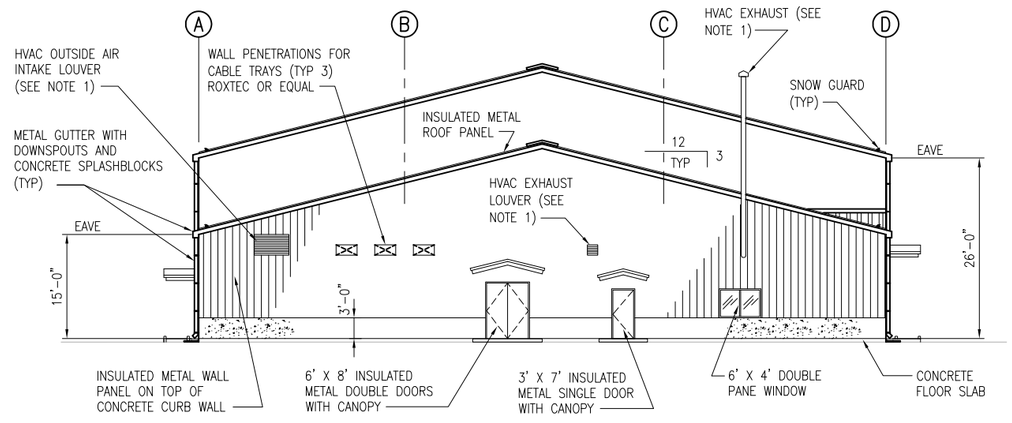
NOTES:

1. HVAC OPENINGS ARE FOR CONCEPTUAL PURPOSES ONLY. HVAC OPENINGS SHALL BE FINALIZED DURING DETAIL DESIGN.

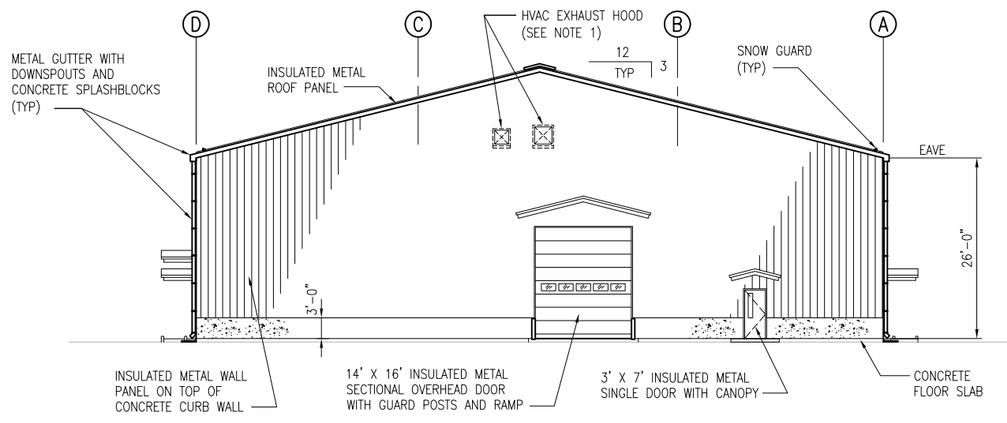
0 10' 20' 30' 40'

SCALE: 3/32"=1'-0"

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WEST ELEVATION — SCALE: **3/32"=1'-0"** — 03



EAST ELEVATION — SCALE: **3/32"=1'-0"** — 01

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
A	27JUL20	ISSUED FOR INTERNAL REVIEW	VA	RM	JP
B	06AUG20	ISSUED FOR CLIENT REVIEW	VA	RM	JP
C	23DEC20	ISSUED FOR FEED	RM	NS	JP
C1	23FEB21	ISSUED FOR FEED	TR	NS	JP

REFERENCE DWG NUMBER	REFERENCE DRAWINGS
M1NN-CCS-DWG-220-00050	MULTI-PURPOSE BUILDING CCS-MPB-001 - DRAWING INDEX LIST
M1NN-CCS-DWG-220-00051	MULTI-PURPOSE BUILDING CCS-MPB-001 - CONCEPTUAL FLOOR PLAN
M1NN-CCS-DWG-220-00053	MULTI-PURPOSE BUILDING CCS-MPB-001 - WALL SECTION
M1NN-CCS-DWG-220-00054	MULTI-PURPOSE BUILDING CCS-MPB-001 - COMMON BUILDING SPECIFICATIONS
M1NN-CCS-DWG-220-00055	MULTI-PURPOSE BUILDING CCS-MPB-001 - HARDWARE AND ACCESSORY NOTES
M1NN-CCS-DWG-220-00056	MULTI-PURPOSE BUILDING CCS-MPB-001 - WALL SECTIONS

FLUOR

CONTRACT M1NN

CONTRACT	M1NN
DESIGNED BY	V. AU
CHECKED BY	R. MARTINEZ
SUPERVISOR	T. RISHFORTH — APP DATE
LEAD ENGR/SPEC.	J. PATEL — APP DATE
FLUOR	APP DATE
CLIENT	APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA

CARBON CAPTURE AND SEQUESTRATION

ARCHITECTURAL

MULTI-PURPOSE BUILDING CCS-MPB-001

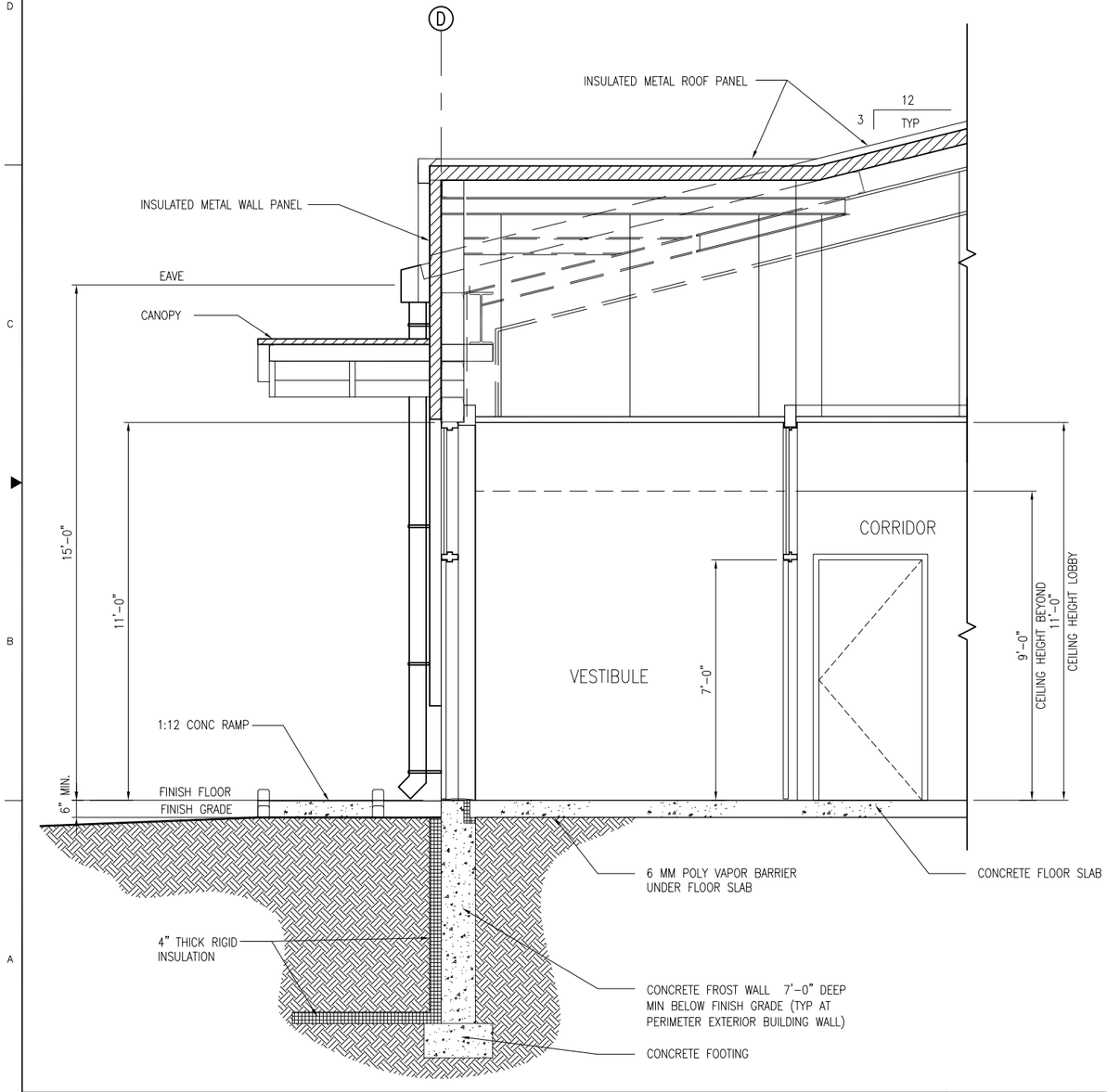
EXTERIOR ELEVATIONS

SCALE	DRAWING NUMBER	REV
3/32"=1'-0"	M1NN-CCS-DWG-220-00052	C1

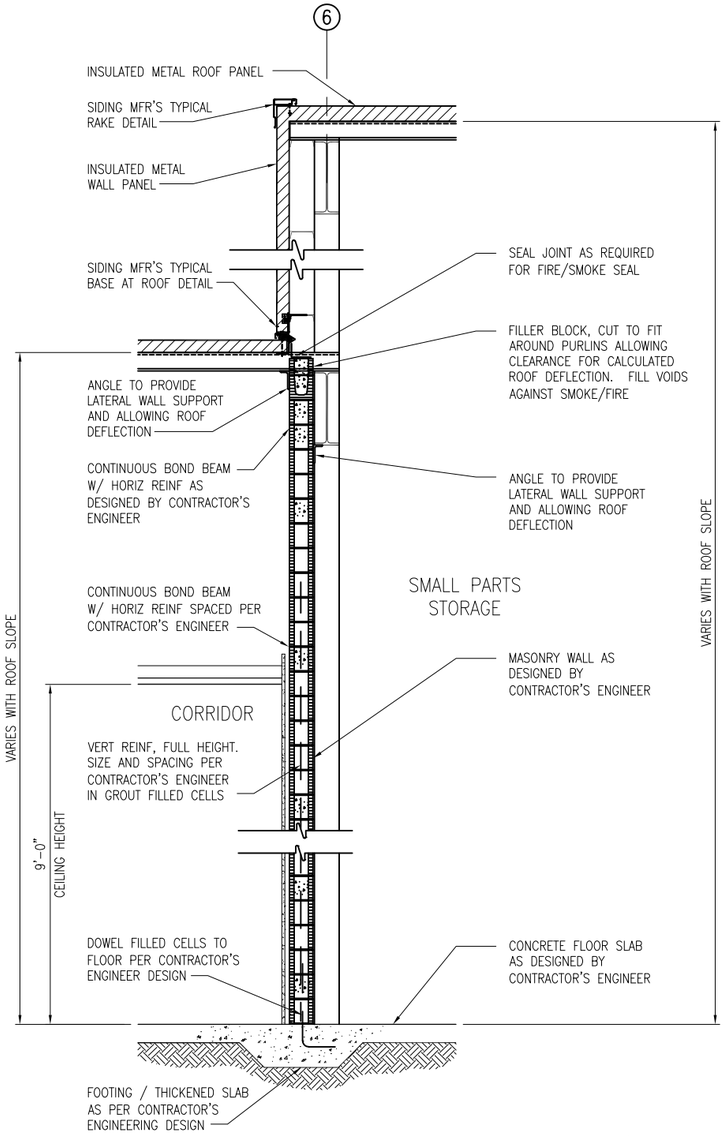
CAD FILE NAME M1NN-CCS-DWG-220-00052_Working.dwg

F-002.DWG 01JUL09

PLOT DATE: X:\CAD\220_ARCHITECTURAL\05 Multi-Purpose Building\M1NN-CCS-DWG-220-00052_Working.dwg 02-21-21 10:51 am Printed By: ris84116



WALL SECTION AT MAIN ENTRANCE — SCALE: 1/2" = 1'-0" — 01



SCALE: 1/2" = 1'-0"

SECTION AT MAINTENANCE / ADMIN DIVIDING WALL — SCALE: 1/2" = 1'-0" — 02

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REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV

REFERENCE DWG NUMBER	REFERENCE DRAWINGS
M1NN-CCS-DWG-220-00050	MULTI-PURPOSE BUILDING CCS-MPB-001 - DRAWING INDEX LIST
M1NN-CCS-DWG-220-00051	MULTI-PURPOSE BUILDING CCS-MPB-001 - CONCEPTUAL FLOOR PLAN
M1NN-CCS-DWG-220-00052	MULTI-PURPOSE BUILDING CCS-MPB-001 - EXTERIOR ELEVATIONS
M1NN-CCS-DWG-220-00054	MULTI-PURPOSE BUILDING CCS-MPB-001 - COMMON BUILDING SPECIFICATIONS
M1NN-CCS-DWG-220-00055	MULTI-PURPOSE BUILDING CCS-MPB-001 - HARDWARE AND ACCESSORY NOTES
M1NN-CCS-DWG-220-00056	MULTI-PURPOSE BUILDING CCS-MPB-001 - WALL SECTIONS

FLUOR®

CONTRACT M1NN

CONTRACT	M1NN
DESIGNED BY	V. AU
CHECKED BY	R. MARTINEZ
SUPERVISOR	T. RISHFORTH — APP DATE
LEAD ENGR/SPEC.	J. PATEL — APP DATE
FLUOR	APP DATE
CLIENT	APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA

CARBON CAPTURE AND SEQUESTRATION

ARCHITECTURAL

MULTI-PURPOSE BUILDING CCS-MPB-001

WALL SECTION

SCALE	DRAWING NUMBER	REV
1/2" = 1'-0"	M1NN-CCS-DWG-220-00053	C1

CAD FILE NAME M1NN-CCS-DWG-220-00053_Working.dwg

PLOT DATE: X:\CAD\220_ARCHITECTURAL\05 Multi-Purpose Building\M1NN-CCS-DWG-220-00053_Working.dwg 02-19-21 9:58 pm Printed By: ris84116

F-022.DWG 01JUL09

COMMON BUILDING MATERIALS SPECIFICATIONS NOTES (CBMS)

1. WHERE THE FOLLOWING SPECIFICATIONS NAME A SINGLE MANUFACTURER AND PRODUCT, PROVIDE THE NAMED PRODUCT IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS AND SPECIFICATIONS. COMPARABLE PRODUCTS OR SUBSTITUTIONS FOR CONTRACTOR'S CONVENIENCE WILL NOT BE CONSIDERED.
2. PROVIDE PRODUCTS COMPLETE WITH ACCESSORIES, TRIM, FINISH, FASTENERS, AND OTHER ITEMS NEEDED FOR A COMPLETE INSTALLATION AND INDICATED USE AND EFFECT.
3. CONFLICTING STANDARDS AND OTHER REQUIREMENTS: IF COMPLIANCE WITH TWO OR MORE STANDARDS OR REQUIREMENTS ARE SPECIFIED AND THE STANDARDS OR REQUIREMENTS ESTABLISH DIFFERENT OR CONFLICTING REQUIREMENTS FOR MINIMUM QUANTITIES OR QUALITY LEVELS, COMPLY WITH THE MOST STRINGENT REQUIREMENT. REFER CONFLICTING REQUIREMENTS THAT ARE DIFFERENT, BUT APPARENTLY EQUAL, TO ARCHITECT FOR DIRECTION BEFORE PROCEEDING.
4. MINIMUM QUANTITY OR QUALITY LEVELS: THE QUANTITY OR QUALITY LEVEL SHOWN OR SPECIFIED SHALL BE THE MINIMUM PROVIDED OR PERFORMED. THE ACTUAL INSTALLATION MAY COMPLY EXACTLY WITH THE MINIMUM QUANTITY OR QUALITY SPECIFIED, OR IT MAY EXCEED THE MINIMUM WITHIN REASONABLE LIMITS. TO COMPLY WITH THESE REQUIREMENTS, INDICATED NUMERIC VALUES ARE MINIMUM OR MAXIMUM, AS APPROPRIATE, FOR THE CONTEXT OF REQUIREMENTS. REFER UNCERTAINTIES TO ARCHITECT FOR A DECISION BEFORE PROCEEDING.
5. CONTRACTOR SHALL PROVIDE A LIST OF SUBMITTALS FOR THE PROJECT BUILDING MATERIALS LISTED BELOW, ARRANGED IN CHRONOLOGICAL ORDER BY DATES REQUIRED BY CONSTRUCTION SCHEDULE. INCLUDE TIME REQUIRED FOR REVIEW, ORDERING, MANUFACTURING, FABRICATION, AND DELIVERY WHEN ESTABLISHING DATES. INCLUDE ADDITIONAL TIME REQUIRED FOR MAKING CORRECTIONS OR REVISIONS TO SUBMITTALS NOTED BY ARCHITECT AND CONSTRUCTION MANAGER AND ADDITIONAL TIME FOR HANDLING AND REVIEWING SUBMITTALS REQUIRED BY THOSE CORRECTIONS.
6. IF CONTRACTOR IS GIVEN THE OPTION OR ELECTS TO SELECT BETWEEN TWO OR MORE PRODUCTS LISTED BELOW FOR USE ON THIS PROJECT, PRODUCT COMPATIBILITY SHALL BE RESEARCHED AND VERIFIED BY THE CONTRACTOR, PRIOR TO PROCEEDING WITH INSTALLATION OF PRODUCTS.
7. UPON COMPLETION OF CONSTRUCTION, CONTRACTOR SHALL PROVIDE, TO THE OWNER, A 5% OVERAGE OF MATERIAL (BY TYPE) FOR THE VINYL COMPOSITION FLOOR TILE, PORCELAIN FLOOR TILE, CARPET TILE, RESILIENT BASE, PORCELAIN TILE BASE, METAL LINER PANEL AND SUSPENDED ACOUSTICAL TILE.

COMMON BUILDING SPECIFICATION SUMMARY (THE FOLLOWING FINISHES ARE BASED ON THE PROJECT DATA SHEETS, PARAGRAPH 2.1)

FLOORING

ITEM NO.	MATERIAL NAME	MATERIAL SINGLE SOURCE SPECIFICATION (CBMS)
F-01	HARDENED CONCRETE FINISH	CONCRETE DENSIFIER AND CHEMICAL HARDENER COMPOUND: LIQUI-HARD ULTRA MANUFACTURED BY W. R. MEADOWS.
F-02	SEALER ON CONCRETE	NON-YELLOWING, ACRYLIC CURING AND SEALING COMPOUND, CS-309 TM-25 OTC, MANUFACTURED BY W. R. MEADOWS.
F-03	PORCELAIN TILE	DALTILE , CONTINENTAL SLATE COLLECTION PORCELAIN 6 X 6 (OR 3 X 3 MOSAIC) FLOOR TILE WITH 6 X 12 COVE BASE. (CS_ _ , SERIES)
F-04	VINYL COMPOSITION TILE	ARMSTRONG, STANDARD EXCELON® IMPERIAL® TEXTURE |?MULTICOLOR™ VINYL COMPOSITION TILE (VCT). 1/8 IN. (3.2 MM) THICK, 12 IN. X 12 IN. (305 MM X 305 MM) TILE SIZE.
F-05	ACCESS FLOORING SYSTEM	TATE CONCORE 2000 RAISED ACCESS FLOOR PANEL WITH 4 FOOT HEAVY DUTY BOLTED STRINGER WITH 8 GA.FILLET WELDED HEADS. COVERING TO BE 1/8" CONDUCTIVE HPL. (UNLESS NOTED OTHERWISE)
F-06	ACID RESISTANT	ACID RESISTANT NOVOLAC EPOXY FLOOR COATING, EPOXY ACID SHIELD AG253-257 , CONSISTING OF NOVOLAC PRIMER AND EPOXY TOPCOAT FOR HIGH TRAFFIC AREAS SUBJECT TO ACID SPILLS.
F-07	CHEMICAL RESISTANT	KEY RESIN CO. CHEMICAL RESISTANT FLOORING, KEY RESISTANT QUARTZ B-195, WITH INTEGRAL COVE BASE.
F-08	CARPET	INTERFACE CARPET, MODULAR, PRODUCT = ACCENT FLANNEL, GLASBAC, TUFTED CUT PILE, 100% SOLUTION DYED, 19.69 INCH X 19.69 INCH.
F-09	EXPOSED CONCRETE	NO FINISH IS REQUIRED ON EXPOSED CONCRETE WHEN NOTED.
F-10	MOISTURE RESISTANT	DALTILE , CONTINENTAL SLATE COLLECTION PORCELAIN 6 X 6 (OR 3 X3 MOSAIC) FLOOR TILE WITH 6 X 12 COVE BASE. (CS_ _ , SERIES). PROVIDE A COMPLETE SYSTEM INSTALLATION IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS AND SPECIFICATIONS. FLOOR SHALL BE WATERPROOFED WITH ""REDGARD"" ELASTOMERIC WATERPROOFING MEMBRANE PRIOR TO TILE INSTALLATION.
F-11	STATIC DISSIPATIVE VCT	ARMSTRONG VCT - SDT™ STATIC DISSIPATIVE TILE 12"X12"X1/8" , SDT PROVIDES STATIC DISSIPATIVE PROTECTION USING A COMPLETE SYSTEM. THESE COMPONENTS MUST BE USED TOGETHER TO OBTAIN THE STATIC DISSIPATIVE PERFORMANCE REQUIREMENTS. TILE WITH INTEGRAL STATIC DISSIPATIVE ELEMENTS, S-202 STATIC DISSIPATIVE ADHESIVE, COPPER GROUNDING STRIPS, S-392 STATIC DISSIPATIVE POLISH. TILE PRODUCTS TO INCLUDE: 51951 ARMOR GRAY, 51953 PEARL WHITE OR 51956 FOSSIL GRAY.
F-12	HARDENED CONCRETE (WITH SEALED EPOXY)	ECO-MPE™ - TENNANT'S ECO-MPE (MULTI-PURPOSE EPOXY) IS A LOW-ODOR, 100% SOLIDS EPOXY THAT SELF-LEVELS FOR EASY APPLICATION. ECO-MPE IS IDEAL FOR USE AS A PRIMER, BROADCAST OR BUILD COAT. (THIS PRODUCT IS A EPOXY COATING AND NOT A TRUE CONCRETE HARDENER OR SEALER)

BASE

ITEM NO.	MATERIAL NAME	MATERIAL SINGLE SOURCE SPECIFICATION (CBMS)
B-01	RESILIENT	ARMSTRONG, 4 INCH HIGH, COVE ROLL, 1/8" THICK, RUBBER MATERIAL, IIN MANUFACTURERS STANDARD COLORS.
B-02	PORCELAIN TILE	DALTILE , AMBASSADOR™ STONE ATTACHÉ™ COLLECTION -COLORBODY™ PORCELAIN COVE BASE , S-36C9T (6" X 12") 3/8"THICK.
B-03	CARPET	INTERFACE CARPET, MODULAR, PRODUCT = ACCENT FLANNEL, GLASBAC, TUFTED CUT PILE, 100% SOLUTION DYED, 19.69 INCH X 19.69 INCH.
B-04	ACID RESISTANT	ACID RESISTANT NOVOLAC EPOXY FLOOR COATING, EPOXY ACID SHIELD AG253-257 ""ARMOR GARAGE"" , CONSISTING OF NOVOLAC PRIMER AND EPOXY TOPCOAT FOR HIGH TRAFFIC AREAS SUBJECT TO ACID SPILLS.(PROVIDE INTEGRAL COVE BASE)
B-05	CHEMICAL RESISTANT	KEY RESIN CO. CHEMICAL RESISTANT FLOORING, KEY RESISTANT QUARTZ B-195 SYSTEM (INTEGRAL WITH FLOOR, COVE BASE)

BOARD

ITEM NO.	MATERIAL NAME	MATERIAL SINGLE SOURCE SPECIFICATION (CBMS)
BD-01	WHITE BOARD	EVER WRITE, 6 FOOT WIDE X 3 FOOT TALL , MAGNETIC WHITEBOARD -ALUMINUM FRAME MAGNETIC WHITEBOARD WITH ALUMINUM FRAME. •STEEL CORE PROVIDES MAGNETIC ATTRACTION •ALUMINUM FRAME WIDTH IS 5/8? •FRAME ALUMINUM IS ANODIZED FOR A CLEAR, SATIN FINISH •DRY ERASE BOARD THICKNESS IS 1/2? •LIFETIME GUARANTEED NON-STAINING DRY ERASE SURFACE.
BD-02	BULLETIN BOARD	EVER WRITE, 6 FOOT WIDE X 3 FOOT TALL , CORK BOARD - HIGH DENSITY CORK BOARD -NARROW ALUMINUM FRAME , CORK BOARD WITH 5/8" ALUMINUM FRAME. CORK IS HIGH DENSITY FOR DURABILITY, AND IS AVAILABLE IN 15 COLORS.

WALLS

ITEM NO.	MATERIAL NAME	MATERIAL SINGLE SOURCE SPECIFICATION (CBMS)
W-01	GYPSUM BOARD	USG SHEETROCK, INTERIOR GYPSUM BOARD SHALL INCLUDE BUT NOT BE LIMITED TO THE FOLLOWING MINIMUM STANDARDS: GYPSUM WALLBOARD IN ACCORDANCE WITH ASTM C1396/C1396M, 1/2" AND 5/8" THICK , TYPE X , CEILING BOARD, FOIL BACKED GYPSUM BOARD, ABUSE-RESISTANT GYPSUM BOARD, MOISTURE RESISTANT, MOLD RESISTANT, IMPACT-RESISTANT GYPSUM BOARD, SPECIALTY GYPSUM BOARD AND TYPE C.
W-02	INSULATED METAL WALL PANEL	CENTRIA, VERSAWALL INSULATED 22 GA METAL WALL PANEL. 36" WIDE, 6 FT TO 52 FT LONG WITH AN R-VALUE OF 26. METALLIC COATED STEEL SHEET: ZINC-COATED (GALVANIZED) STEEL SHEET INSULATED WALL PANELS, FLASHING, AND TRIM SHALL BE GALVANIZED STEEL IN ACCORDANC WITH ASTM A653 / A653M, GRADE 37, G90 (Z275), STRUCTURAL QUALITY COIL COATED PER ASTM A755 / A755M. FACTORY APPLIED KYNAR COATING WITH A COATING LIFE EXPANTANCY OF APPROXIMATELY 20 YEARS. COLOR TO BE SELECTED BY OWNER TO MATCH EXISTING BUILDINGS. WEATHER-TIGHT DOUBLE TONGUE-AND-GROOVE VERTICAL JOINERY WITH FACTORY-APPLIED, NON-CURING, VAPOR-RESISTANT SEALANT TO PROVIDE A COMPLETE AIR AND VAPOR BARRIER. FOAMED-IN-PLACE POLYISOCYANURATE.
W-03	PORCELAIN TILE	DALTILE , KIMONA SILK, COLLECTION PORCELAIN 12 X 12 WALL TILE. (P3_ _ , SERIES) PROVIDE A COMPLETE SYSTEM INSTALLATION IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS AND SPECIFICATIONS.
W-04	PAINT	SHERWIN WILLIAMS, PRO INDUSTRIAL™ MULTI-SURFACE ACRYLIC, EGG SHELL, IS SPECIFICALLY ENGINEERED TO PROVIDE HIGH HIDE AND GOOD STAIN RESISTANCE.
W-05	MOISTURE RESISTANT	DALTILE , KIMONA SILK, COLLECTION PORCELAIN 12 X 12 WALL TILE. (P3_ _ , SERIES) . PROVIDE A COMPLETE SYSTEM INSTALLATION IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS AND SPECIFICATIONS. WALL SHALL BE SHEATHED WITH USG DUROCK® BRAND CEMENT BOARD WITH EDGEGUARD™ AND WATERPROOFED WITH ""REDGARD"" ELASTOMERIC WATERPROOFING MEMBRANE PRIOR TO TILE INSTALLATION.
W-06	BLOCK FILLER COATING	SHERWIN WILLIAMS, PREPRITE BLOCK FILLER, EFFECTIVE ON ABOVE AND UNPAINTED MASONARY SURFACES. ALLOWS TOPCOAT ON CONCRETE BLOCK TO BE SMOOTH AND UNIFORM.
W-07	EXPOSED STRUCTURE	NO FINISH IS REQUIRED ON EXPOSED CONSTRUCTION WHEN NOTED.
W-08	CHEMICAL RESISTANT	KEY RESIN CO. CHEMICAL RESISTANT WALL FINISH, THE SYSTEM AS FORMULATED BY KEY RESIN COMPANY SHALL BE A 20 - 25 MIL EPOXY ELASTOMERIC WALL FINISH USING KEY #580-WG 100% SOLIDS EPOXY ELASTOMERIC WALL COATING, KEY #535 EPOXY AND KEY #446 ALIPHATIC URETHANE (PIGMENTED) FINISH COATS. THIS SYSTEM SHALL BE APPLIED OVER A CLEAN, PREPARED SUBSTRATE. THE SYSTEM IS TO BE APPLIED OVER APPROPRIATE EPOXY PRIMER AND/OR BLOCK FILLER AS RECOMMENDED BY KEY RESIN COMPANY FOR EACH TYPE OF SUBSTRATE. (KEY RESIN #554 EPOXY BLOCK FILLER) (KEY #502 PRIMER).
W-09	CONCRETE BLOCK	CONCRETE MASONRY UNITS - COMPLY WITH REFERENCED STANDARDS APPLICABLE TO EACH FORM OF CONCRETE MASONRY UNIT REQUIRED. PROVIDE SPECIAL SHAPES WHERE REQUIRED FOR LINTELS, JAMBS, CORNERS, SASH, CONTROL JOINTS, HEADERS, BONDING AND OTHER SPECIAL CONDITIONS. PROVIDE CONCRETE BLOCK UNITS COMPLYING WITH CHARACTERISTICS INDICATED BELOW FOR FACE SIZE, EXPOSED FACE, AND UNDER EACH FORM OF BLOCK INCLUDED FOR WEIGHT CLASSIFICATION. SIZE: MANUFACTURER'S STANDARD UNITS WITH NOMINAL FACE DIMENSIONS OF 16" LONG X 8"HIGH (15 5/8"X 7 5/8"ACTUAL) X THICKNESS INDICATED. HOLLOW LOAD-BEARING BLOCK ASTM C-90, NORMAL WEIGHT (125 LBS. PER CUBIC FOOT DRY WEIGHT). SOLID LOAD-BEARING BLOCK: ASTM C-90N NORMAL WEIGHT (125 LBS. PER CUBIC FOOT DRY WEIGHT). SYSTEM SHALL BE COMPLETE WITH REQUIRED MORTAR, GROUT, JOINT REINFORCEMENT, FLASHING AND WALL REINFORCEMENT.
W-10	WOOD PANELING (EQUIPMENT BACKBOARD)	WALL MOUNTED EQUIPMENT BACK BOARD - DRICON® FRT WOOD MEETS MODEL CODE REQUIREMENTS FOR A CLASS A/CLASS 1 FIRE RETARDANT. THIS PLYWOOD HAS BEEN GRADE STAMPED AND THIRD PARTY INSPECTED TO ENSURE QUALITY. CLASS A/CLASS 1 FIRE RETARDANT (ASTM E-84), THIS PLYWOOD SLOWS THE SPREAD OF FLAMES AND REDUCES SMOKE, WOOD SPECIES IS FIR, UL LISTED, RATED SHEATHING, FOR USE IN GENERAL CONSTRUCTION, MIL-L-19140E QPL LISTED, DIMENSIONS: 3/4 X 4 X 8.
W-11	METAL LINER PANEL	METAL LINER PANELS SHALL BE 26 GAUGE NUCOR , ""CLASSIC WALL"", COLOR TO BE SELECTED FROM MANUFACTURER'S STANDARD COLORS. LINER PANELS SHALL BE PARTIAL HEIGHT AT 7'-2" TALL. JAMB, BASE, CAP TRIM, ADDITIONAL REQUIRED SUPPORT AND FASTENERS SHALL BE PROVIDED FOR A COMPLETE SYSTEM INSTALLATION.
W-12	CEMENT BACKING BOARD	USG DUROCK® BRAND CEMENT BOARD

CEILING

ITEM NO.	MATERIAL NAME	MATERIAL SINGLE SOURCE SPECIFICATION (CBMS)
C-01	SUSP. ACOUSTICAL TILE	ARMSTRONG, CEILINGS, ""CORTEGA"" SQUARE LAY-IN, 15/16" GRID. 24 X 48 X 5/8" TILE, NRC 0.55, CLASS A FIRE RESISTANCE.
C-02	MOLD TOUGH GYP PANEL	USG SHEETROCK, INTERIOR GYPSUM BOARD SHALL INCLUDE BUT NOT BE LIMITED TO THE FOLLOWING MINIMUM STANDARDS: GYPSUM WALLBOARD IN ACCORDANCE WITH ASTM C1396/C1396M, 5/8" THICK, MOLD TOUGH.
C-03	PAINT	SHERWIN WILLIAMS, PRO INDUSTRIAL™ MULTI-SURFACE ACRYLIC, EGG SHELL, IS SPECIFICALLY ENGINEERED TO PROVIDE HIGH HIDE AND GOOD STAIN RESISTANCE.
C-04	EXPOSED CONSTRUCTION	NO FINISH IS REQUIRED ON EXPOSED CONSTRUCTION WHEN NOTED.
C-05	PAINTED EXPOSED CONSTRUCTION	SHERWIN WILLIAMS, PRO INDUSTRIAL™ MULTI-SURFACE ACRYLIC, EGG SHELL, IS SPECIFICALLY ENGINEERED TO PROVIDE HIGH HIDE AND GOOD STAIN RESISTANCE.
C-06	SUSP. GYPSUM BOARD	USG SHEETROCK, INTERIOR GYPSUM BOARD SHALL INCLUDE BUT NOT BE LIMITED TO THE FOLLOWING MINIMUM STANDARDS: GYPSUM WALLBOARD IN ACCORDANCE WITH ASTM C1396/C1396M, 5/8" THICK.

ROOF

ITEM NO.	MATERIAL NAME	MATERIAL SINGLE SOURCE SPECIFICATION (CBMS)
R-01	INSULATED METAL ROOF PANEL	CENTRIA, VERSAPANEL INSULATED 22 GA METAL ROOF PANEL. 36" WIDE, 6 FT TO 40 FT LONG WITH AN R-VALUE OF 36. METALLIC COATED STEEL SHEET: ZINC-COATED (GALVANIZED) STEEL SHEET INSULATED WALL PANELS, FLASHING, AND TRIM SHALL BE GALVANIZED STEEL IN ACCORDANCE WITH ASTM A653 / A653M, GRADE 37, G90 (Z275), STRUCTURAL QUALITY COIL COATED PER ASTM A755 / A755M. FACTORY APPLIED KYNAR COATING WITH A COATING LIFE EXPANTANCY OF APPROXIMATELY 20 YEARS. COLOR TO BE SELECTED BY OWNER TO MATCH EXISTING BUILDINGS. WEATHERTIGHT DOUBLE TONGUE-AND-GROOVE VERTICAL JOINERY WITH FACTORY-APPLIED, NON-CURING, VAPOR-RESISTANT SEALANT TO PROVIDE A COMPLETE AIR AND VAPOR BARRIER. FOAMED-IN-PLACE POLYISOCYANURATE.
R-02	SNOW GUARDS	CENTRIA SNOW GUARDS SHALL BE SUPPLIED AND INSTALLED ON ALL BUILDING ROOFS. SNOW GUARDS TO BE COMPATIBLE WITH INSULATED VERSAPANEL ROOF SYSTEM. SNOW GUARD SYSTEM LAYOUT, ATTACHMENT, MATERIAL AND FINISH AS RECOMMENDED BY THE ROOF MANUFACTURER.

DOOR

ITEM NO.	MATERIAL NAME	MATERIAL SINGLE SOURCE SPECIFICATION (CBMS)
D-01	INSULATED SECTIONAL OVERHEAD DOOR	OVERHEAD DOOR, THERMACORE SECTIONAL STEEL DOORS 593. EXTERIOR STEEL .015" (.38 mm) GALVANIZED STEEL. 20 YEAR WARRANTY ON HIGH PERFORMANCE FLUOROPOLYMER COATING. PANEL THICKNESS 1 3/8" (35 mm), R-VALUE 12.76. DOORS SHALL HAVE DOUBLE THERMAL ACRYLIC GLAZING (25" W x 12" H) ACROSS A PANEL COMPATIBLE WITH THE 593 DOOR MODEL.

THIS DRAWING IS ISSUED AS A CONCEPTUAL DRAWING FOR PRICING PURPOSES ONLY ON THE DATE INDICATED. THIS DRAWING IS NOT TO BE USED FOR CONSTRUCTION OR AS THE BASIS FOR THE ISSUANCE OF A PERMIT. THE ARCHITECT OF RECORD FOR IFC DOCUMENTS SHALL USE THESE CONCEPTUAL DRAWINGS AS A BASIS FOR THEIR FINAL IFC DOCUMENTS DESIGN AND SHALL BE RESPONSIBLE FOR THEIR OWN REVIEW AND COMPLIANCE OF CODES AND REGULATIONS.

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
A	27JUL20	ISSUED FOR INTERNAL REVIEW	VA	RM	JP
B	06AUG20	ISSUED FOR CLIENT REVIEW	VA	RM	JP
C	23DEC20	ISSUED FOR FEED	RM	NS	JP
C1	23FEB21	ISSUED FOR FEED	TR	NS	JP

REFERENCE DWG NUMBER	REFERENCE DRAWINGS
M1NN-CCS-DWG-220-00050	MULTI-PURPOSE BUILDING CCS-MPB-001 - DRAWING INDEX LIST
M1NN-CCS-DWG-220-00051	MULTI-PURPOSE BUILDING CCS-MPB-001 - CONCEPTUAL FLOOR PLAN
M1NN-CCS-DWG-220-00052	MULTI-PURPOSE BUILDING CCS-MPB-001 - EXTERIOR ELEVATIONS
M1NN-CCS-DWG-220-00053	MULTI-PURPOSE BUILDING CCS-MPB-001 - WALL SECTION
M1NN-CCS-DWG-220-00055	MULTI-PURPOSE BUILDING CCS-MPB-001 - HARDWARE AND ACCESSORY NOTES
M1NN-CCS-DWG-220-00056	MULTI-PURPOSE BUILDING CCS-MPB-001 - WALL SECTIONS

FLUOR®

CONTRACT M1NN

CONTRACT	M1NN
DESIGNED BY	V. AU
CHECKED BY	R. MARTINEZ
SUPERVISOR	T. RISHFORTH — APP DATE
LEAD ENGR/SPEC.	J. PATEL — APP DATE
FLUOR	APP DATE
CLIENT	APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA

CARBON CAPTURE AND SEQUESTRATION

ARCHITECTURAL

MULTI-PURPOSE BUILDING CCS-MPB-001

COMMON BUILDING SPECIFICATIONS

SCALE	DRAWING NUMBER	REV
1"=1"	M1NN-CCS-DWG-220-00054	C1

CAD FILE NAME M1NN-CCS-DWG-220-00054_Working.dwg

F-022.DWG 01JUL09

PLOT DATE: X:\CAD\220_ARCHITECTURAL\05 Multi-Purpose Building\M1NN-CCS-DWG-220-00054_Working.dwg 02-21-21 11:15 am Printed By: ris84116

BUILDING HARDWARE AND ACCESSORIES NOTES (BHA)

1. WHERE THE FOLLOWING SPECIFICATIONS NAME A SINGLE MANUFACTURER AND PRODUCT, PROVIDE THE NAMED PRODUCT IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS AND SPECIFICATIONS. COMPARABLE PRODUCTS OR SUBSTITUTIONS FOR CONTRACTOR'S CONVENIENCE WILL NOT BE CONSIDERED.

2. PROVIDE PRODUCTS COMPLETE WITH ACCESSORIES, TRIM, FINISH, FASTENERS, AND OTHER ITEMS NEEDED FOR A COMPLETE INSTALLATION AND INDICATED USE AND EFFECT.

3. CONFLICTING STANDARDS AND OTHER REQUIREMENTS: IF COMPLIANCE WITH TWO OR MORE STANDARDS OR REQUIREMENTS ARE SPECIFIED AND THE STANDARDS OR REQUIREMENTS ESTABLISH DIFFERENT OR CONFLICTING REQUIREMENTS FOR MINIMUM QUANTITIES OR QUALITY LEVELS, COMPLY WITH THE MOST STRINGENT REQUIREMENT. REFER CONFLICTING REQUIREMENTS THAT ARE DIFFERENT, BUT APPARENTLY EQUAL, TO ARCHITECT FOR DIRECTION BEFORE PROCEEDING.

4. MINIMUM QUANTITY OR QUALITY LEVELS: THE QUANTITY OR QUALITY LEVEL SHOWN OR SPECIFIED SHALL BE THE MINIMUM PROVIDED OR PERFORMED. THE ACTUAL INSTALLATION MAY COMPLY EXACTLY WITH THE MINIMUM QUANTITY OR QUALITY SPECIFIED, OR IT MAY EXCEED THE MINIMUM WITHIN REASONABLE LIMITS. TO COMPLY WITH THESE REQUIREMENTS, INDICATED NUMERIC VALUES ARE MINIMUM OR MAXIMUM, AS APPROPRIATE, FOR THE CONTEXT OF REQUIREMENTS. REFER UNCERTAINTIES TO ARCHITECT FOR A DECISION BEFORE PROCEEDING.

5. CONTRACTOR SHALL PROVIDE A LIST OF SUBMITTALS FOR THE PROJECT BUILDING MATERIALS LISTED BELOW, ARRANGED IN CHRONOLOGICAL ORDER BY DATES REQUIRED BY CONSTRUCTION SCHEDULE. INCLUDE TIME REQUIRED FOR REVIEW, ORDERING, MANUFACTURING, FABRICATION, AND DELIVERY WHEN ESTABLISHING DATES. INCLUDE ADDITIONAL TIME REQUIRED FOR MAKING CORRECTIONS OR REVISIONS TO SUBMITTALS NOTED BY ARCHITECT AND CONSTRUCTION MANAGER AND ADDITIONAL TIME FOR HANDLING AND REVIEWING SUBMITTALS REQUIRED BY THOSE CORRECTIONS.

6. ACCESSORIES MATERIALS – STAINLESS STEEL: ASTM A666, TYPE 304, 0.031 INCH MINIMUM NOMINAL THICKNESS UNLESS OTHERWISE INDICATED. GALVANIZED–STEEL MOUNTING DEVICES: ASTM A153 / A153M, HOT–DIP GALVANIZED AFTER FABRICATION. FASTENERS: SCREWS, BOLTS, AND OTHER DEVICES OF SAME MATERIAL AS ACCESSORY UNIT AND TAMPER–AND–THEFT RESISTANT WHERE EXPOSED, AND OF GALVANIZED STEEL WHERE CONCEALED. MIRRORS: ASTM C1503, MIRROR GLAZING QUALITY, CLEAR–GLASS MIRRORS.

7. ACCESSORIES FABRICATION AND MANUFACTURER – MATERIALS DESCRIBED IN THIS SPECIFICATION SHALL BE MANUFACTURED BY BOBRICK WASHROOM EQUIPMENT, INC., 11611 HART STREET, NORTH HOLLYWOOD, CA 91605. KEYS FOR ACCESSORIES: PROVIDE UNIVERSAL KEYS FOR INTERNAL ACCESS TO ACCESSORIES FOR SERVICING AND RE–SUPPLYING. PROVIDE MINIMUM OF SIX KEYS PER BUILDING IN WHICH ACCESSORIES ARE INSTALLED TO COMPANY.

8. CARD READERS, EPT (ELECTRIC POWER TRANSFER) & ELECTRIC STRIKES AND MAG LOCKS SHALL BE DESIGNED AND PROVIDED BY OWNER'S SECURITY VENDOR.

9. FOR LAB CASEWORK REFER TO SPECIFICATION M1NN–CCS–SPC–220–00008 METAL LABORATORY CASEWORK.

BUILDING HARDWARE AND ACCESSORIES SUMMARY

ITEM NO.	MATERIAL NAME	MATERIAL SINGLE SOURCE SPECIFICATION (BHA)
BA–01	TOILET TISSUE (ROLL) DISPENSER	BOBRICK B–2840 – SURFACE MOUNTED, TYPE 304, STAINLESS STEEL, SATIN FINISH, 2–ROLL TOILET PAPER HOLDER, WITH CHROME PLATED PLASTIC SPRING LOADED SPINDLES ON UTILITY SHELF. INSTALLATION – ONE PER WATER CLOSET.
BA–02	PAPER TOWEL (FOLDED) DISPENSER	BOBRICK B–262, SURFACE MOUNTED, TYPE 304, STAINLESS STEEL, SATIN FINISH, KEYED TUMBLER LOCK. INSTALLATION –AS APPROPRIATE FOR DESIGN SITUATION.
BA–03	COMBINATION TOWEL (FOLDED) DISPENSER/WASTE RECEPTACLE	BOBRICK B–3944, RECESSED, TYPE 304 STAINLESS STEEL, SATIN FINISH, WITH DISPENSER FOR C–FOLD OR MULTI–FOLD PAPER TOWELS AND TWO KEYED TUMBLER LOCKS, 54L (12 GAL.) CAPACITY WASTE CONTAINER, WITH OPTIONAL REUSABLE VINYL LINER. INSTALLATION AS APPROPRIATE FOR DESIGN SITUATION.
BA–04	SANITARY NAPKIN DISPENSER	BOBRICK B–3706 SEMI– OR FULLY RECESSED, SINGLE COIN OPERATION, TYPE 304 STAINLESS STEEL, SATIN FINISH, TWO KEYED TUMBLER LOCKS WITH TWO DISPENSING MECHANISMS. INSTALLATION – ONE PER EACH WOMEN'S TOILET ROOM.
BA–05	SANITARY NAPKIN DISPOSER	BOBRICK B–354, PARTITION MOUNTED, DUAL ACCESS WITH SELF–CLOSING DISPOSAL OPENING COVER AND REMOVABLE RECEPTACLE. FINISH SHALL BE STAINLESS STEEL, SATIN FINISH.
BA–06	MOP/BROOM HOLDER	BASIS–OF–DESIGN PRODUCT: BOBRICK B–224, 36 INCH (914 MM) LONG TYPE 304 STAINLESS STEEL STRIP WITH 4 MOP HOLDERS WITH RUBBER CAMS, 3 HOOKS AND ROD FOR WET RAGS BELOW SHELF. INSTALLATION – ONE IN EACH JANITOR ROOM.
BA–07	MIRROR	BOBRICK B–166–1830, WITH SATIN TYPE 304 STAINLESS STEEL FRAME AND SHELF, SATIN FINISH, WITH CONCEALED FASTENER MOUNTING PLATE. MIRROR SHALL BE NO. 1 QUALITY, 0.25 INCH (6 MM) SELECT FLOAT GLASS, WARRANTED AGAINST SILVER SPOILAGE FOR 15 YEARS. INSTALLATION – ONE UNIT FOR EACH RESTROOM SINK. SIZES OF UNIT 18"W x 30"H.
BA–08	LAVATORY MOUNTED LIQUID–SOAP DISPENSER	BOBRICK B–822, DECK–MOUNTED PISTON AND SPOUT TYPE UNIT WITH POLYETHYLENE HIGH–IMPACT PLASTIC RESERVOIR CONCEALED BELOW DECK TO DISPENSE LIQUID HAND SOAP. CAPACITY OF RESERVOIR SHALL BE 1.0L (34 FL. OZ). PISTON AND 4 INCH (100 MM) LONG SPOUT SHALL BE TYPE 304 STAINLESS STEEL WITH DECK ESCUTCHEON. ESCUTCHEON SHALL LOCK TO BODY WITH CONCEALED LOCKING MECHANISM THAT IS OPENED BY SPECIAL KEY PROVIDED. PISTON, SPOUT, AND SUPPLY–TUBE ASSEMBLY SHALL BE REMOVABLE FOR TOP FILLING. VALVE SHALL BE EQUIPPED WITH PLASTIC CYLINDER, STAINLESS STEEL SPRING, U–PACKING SEAL, AND DUCKBILLS. SHANK SHALL ACCOMMODATE MOUNTING THICKNESS UP TO 4 INCHES (100 MM). INSTALLATION– ONE UNIT FOR EACH TOILET ROOM SINK.
BA–09	WALL MOUNTED LIQUID–SOAP DISPENSER	BOBRICK B–2111, WALL–MOUNTED PUSH–BUTTON AND SPOUT TYPE WITH CORROSION RESISTANT VALVE UNIT TO DISPENSE LIQUID HAND SOAP. UNIT TO BE TYPE 304 STAINLESS STEEL, SATIN FINISH, WITH LOCKING HINGED LID, AND UNBREAKABLE ACRYLIC REFILL–INDICATOR WINDOW, AND CONCEALED, VANDAL RESISTANT MOUNTING. CAPACITY OF RESERVOIR SHALL BE 1.2L (40 FL. OZ.). INSTALLATION–ONE UNIT FOR EACH TOILET ROOM SINK, WHERE DECK MOUNTS IS NOT DESIRED.
BA–10	SS HOOK STRIP	BOBRICK B–232 X 24
BA–11	WASTE RECEPTACLE 01	BOBRICK B–2300, FREE STANDING, DOME TOP, TYPE 304, STAINLESS STEEL, SATIN FINISH, WITH GALVANIZED STEEL LINER, 68L (18 GAL.) CAPACITY. INSTALLATION AS APPROPRIATE FOR DESIGN SITUATION.
BA–12	WASTE RECEPTACLE 02	BOBRICK B–3644, SEMI–RECESSED, SATIN–FINISH STAINLESS STEEL. SEAMLESS BEVELED FLANGE. REMOVABLE, 12–GAL. (45.4–L) RECEPTACLE.
BA–13	GRAB BAR	STAINLESS STEEL, 1–1/4 INCH (32 MM) OUTSIDE DIAMETER, MINIMUM 0.05 INCH (1.27 MM) WALL THICKNESS, NON–SLIP GRASPING SURFACE FINISH, CONCEALED FLANGE MOUNTING, 1–1/2 INCH (38 MM) CLEARANCE BETWEEN WALL AND INSIDE OF GRAB BAR.
BA–14	SHOWER CURTAIN ROD	BOBRICK B–6047, 1–1/4 INCH (25 MM) OUTSIDE–DIAMETER TYPE 304 STAINLESS STEEL, SATIN FINISH, 20 GAUGE (0.91 MM) TUBING, WITH B–204–1 STAINLESS STEEL SHOWER CURTAIN HOOKS. INSTALLATION – ONE PER SHOWER UNIT.
BA–15	SHOWER CURTAIN	BOBRICK 204–2 OPAQUE, MATTE WHITE VINYL, 0.008 INCH (0.2 MM) THICK, NICKEL–PLATED BRASS GROMMETS AT 6 INCH (150 MM) O.C., BOTTOM AND SIDES HEMMED, 42 INCH (1066 MM) WIDE. (INSTALL ON SHOWER CURTAIN HOOKS). INSTALLATION – ONE PER SHOWER UNIT.
BA–16	SHOWER/DRESSING AREA SEAT	BOBRICK B–5181, L–SHAPED SEAT, DESIGNED FOR WHEELCHAIR ACCESS. SEAT SHALL BE PHENOLIC OR POLYMERIC COMPOSITE OF SLAT–TYPE OR ONE PIECE CONSTRUCTION IN COLOR AS SELECTED BY COMPANY. FRAME SHALL BE TYPE 304, STAINLESS STEEL, SATIN FINISH. INSTALLATION – ONE PER SHOWER DRESSING UNIT.
BA–17	DOUBLE ROBE HOOK	BOBRICK B–6727, TYPE 304 STAINLESS STEEL, SATIN FINISH, DOUBLE PRONG; RECTANGULAR WALL BRACKET WITH BACKPLATE FOR CONCEALED MOUNTING. INSTALLATION – ONE PER SHOWER UNIT.
BA–18	RECESSED SOAP DISH	BOBRICK B–4380, SHOWER STALLS ONLY
BA–19	WARM–AIR DRYER	EXCEL DRYER "XLERATOR MODEL XL–SB." SURFACE–MOUNTED, AUTOMATIC WITH BRUSHED STAINLESS STEEL COVER
BA–20	STAINLESS STEEL TOILET AND SHOWER COMPARTMENTS	TOILET COMPARTMENT STYLE: FLOOR ANCHORED OVER HEAD BRACED. URINAL–SCREEN STYLE: WALL HUNG. HARDWARE AND ACCESSORIES: MANUFACTURER'S STANDARD DESIGN, HEAVY–DUTY OPERATING HARDWARE AND ACCESSORIES. MATERIALS DESCRIBED IN THIS SPECIFICATION SHALL BE MANUFACTURED BY BRADLEY CORPORATION, W142 N9101 FOUNTAIN BOULEVARD, MENOMONEE FALLS, WI 53051.
BA–21	FIRE EXTINGUISHER CABINET	LARSEN'S ARCHITECTURAL SERIES SEMI–RECESSED MOUNTED FIRE EXTINGUISHER CABINET, 2409R7, HOLDS 10 LB. FIRE EXTINGUISHERS 1 1/2" TRIM ADA COMPLIANT, 9 1/2 X 24 X 6, STAINLESS STEEL FINISH (SS), LAMINATED SAFETY GLASS. STAINLESS STEEL FINISH WITH VERTICAL DUO DOOR.
BA–22	INTERIOR ROOM IDENTIFICATION SIGNAGE	MANUFACTURER SHALL BE ""BEST SIGN SYSTEMS, INC."": 1202 N. PARK AVENUE, MONTROSE, CO 81401. ASD. TEL: (800) 235–BEST. FAX (970) 249–0223. INTERIOR ROOM IDENTIFICATION SIGNAGE IS A STANDARD MONOLITHIC TACTILE PLAQUE CONSTRUCTED UTILIZING A THERMOFORMING PROCESS, WHICH PROVIDES A FULLY HOMOGENEOUS PLAQUE SIGN. THE SIGN BODY, FACE, RAISED TEXT AND BRAILLE ARE COMPRESSION MOLDED TO FORM A SINGLE DIMENSIONAL COMPONENT THAT RESULTS IN A SIGN SURFACE THAT EXHIBITS A TOUGHNESS THAT RESISTS SCRATCHING, CRACKING, GOUGING AND GRAFFITI. THE FOLLOWING ELEMENTS MAKE UP THE CRITERIA FOR THE ROOM IDENTIFICATION SIGNAGE. STYLE: CUSTOM LUCENT SIGN BY BEST SIGN SYSTEMS, INC. MATERIAL: EXTRUDED CLEAR ACRYLIC MATERIAL: EXTRUDED GREEN GLASS ACRYLIC SIGN THICKNESS: 1/4 INCH (6MM) TACTILE CHARACTERS/SYMBOLS: RAISED 1/32 INCH (1 MM) FROM SIGN PLATE FACE CONSTRUCTION: ONE–PIECE; ADDED ON OR ENGRAVED CHARACTERS NOT ACCEPTABLE LETTERING STYLE: TYPEFACE AS SELECTED FROM THE MANUFACTURER'S STANDARD SANS SERF OR SIMPLE SERF TYPEFACES, UPPER CASE LETTERS, MINIMUM HEIGHT 5/8", MAXIMUM HEIGHT 2" BRAILLE: GRADE 2 BRAILLE, PLACED DIRECTLY BELOW LAST LINE OF LETTERS OR NUMBERS CONTRAST: LETTERS, NUMBERS AND SYMBOLS SHALL CONTRAST WITH BACKGROUND. BEVEL OPTIONS: CLASSIC PROFILES: STANDARD RECTANGULAR COLOR OF BACKGROUND: COLORS CHOSEN FROM 73 STANDARD PAINT COLORS, SUBSURFACE OR SURFACE APPLIED COLOR OF TEXT AND RAISED CHARACTERS: AS SELECTED FROM 73 STANDARD COLORS SURFACE TEXTURE: MATTE REFER TO INDIVIDUAL BUILDING FLOOR PLAN FOR INTERIOR SIGNAGE REQUIREMENTS. CONTRACTOR TO DEVELOP LIST OF INTERIOR SIGNS FOR OWNER REVIEW AND APPROVAL. SIGNAGE FOR INDUSTRIAL PLANT, OPERATIONS, SAFETY AND EQUIPMENT , SHALL BE BY OWNER. CONTRACTOR TO PROVIDE SIGNAGE SAMPLES AND DETAILED SCOPE FOR OWNER'S REVIEW AND APPROVAL. SIGNAGE SHALL BE ADA COMPLIANT. ALL ROOMS SHALL BE NUMBERED AND IDENTIFIED.
BA–23	ARCHITECTURAL WOODWORK AND INTERIOR FINISH CARPENTRY	FINISH CARPENTRY SHALL COMPLY WITH THE ARCHITECTURAL WOODWORK INSTITUTE (AWI), ARCHITECTURAL WOODWORK STANDARDS, EDITION 2 (2014) FOR GRADES OF INTERIOR ARCHITECTURAL WOODWORK INDICATED FOR CONSTRUCTION, FINISHES, INSTALLATION, AND OTHER REQUIREMENTS. PROVIDE LABELS AND CERTIFICATES FROM THE AWI CERTIFICATION PROGRAM, INDICATING THAT WOODWORK AND INSTALLATION COMPLIES WITH THE REQUIREMENTS OF GRADES SPECIFIED. SHOP DRAWINGS SHALL BE REQUIRED FOR ALL INTERIOR WOOD WORK PRODUCTS. CABINETS AND WOOD PRODUCTS SHALL BE AWI, CUSTOM GRADE OR BETTER. PROVIDE: ALLISON VALUE HARDWARE 4 INCH WIRE PULLS, LENGTH: 4.25"", WIDTH: .25"", PROJECTION: 1.25"", CONCEALED CUP HINGES W/FULL OVERLAY, SELF CLOSING, KNAPE & VOGT FULL EXTENSION SIDE MOUNT DRAW GUIDES, CABINETS TO BE PLASTIC CLAD ON ALL EXPOSED EDGES. HARDWARE TO BE SATIN STAINLESS STEEL OR BRUSHED CHROME. ARCHITECTURAL WOODWORK AND HARDWARE DESIGN SHALL BE SUBMITTED TO OWNER FOR REVIEW AND APPROVAL PRIOR TO COMPLETION OF DESIGN DEVELOPMENT.
BA–24	WALL AND DOOR PROTECTION	WALL AND DOOR PROTECTION, SHALL CONSIST OF CORNER GUARDS, WALL GUARDS AND IMPACT RESISTANT HANDRAILS. CORNER GUARDS SHALL BE CONSTRUCTION SPECIALTIES, ACROVYN SELF–ADHESIVE, VA SERIES, VA–250N–2 1/2"" (63.4MM) LEGS; .090"" (2.3MM) THICK ACROVYN: 10' (3.0M) MAXIMUM HEIGHT WITH TOP AND BOTTOM CAPS. CHAMELEON PATTERN IN STANDARD SOLID COLORS. WALL AND DOOR GUARD SHALL BE CONSTRUCTION SPECIALTIES, .060"" (1.52MM) THICK ACROVYN WALL COVERING IN SOLID COLORS WITH STANDARD TEXTURE SUPPLIED IN STANDARD 4'X 8'(1.2M X 2.4M) OR 4' X 10'(1.2M X 3.0M) RIGID SHEETS. HANDRAIL/ CRASH RAIL SHALL BE A 6 1/4" (158.2MM) HIGH ACROVYN HRB–10CN, HANDRAIL/CRASH RAIL CONFIGURATION, INCLUDING INTEGRATING UP TO THREE DIFFERENT COLORWAYS.
BA–25	LOCKERS AND BENCHES	PENCO LOCKERS AND BENCHES – ALL–WELDED STEEL LOCKERS SHALL BE SINGLE TIER 12" X 18" X 72" WITH 16 GA. BODY & 18 GA. BACK, 14 GA. DOOR AND CLASSIC ILL HANDLE RECESSED SINGLE POINT LATCH, STANDARD LOUVERS, CHANNEL BASE AND SLOPED TOP HOODS. COLOR SHALL BE ONE OF 24 STANDARD COLORS. BENCH TOP AND PEDESTAL – STANDARD BENCH TOP IS 9– 1/2" X 1– 1/2" X LENGTH ON DRAWINGS. STANDARD PEDESTAL – TO BE HEAVY DUTY 16–1/4" A.F.F.. PROVIDE ADA LOCKERS AND BENCHES TO COMPLY WITH LOCAL, STATE AND FEDERAL REGULATIONS.
BA–26	GLAZING	GLAZING SHALL BE GLASS AND FABRICATED GLASS PRODUCTS, WHICH SHALL INCLUDE, BUT NOT BE LIMITED TO THE FOLLOWING: FLOAT GLASS, GL–1 ,ASTM C 1036, TYPE I, CLASS 1&2,QUALITY Q3; HEAT–TREATED FLOAT GLASS , GL–2 : ASTM C 1048, TYPE I, CLASS 1&2 QUALITY Q3, HS & FT; COATED GLASS GL–3: ASTM C 1048, CONDITION C, TYPE I, CLASS 1 & 2, QUALITY Q3, HS & FT ; WIRED GLASS GL–4 : ASTM C 1036, TYPE II, CLASS 1, QUALITY Q8; FORM AND TYPE; PATTERNED GLASS GL–5 : ASTM C 1036, TYPE II, CLASS 1, FORM 3, QUALITY Q8, FINISH PATTERN ; TEMPERED PATTERNED GLASS GL–6 : ASTM C 1048, TYPE II, CLASS 1, FORM 3, QUALITY Q8 ; MIRROR GLASS, GL–7 ; ASTM C 1036, TYPE 1, CLASS 1, SILVER COATED PER FS DDM411C, 6.0 MM THICK, WITH EDGES FLAT POLISHED. (SAFETY GLASS FOR MIRRORS: FULLY TEMPERED.) ; LAMINATED GLASS GL–8 , TWO SHEETS OF GLASS , WITH POLYVINYL BUTYL SHEET INTERLAYER. COMPLY WITH ASTM C 1172 ; SEALED INSULATING–GLASS UNITS GL–9 , PREASSEMBLED UNITS COMPLYING WITH ASTM E2190 REQUIREMENTS, WITH TWO SHEETS OF GLASS SEPARATED BY A 1/4–INCH (6.35–MM) DEHYDRATED SPACE FILLED WITH ARGON. INSULATED GLASS SHALL BE CERTIFIED BY THE INSULATING GLASS CERTIFICATION COUNCIL. INSTALLATION OF GLAZING PRODUCTS SHALL COMPLY WITH THE COMBINED RECOMMENDATIONS OF MANUFACTURERS OF GLASS, SEALANTS, GASKETS, AND OTHER GLAZING MATERIALS, UNLESS MORE STRINGENT REQUIREMENTS ARE CONTAINED IN GANA'S ""GLAZING MANUAL."" SET GLASS LITES IN EACH SERIES WITH UNIFORM PATTERN, DRAW, BOW, AND SIMILAR CHARACTERISTICS. SUBMIT PRODUCT DATA AND SAMPLES FOR OWNER'S APPROVAL PRIOR TO COMPLETION OF DESIGN DEVELOPMENT. FIRE–RESISTANCE–RATED ASSEMBLIES: PRODUCTS IDENTICAL TO THOSE TESTED PER NFPA 252 FOR DOORS AND NFPA 257 FOR WINDOW ASSEMBLIES; BOTH LABELED AND LISTED BY A TESTING AND INSPECTING AGENCY ACCEPTABLE TO AUTHORITIES HAVING JURISDICTION. SAFETY GLASS: CATEGORY II MATERIALS COMPLYING WITH TESTING REQUIREMENTS IN 16 CFR 1201 AND ANSI Z97. GLAZING WORK SHALL COMPLY WITH ALL APPLICABLE GLASS STANDARD ASTM SPECIFICATIONS AND THE PUBLISHED RECOMMENDATIONS OF GLASS PRODUCT MANUFACTURERS AND ORGANIZATIONS BELOW(UNLESS MORE STRINGENT REQUIREMENTS ARE INDICATED): GANA/NGA (GLASS ASSOCIATION OF NORTH AMERICA / NATIONAL GLASS ASSOCIATION, AAMA (AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION), IGMA (INSULATION GLASS MANUFACTURERS ASSOCIATION) AND SIGMA (SEALED INSULATION GLASS MANUFACTURERS ASSOCIATION). ALL ASSEMBLIES CONTAINING GLASS PRODUCTS SHALL BE SUBMITTED FOR OWNER'S APPROVAL PRIOR TO COMPLETING DESIGN DEVELOPMENT.
BA–27	WIND DRIVEN RAIN RESISTANT LOUVER	GREENHECK, ESD_635D, IS A FLORIDA PRODUCT APPROVED AND MIAMI–DADE QUALIFIED STATIONARY DRAINABLE BLADE EXTRUDED ALUMINUM LOUVER DESIGNED TO PROTECT AIR INTAKE AND EXHAUST OPENINGS IN BUILDING EXTERIOR WALLS. ESD–635D IS TESTED IN ACCORDANCE WITH AMCA 500–L AIR PERFORMANCE AND WATER PENETRATION. ESD–635D IS TESTED IN ACCORDANCE WITH AMCA 540 TEST METHOD FOR LOUVERS IMPACTED BY WIND BORNE DEBRIS. *THE BEGINNING POINT OF WATER PENETRATION FOR MODEL ESD–6350 IS ABOVE 1250 FPM FREE AREA VELOCITY.
BA–28	EXTERIOR, OUTSIDE WALL, ALL GLASS SLIDING BI–PART DOUBLE DOOR	STANLEY – DURA–GLIDE 2000/3000 AG: THE BEAUTY OF AN ALL GLASS DOOR WITH THE DURABILITY OF THE #1 SELLING DURA–GLIDE. SERIES 3000 FULL BREAKOUT, DARK BRONZE ANODIZED OPTION: PAINTED AND CLADDING, 7?–8? (2.3M), CLEAR DOOR OPENING OF 6?–11? (2.1M), JAMB DIMENSION 1 3/4? X 4 1/2? , POWER REQUIRED 120 VAC, 50/60 HZ, 5 AMPS MINIMUM | OPTION: UNINTERRUPTED POWER SUPPLY , GLASS 1/2? TEMPERED WITH POLISHED EDGES, CODES AND STANDARDS UL, CUL, ANSI 156.10, IBC, NFPA 101.

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REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
A	27JUL20	ISSUED FOR INTERNAL REVIEW	VA	RM	JP
B	06AUG20	ISSUED FOR CLIENT REVIEW	VA	RM	JP
C	23DEC20	ISSUED FOR FEED	RM	NS	JP
C1	23FEB21	ISSUED FOR FEED	TR	NS	JP

REFERENCE DWG NUMBER	REFERENCE DRAWINGS
M1NN–CCS–DWG–220–00050	MULTI–PURPOSE BUILDING CCS–MPB–001 – DRAWING INDEX LIST
M1NN–CCS–DWG–220–00051	MULTI–PURPOSE BUILDING CCS–MPB–001 – CONCEPTUAL FLOOR PLAN
M1NN–CCS–DWG–220–00052	MULTI–PURPOSE BUILDING CCS–MPB–001 – EXTERIOR ELEVATIONS
M1NN–CCS–DWG–220–00053	MULTI–PURPOSE BUILDING CCS–MPB–001 – WALL SECTION
M1NN–CCS–DWG–220–00054	MULTI–PURPOSE BUILDING CCS–MPB–001 – COMMON BUILDING SPECIFICATIONS
M1NN–CCS–DWG–220–00056	MULTI–PURPOSE BUILDING CCS–MPB–001 – WALL SECTIONS

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CONTRACT M1NN

CONTRACT	M1NN
DESIGNED BY	V. AU
CHECKED BY	R. MARTINEZ
SUPERVISOR	T. RISHFORTH — APP DATE
LEAD ENGR/SPEC.	J. PATEL — APP DATE
FLUOR	APP DATE
CLIENT	APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA

CARBON CAPTURE AND SEQUESTRATION

ARCHITECTURAL

MULTI–PURPOSE BUILDING CCS–MPB–001

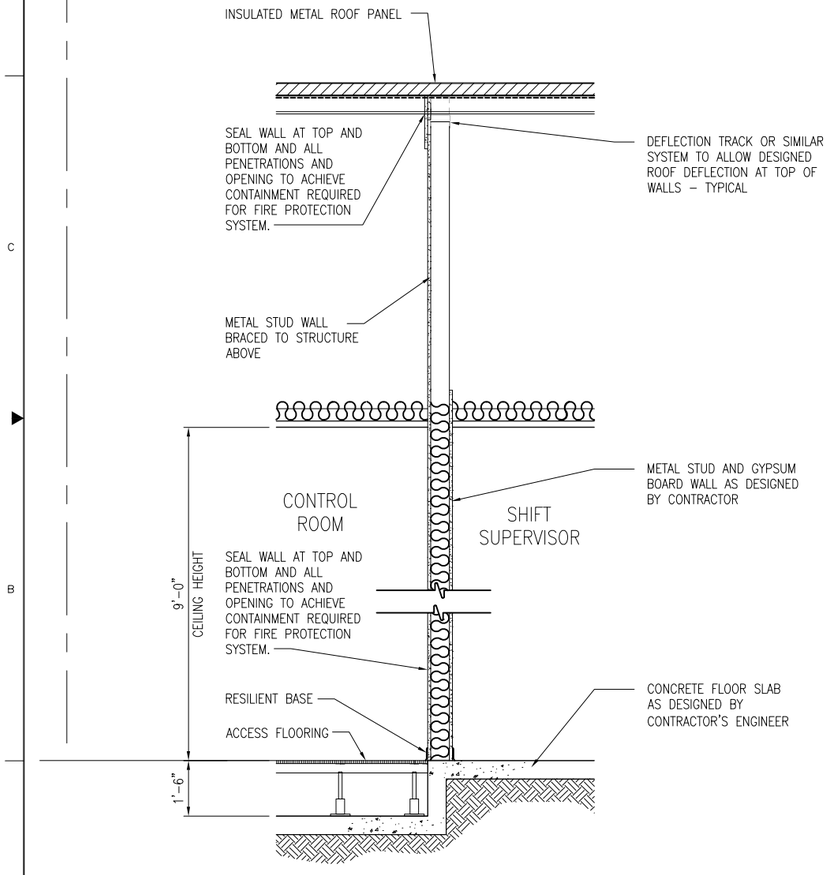
HARDWARE AND ACCESSORY NOTES

SCALE	DRAWING NUMBER	REV
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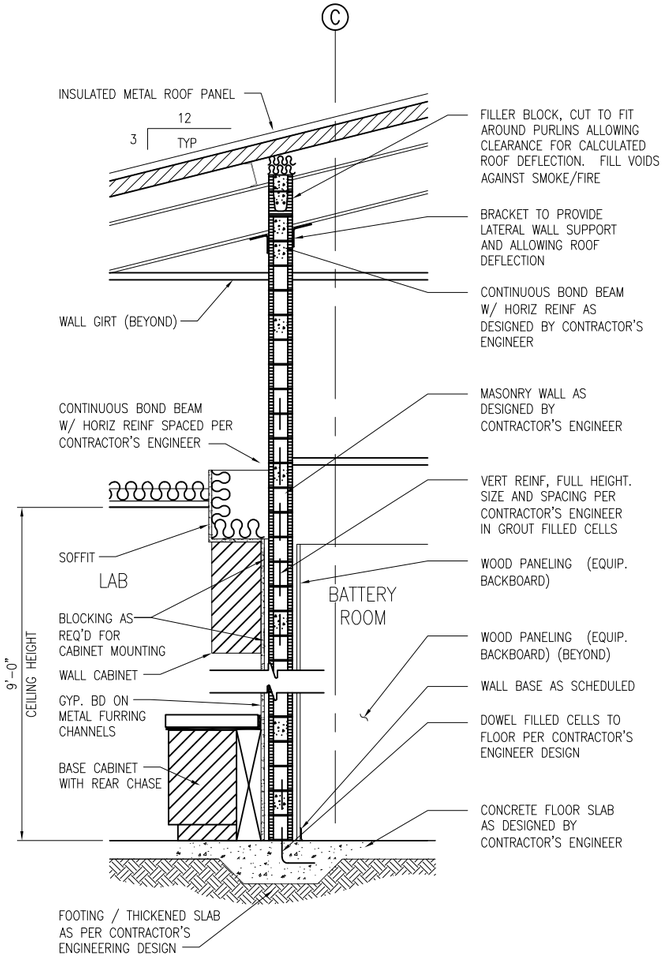
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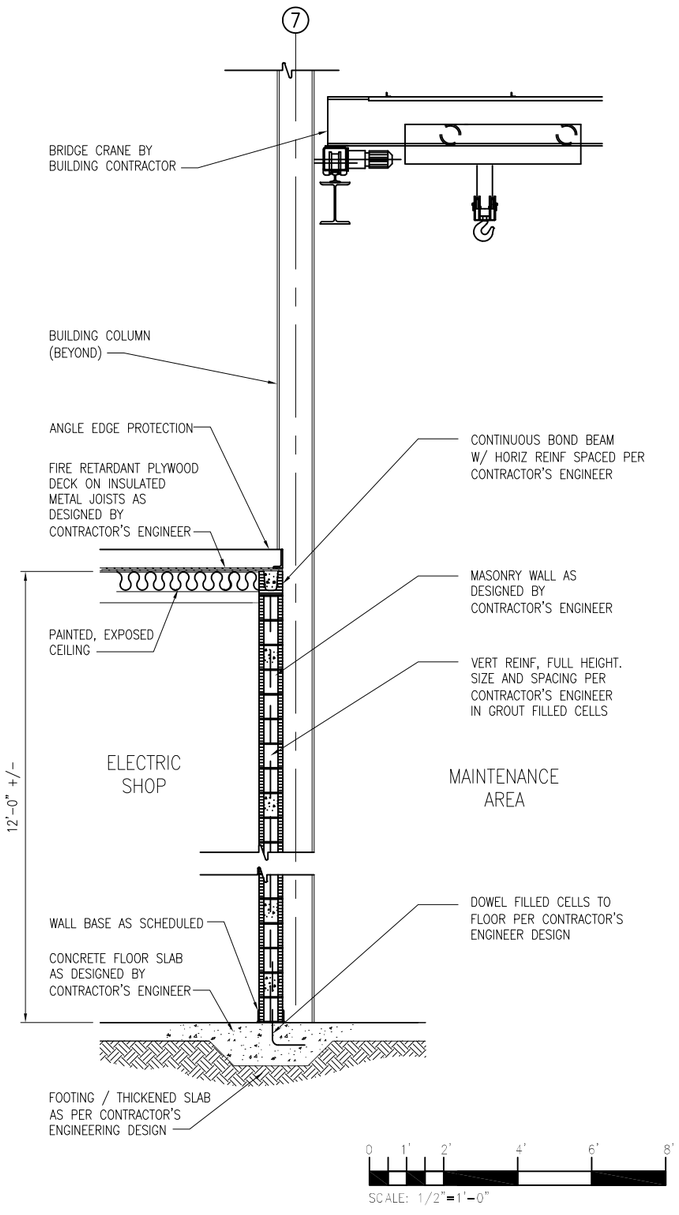
F–022.DWG 01JUL09



WALL SECTION AT CONTROL ROOM — SCALE: 1/2" = 1'-0" — 01



SECTION AT LAB WALL — SCALE: 1/2" = 1'-0" — 02



SECTION AT ELEC SHOP / MAINTENANCE WALL — SCALE: 1/2" = 1'-0" — 03

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REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
A	22FEB21	ISSUED FOR INTERNAL REVIEW	TR	RM	JP
B		NOT USED			
C	23FEB21	ISSUED FOR FEED	TR	NS	JP

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV

REFERENCE DWG NUMBER	REFERENCE DRAWINGS
M1NN-CCS-DWG-220-00050	MULTI-PURPOSE BUILDING CCS-MPB-001 – DRAWING INDEX LIST
M1NN-CCS-DWG-220-00051	MULTI-PURPOSE BUILDING CCS-MPB-001 – CONCEPTUAL FLOOR PLAN
M1NN-CCS-DWG-220-00052	MULTI-PURPOSE BUILDING CCS-MPB-001 – EXTERIOR ELEVATIONS
M1NN-CCS-DWG-220-00053	MULTI-PURPOSE BUILDING CCS-MPB-001 – WALL SECTION
M1NN-CCS-DWG-220-00054	MULTI-PURPOSE BUILDING CCS-MPB-001 – COMMON BUILDING SPECIFICATIONS
M1NN-CCS-DWG-220-00055	MULTI-PURPOSE BUILDING CCS-MPB-001 – HARDWARE AND ACCESSORY NOTES

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CONTRACT M1NN

CONTRACT	M1NN
DESIGNED BY	T. RISHFORTH
CHECKED BY	R. MARTINEZ
SUPERVISOR	N. SWAMY — APP DATE
LEAD ENGR/SPEC.	J. PATEL — APP DATE
FLUOR	APP DATE
CLIENT	APP DATE

MINNKOTA POWER COOPERATIVE

PROJECT TUNDRA

CARBON CAPTURE AND SEQUESTRATION

ARCHITECTURAL

MULTI-PURPOSE BUILDING CCS-MPB-001

WALL SECTIONS

SCALE	DRAWING NUMBER	REV
1/2" = 1'-0"	M1NN-CCS-DWG-220-00056	C

CAD FILE NAME M1NN-CCS-DWG-220-00056_Working.dwg

PLOT DATE: X:\CAD\220_ARCHITECTURAL\05 Multi-Purpose Building\M1NN-CCS-DWG-220-00056_Working.dwg 02-21-21 10:44 am Printed By: ris84116

ATTACHMENT 9 – ELECTRICAL EQUIPMENT LIST

Minnkota Power Cooperative

Project Tundra Carbon Capture and Sequestration Project

ELECTRICAL EQUIPMENT LIST

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
A	10/01/20	ISSUED FOR INTERNAL REVIEW	AB	JS	JP
B	10/05/20	ISSUED FOR CLIENT REVIEW	AB	JS	JP
C	10/29/20	ISSUED FOR FEED	AB	JS	JP
C1	12/31/20	ISSUED FOR FEED	AB	JS	JP

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M1NN	
A. BROWN	
J. SEYMOUR	
D.HOELSCHER	
J.SEYMOUR	

PROJECT TUNDRA

ELECTRICAL EQUIPMENT LIST

SCALE	DWG. NO.	REV.
	M1NN-CCS-LST-265-00002	C1

PLOT DATE: 12/31/20

FILE NAME: M1NN-CCS-LST-265-00002_C1

ELECTRICAL EQUIPMENT LIST

REV	TAG NUMBER	DESCRIPTION	EQUIPMENT RATINGS	PO NUMBER	VENDOR	CWP No	TURNOVER PACKAGE SYSTEM	NOTE
--	CCS-ASD-P101A	DCC WATER PUMP ASD	2250 HP, 4160 V			BPSS01	--	
--	CCS-ASD-P101B	DCC WATER PUMP ASD	2250 HP, 4160 V			BPSS01	--	
--	CCS-B-001	125VDC SYSTEM BATTERY	125 VDC, 595 AH			BPSS01	--	
--	CCS-B-002	UPS SYSTEM BATTERY	120 VDC, 415 AH			BPSS01	--	
--	CCS-B-003	UPS SYSTEM BATTERY	120 VDC, 415 AH			BPMB01	--	
--	CCS-B-021	125VDC SYSTEM BATTERY	125 VDC, 200 AH			BPCT02	--	
--	CCS-BC-001A	125VDC SYSTEM BATTERY CHARGER	480 VAC, 75 A			BPSS01	--	
--	CCS-BC-001B	125VDC SYSTEM BATTERY CHARGER	480 VAC, 75 A			BPSS01	--	
--	CCS-BC-021A	125VDC SYSTEM BATTERY CHARGER	480 VAC, 25 A			BPCT02	--	
--	CCS-BC-021B	125VDC SYSTEM BATTERY CHARGER	480 VAC, 25 A			BPCT02	--	
--	CCS-D-003A	BUS DUCT	4160 V, 3000 A			BPSS00	--	
--	CCS-D-003B	BUS DUCT	4160 V, 3000 A			BPSS00	--	
--	CCS-D-005A	BUS DUCT	480 V, 4000 A			BPSS00	--	
--	CCS-D-005B	BUS DUCT	480 V, 4000 A			BPSS00	--	
--	CCS-D-006	BUS DUCT	480 V, 4000 A			BPSS00	--	
--	CCS-D-007	BUS DUCT	480 V, 4000 A			BPSS00	--	
--	CCS-D-008	BUS DUCT	480 V, 4000 A			BPCT02	--	
--	CCS-D-009	BUS DUCT	480 V, 4000 A			BPCT02	--	
--	CCS-IRP-001	INTERPOSING RELAY PANEL				BPSS01	--	
--	CCS-IRP-021	INTERPOSING RELAY PANEL				BPCT02	--	
--	CCS-GR-003A	NEUTRAL GROUNDING RESISTOR	2.4 kV, 100 A, 10 sec			BPSS01	--	
--	CCS-GR-003B	NEUTRAL GROUNDING RESISTOR	2.4 kV, 100 A, 10 sec			BPSS01	--	
--	CCS-HP-301	HEAT TRACE POWER PANEL	480/277V, 225A			BPCT01	--	
--	CCS-HP-302	HEAT TRACE POWER PANEL	480/277V, 225A			CCCE02	--	
--	CCS-HP-303	HEAT TRACE POWER PANEL	480/277V, 225A			CCPE02	--	
--	CCS-HP-304	HEAT TRACE POWER PANEL	480/277V, 225A			BPBE01	--	
--	CCS-HP-305	HEAT TRACE POWER PANEL	480/277V, 225A			CCAB01	--	
--	CCS-HP-306	HEAT TRACE POWER PANEL	480/277V, 225A			CCST01	--	
--	CCS-HP-307	HEAT TRACE POWER PANEL	480/277V, 225A			CCPR06	--	
--	CCS-HP-308	HEAT TRACE POWER PANEL	480/277V, 225A			BPUT03	--	
--	CCS-HP-309	HEAT TRACE POWER PANEL	480/277V, 225A			BPBE01	--	
--	CCS-HP-310	HEAT TRACE POWER PANEL	480/277V, 225A			BPPR04	--	
--	CCS-HP-311	HEAT TRACE POWER PANEL	480/277V, 225A			BPUT01	--	
--	CCS-HP-312	HEAT TRACE POWER PANEL	480/277V, 225A			CCPR06	--	
--	CCS-HT-301	EHT POWER TRANSFORMER	480 V / 480/277V, 45 kVA			BPCT01	--	
--	CCS-HT-302	EHT POWER TRANSFORMER	480 V / 480/277V, 45 kVA			CCCE02	--	

Minnkota Power Cooperative
Project Tundra Carbon Capture and Sequestration Project
Contract: M1NN

ELECTRICAL EQUIPMENT LIST

Document Number: M1NN-CCS-LST-265-00002
Date: 12/31/2020
Revision Number: C1

REV	TAG NUMBER	DESCRIPTION	EQUIPMENT RATINGS	PO NUMBER	VENDOR	CWP No	TURNOVER PACKAGE SYSTEM	NOTE
--	CCS-HT-303	EHT POWER TRANSFORMER	480 V / 480/277V, 45 kVA			CCPE02	--	
--	CCS-HT-304	EHT POWER TRANSFORMER	480 V / 480/277V, 45 kVA			BPBE01	--	
--	CCS-HT-305	EHT POWER TRANSFORMER	480 V / 480/277V, 45 kVA			CCAB01	--	
--	CCS-HT-306	EHT POWER TRANSFORMER	480 V / 480/277V, 45 kVA			CCST01	--	
--	CCS-HT-307	EHT POWER TRANSFORMER	480 V / 480/277V, 45 kVA			CCPR06	--	
--	CCS-HT-308	EHT POWER TRANSFORMER	480 V / 480/277V, 45 kVA			BPUT03	--	
--	CCS-HT-309	EHT POWER TRANSFORMER	480 V / 480/277V, 45 kVA			BPBE01	--	
--	CCS-HT-310	EHT POWER TRANSFORMER	480 V / 480/277V, 45 kVA			BPPR04	--	
--	CCS-HT-311	EHT POWER TRANSFORMER	480 V / 480/277V, 45 kVA			BPUT01	--	
--	CCS-HT-312	EHT POWER TRANSFORMER	480 V / 480/277V, 45 kVA			CCPR06	--	
--	CCS-IP-101	UPS POWER PANEL	208/120V, 100A			BPBE01	--	
--	CCS-IP-102	UPS POWER PANEL	208/120V, 100A			CCCE02	--	
--	CCS-IP-103	UPS POWER PANEL	208/120V, 100A			CCPE02	--	
--	CCS-IP-103	UPS POWER PANEL	208/120V, 100A			CCAB01	--	
--	CCS-LC-001	MEDIUM VOLTAGE LCI	13,000 HP, 5.2 kV			BPSS01	--	
--	CCS-LP-201	LIGHTING PANEL	208/120V, 100A			BPUT03	--	
--	CCS-LP-202	LIGHTING PANEL	208/120V, 100A			BPCT01	--	
--	CCS-LP-203	LIGHTING PANEL	208/120V, 100A			CCPR06	--	
--	CCS-LP-204	LIGHTING PANEL	208/120V, 100A			CCAB01	--	
--	CCS-LP-205	LIGHTING PANEL	208/120V, 100A			BPPR04	--	
--	CCS-LT-201	LIGHTING TRANSFORMER	480 V / 208-120 V, 15 kVA			BPUT03	--	
--	CCS-LT-202	LIGHTING TRANSFORMER	480 V / 208-120 V, 15 kVA			BPCT01	--	
--	CCS-LT-203	LIGHTING TRANSFORMER	480 V / 208-120 V, 15 kVA			CCPR06	--	
--	CCS-LT-204	LIGHTING TRANSFORMER	480 V / 208-120 V, 15 kVA			CCAB01	--	
--	CCS-LT-205	LIGHTING TRANSFORMER	480 V / 208-120 V, 15 kVA			BPPR04	--	
--	CCS-MC-003A	MEDIUM VOLTAGE MOTOR CONTROL CENTER	4160 V, 3000 A			BPSS01	--	
--	CCS-MC-003B	MEDIUM VOLTAGE MOTOR CONTROL CENTER	4160 V, 3000 A			BPSS01	--	
--	CCS-MC-005-1	LOW VOLTAGE MOTOR CONTROL CENTER	480 V, 1200 A			BPSS01	--	
--	CCS-MC-005-2	LOW VOLTAGE MOTOR CONTROL CENTER	480 V, 1200 A			BPSS01	--	
--	CCS-MC-005-3	LOW VOLTAGE MOTOR CONTROL CENTER	480 V, 1200 A			BPSS01	--	
--	CCS-MC-005-4	LOW VOLTAGE MOTOR CONTROL CENTER	480 V, 1200 A			BPSS01	--	
--	CCS-MC-006	LOW VOLTAGE MOTOR CONTROL CENTER	480 V, 4000 A			BPSS01	--	
--	CCS-MC-007	LOW VOLTAGE MOTOR CONTROL CENTER	480 V, 4000 A			BPSS01	--	
--	CCS-MC-008	LOW VOLTAGE MOTOR CONTROL CENTER	480 V, 4000 A			BPCT02	--	
--	CCS-MC-009	LOW VOLTAGE MOTOR CONTROL CENTER	480 V, 4000 A			BPCT02	--	
--	CCS-PP-001	MULTIPURPOSE BUILDING 480V PANELBOARD	480 V, 225 A			BPMB01	--	

Minnkota Power Cooperative
Project Tundra Carbon Capture and Sequestration Project
Contract: M1NN

ELECTRICAL EQUIPMENT LIST

Document Number: M1NN-CCS-LST-265-00002
Date: 12/31/2020
Revision Number: C1

REV	TAG NUMBER	DESCRIPTION	EQUIPMENT RATINGS	PO NUMBER	VENDOR	CWP No	TURNOVER PACKAGE SYSTEM	NOTE
--	CCS-PP-002	MULTIPURPOSE BUILDING 480V PANELBOARD	480 V, 225 A			BPMB01	--	
--	CCS-PP-003	PROCESS ENCLOSURE 480V PANELBOARD	480 V, 225 A			CCPE01	--	
--	CCS-PP-004	PROCESS ENCLOSURE 480V PANELBOARD	480 V, 225 A			CCPE01	--	
--	CCS-PP-005	BOILER ENCLOSURE 480V PANELBOARD	480 V, 225 A			BPBE01	--	
--	CCS-PP-006	BOILER ENCLOSURE 480V PANELBOARD	480 V, 225 A			BPBE01	--	
--	CCS-PP-007	COMPRESSOR ENCLOSURE 480V PANELBOARD	480 V, 225 A			CCCE02	--	
--	CCS-PP-008	COMPRESSOR ENCLOSURE 480V PANELBOARD	480 V, 225 A			CCCE01	--	
--	CCS-PP-101	CCS-SUB-001 POWER PANEL	208/120V, 225A			BPSS01	--	
--	CCS-PP-102	CCS-SUB-001 POWER PANEL	208/120V, 225A			BPSS01	--	
--	CCS-PP-103	POWER PANEL	208/120V, 225A			BPCT01	--	
--	CCS-PP-104	POWER PANEL	208/120V, 225A			CCAB01	--	
--	CCS-PP-105	POWER PANEL	208/120V, 225A			CCPR06	--	
--	CCS-PP-106	POWER PANEL	208/120V, 225A			BPUT05	--	
--	CCS-PP-107	POWER PANEL	208/120V, 225A			BPBE01	--	
--	CCS-PP-108	POWER PANEL	208/120V, 225A			CCCE02	--	
--	CCS-PP-109	POWER PANEL	208/120V, 225A			CCPE02	--	
--	CCS-PP-110	POWER PANEL	208/120V, 225A			BPUT03	--	
--	CCS-PP-121	CCS-SUB-002 POWER PANEL	208/120V, 225A			BPCT02	--	
--	CCS-PT-001	MAIN POWER TRANSFORMER	230 kV / 13800 V, 3-Winding, 140 MVA / 70 MVA / 70 MVA			BPSS01	--	
--	CCS-PT-001S	STANDBY POWER TRANSFORMER	230 kV / 13800 V, 3-Winding, 140 MVA / 70 MVA / 70 MVA			BPSS01	--	
--	CCS-PT-003A	TRANSFORMER	13800 V / 4160 V, 15 MVA / 22.4 MVA			BPSS01	--	
--	CCS-PT-003B	TRANSFORMER	13800 V / 4160 V, 15 MVA / 22.4 MVA			BPSS01	--	
--	CCS-PT-005A	TRANSFORMER	13800 V / 480 V, 2500 kVA / 3500 kVA			BPSS01	--	
--	CCS-PT-005B	TRANSFORMER	13800 V / 480 V, 2500 kVA / 3500 kVA			BPSS01	--	
--	CCS-PT-006	TRANSFORMER	13800 V / 480 V, 2500 kVA / 3500 kVA			BPSS01	--	
--	CCS-PT-007	TRANSFORMER	13800 V / 480 V, 2500 kVA / 3500 kVA			BPSS01	--	
--	CCS-PT-008	TRANSFORMER	13800 V / 480 V, 2500 kVA / 3500 kVA			BPCT02	--	
--	CCS-PT-009	TRANSFORMER	13800 V / 480 V, 2500 kVA / 3500 kVA			BPCT02	--	
--	CCS-PT-101	SMALL POWER TRANSFORMER - SUBSTATION CCS-SUB-001	480 V / 208-120 V, 45 kVA			BPSS01	--	
--	CCS-PT-102	SMALL POWER TRANSFORMER - SUBSTATION CCS-SUB-001	480 V / 208-120 V, 45 kVA			BPSS01	--	
--	CCS-PT-103	SMALL POWER TRANSFORMER	480 V / 208-120 V, 30 kVA			BPCT01	--	
--	CCS-PT-104	SMALL POWER TRANSFORMER	480 V / 208-120 V, 45 kVA			CCAB01	--	
--	CCS-PT-105	SMALL POWER TRANSFORMER	480 V / 208-120 V, 30 kVA			CCPR06	--	
--	CCS-PT-106	SMALL POWER TRANSFORMER	480 V / 208-120 V, 30 kVA			BPUT05	--	
--	CCS-PT-107	BOILER ENCL SMALL POWER TRANSFORMER	480 V / 208-120 V, 30 kVA			BPBE01	--	
--	CCS-PT-108	COMPR ENCL SMALL POWER TRANSFORMER	480 V / 208-120 V, 30 kVA			CCCE02	--	

Minnkota Power Cooperative
Project Tundra Carbon Capture and Sequestration Project
Contract: M1NN

ELECTRICAL EQUIPMENT LIST

Document Number: M1NN-CCS-LST-265-00002
Date: 12/31/2020
Revision Number: C1

REV	TAG NUMBER	DESCRIPTION	EQUIPMENT RATINGS	PO NUMBER	VENDOR	CWP No	TURNOVER PACKAGE SYSTEM	NOTE
--	CCS-PT-109	PROCESS ENCL SMALL POWER TRANSFORMER	480 V / 208-120 V, 30 kVA			CCPE02	--	
--	CCS-PT-110	SMALL POWER TRANSFORMER	480 V / 208-120 V, 30 kVA			BPUT03	--	
--	CCS-PT-121	SMALL POWER TRANSFORMER - SUBSTATION CCS-SUB-002	480 V / 208-120 V, 45 kVA			BPCT02	--	
--	CCS-S-001	MEDIUM VOLTAGE SWITCHGEAR	13800 V, 3000 A			BPSS01	--	
--	CCS-S-002	MEDIUM VOLTAGE SWITCHGEAR	13800 V, 3000 A			BPSS01	--	
--	CCS-S-003	MEDIUM VOLTAGE SWITCHGEAR	4160 V, 3000 A			BPSS01	--	
--	CCS-S-005	LOW VOLTAGE SWITCHGEAR	480 V, 4000 A			BPSS01	--	
--	CCS-S-006	LOW VOLTAGE SWITCHGEAR	480 V, 4000 A			BPSS01	--	
--	CCS-S-007	LOW VOLTAGE SWITCHGEAR	480 V, 4000 A			BPSS01	--	
--	CCS-S-008	LOW VOLTAGE SWITCHGEAR	480 V, 4000 A			BPCT02	--	
--	CCS-S-009	LOW VOLTAGE SWITCHGEAR	480 V, 4000 A			BPCT02	--	
--	CCS-U-001	UPS SYSTEM	480 V / 208-120 V, 30 kVA, 30 min			BPSS01	--	
--	CCS-U-002	UPS SYSTEM	480 V / 208-120 V, 30 kVA, 30 min			BPMB01	--	

ATTACHMENT 10 – NETWORK ARCHITECTURE DRAWING

DCS ARCHITECTURE BLOCK DIAGRAM

MULTI-PURPUSE BUILDING (MPB)

CONTROL ROOM

Operator Console

Large Wall Screen

RACK ROOM

BUSINESS NETWORK LEVEL 4

Note 3

To Client Business Network

Fire Wall

Anti-Virus Server

Routers

IT Firewalls

Redundant FO

Routers

IT Firewalls

Redundant FO

Note 5

NETWORK LEVEL3 ETHERNET SWITCHES

DCS Workstation

AMS Workstation

Rack Room Printer

AMS (Asset Man. Sys)

Historian

Database Server

Scada Server

GPS Master Clock

NETWORK LEVEL2 ETHERNET SWITCHES

Router

Redundant Ovation DCS

Serial

ELC Controller Module

SIMULATION ROOM

Operator Interface

Instructor Station

Virtual Controllers

EXISTING MRY RELAY ROOM

IT Firewalls

Note 4

MRY1 ELC Controller Module

IT Firewalls

Note 4

Serial

Serial

MRY2 ELC Controller Module

NOTES:

1. PLC supplied by package equipment vendor. PLC maintenance functions will be performed locally with a laptop.
2. Equipment (JB or PLC) provided by B&M.
3. Equipment shown in grayed area are not in Tundra scope.
4. Data interface with existing MRY1 and MRY2 DCSs shall use Ethernet Link Controller modules (ELC) and firewalls. The ELC modules will convert Ethernet DNP3 to Serial at the controller connection side.
5. This network is independent to the MRY network.
6. This block diagram does not indicate quantities.

Modbus TCP/IP

LINE LEGEND

- Redundant Fiber Optic
- CAT 5 UTP
- Hardwired Single pair
- Hardwired Multi pair

Compressor Enclosure

Modbus TCP/IP

Anti-surge Controller

DCS Remote I/O

Analyzer Shelter

Modbus TCP via ELC

PLC (Note 1)

HMI

Analyzers

Utilities Enclosure

DCS Remote I/O

Impurity Removal Package Enclosure

DCS Remote I/O

Modbus TCP via ELC

PLC (Note 1)

Process Building

DCS Remote I/O

Modbus TCP via ELC

PLC (Note 1)

Instrument Air Compr.

PLC (Note 1)

Solvent Maintenance System

Water Treatment Building B&M scope @ Batt. Limits

PLC (Note 2)

(Note 2) JB

(Note 2) JB

Boiler Enclosure

CEMS

DCS Remote I/O

PLC (Note 1)

Modbus TCP via ELC

HMI

CT Chem Inj. Enclosure

DCS Remote I/O

Substation

DCS Remote I/O

Modbus TCP via ELC

Smart MCC (LV, MV & HV)

Analyzer Shelter

Analyzers

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
C1	12-Oct-2020	RE-ISSUED FOR FEED	EM	ST	JP
C	24-Sep-2020	ISSUED FOR FEED	EM	ST	JP

PROJECT TUNDRA

Minkotta Power Cooperative
PROJECT TUNDRA
CARBON CAPTURE AND SEQUESTRATION

DCS ARCHITECTURE BLOCK DIAGRAM

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M1NN-CCS-SKT-270-00001 C1

ATTACHMENT 11 – FIRE PROTECTION DESIGN BASIS

Minnkota Power Cooperative

Project Tundra Carbon Capture and Sequestration Project

FIRE PROTECTION DESIGN BASIS

DOCUMENT NUMBER:
M1NN-CCS-DBD-653-00001
Fluor Project No: M1NN

						Jayesh Patel Digitally signed by Jayesh Patel Date: 2020.09.23	
C	23Sep2020	23	Issued for Design	JST	SB	JP	
B	21Aug2020	22	Issued for Client Review	JST	SB	JP	
A	13Aug2020	12	Issued for Internal Review	JST	SB	JP	
REV	**DATE**	**PAGES**	**DESCRIPTION**	**ORIG.**	**CHKD**	**Fluor APPROVED BY**	**CLIENT**

FIRE PROTECTION DESIGN BASIS

RECORD OF REVISIONS

Revision No.	Date	Description
A	13Aug2020	Issued for Internal Review
B	21Aug2020	Issued for Client Review
C	23Sep2020	Issued for Design



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FIRE PROTECTION DESIGN BASIS

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FIRE PROTECTION DESIGN BASIS

1.0 GENERAL

1.1 Purpose

The purpose of this document is describe the fire protection philosophy and design basis for the Minnkota Project Tundra Carbon Capture and Sequestration (CCS) scope.

1.2 Scope

The scope of this Fire Protection Design Basis covers the active and passive fire protection systems for the Minnkota Project Tundra Fluor CCS scope. The fire and gas detection system basis is also covered in this document.

This document is intended to complement Doc. No. M1NN-CCS-SPC-653-00001, Fire Protection Specification-Equipment, which provides design requirements for active fire protection equipment.

Fire and Gas system design is also covered in documents M1NN-CCS-SPC-235-00010, Building Fire Detection & Protection Systems and M1NN-CCS-PHL-270-00001, Control Philosophy and Design Criteria.

2.0 REFERENCES

Document No.	Title
M1NN-CCS-SPC-235-00010	Building Fire Detection & Protection Systems
M1NN-CCS-PHL-270-00001	Control Philosophy and Design Criteria
M1NN-CCS-SPC-653-00001	Fire Protection Specification - Equipment
M1NN-CCS-RPT-653-00001	Firewater Demand and Hydraulic Calculations
M1NN-CCS-SPC-210-00001	Civil Design Criteria

3.0 ABBREVIATIONS

Abbreviation	Description
AHJ	Authority Having Jurisdiction
ANSI	American National Standards Institute
B&M	Burns and McDonnell
CCS	Carbon Capture and Sequestration
FGCP	Fire and Gas Control Panel



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FIRE PROTECTION DESIGN BASIS

Abbreviation	Description
DCS	Distributed Control System
FM	Factory Mutual
MCP	Manual Alarm Call-Point
MFGCP	Main Fire and Gas Control Panel
MPC	Minnkota Power Cooperative
NFPA	National Fire Protection Association
PFP	Passive Fire Protection
TEG	Triethylene Glycol
UL	Underwriters Laboratories
1oo1	One-out-of-One

4.0 FIRE PROTECTION DESIGN PHILOSOPHY

The design of Project Tundra CCS fire protection systems shall meet the requirements specified by MPC and regulatory authorities having jurisdiction. The design shall be consistent with MPC specifications and FM Global requirements. In addition, good engineering design practices from recognized industry standards such as NFPA shall be applied in the design of the CCS facilities.

Fire protection includes active and passive fire protection systems. Based on guidance provided by guidelines for Fire Protection in Chemical, Petrochemical, and Hydrocarbon Processing Facilities © 2003, Center for Chemical Process Safety (CCPS)/AIChE, the overall project design basis as it relates to risk should focus on the following:

- Elimination - The removal or minimization of a hazard through inherently safer design.
- Prevention – The minimization of the likelihood of an event through the installation, integrity, and application of prevention systems to address each hazard through design practices.
- Detection and Control – The limitation of the severity of incidents by early detection of the incident and the operation of safety systems, including fire protection systems through fire and gas detection and process isolation.
- Mitigation – The protection of people and physical assets from the effects of any remaining credible hazards through fire protection systems (passive or active).
- Emergency Response – The protection of people from the effects of an escalating or catastrophic incident.



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FIRE PROTECTION DESIGN BASIS

If the prevention of a release fails and subsequent ignition occurs, passive or active fire protection systems may be utilized for suppression and escalation protection.

Passive fire protection systems include fireproofing using fire-resistant rated materials on critical equipment supports and steel structures to limit the spread of fire, prevent failure of the structure, and enable fire-fighting and evacuation. Passive fire protection systems also include fire barriers and equipment separation.

Active fire protection systems will be comprised of fire hydrants, monitors, hose reels, deluge/sprinkler systems and portable fire extinguishers.

The final determination of specific fire protection systems and/or features will be based on the results of a risk/hazard analysis, local conditions, potential exposures/issues for the CCS facilities, as well as emergency response capabilities.

5.0 FIREWATER DEMAND CALCULATION

5.1 Fire Zones

The CCS facility will be divided into several “fire zones”. Fire areas within the CCS facility will be defined by developing zone boundaries on the plot plan for the main purpose of determining water demand requirements to control and contain a single fire within an area. Where separation of areas or hazardous equipment is less than 50 ft the combined area should be considered as a single fire area.

Each fire zone will have its own fire water demand calculation and the firewater supply and distribution systems designed for appropriate water flow and pressure requirements.

For CCS facility areas, other than that of storage tanks, a fire zone shall be an area segregated by road, accessways, pipe racks, or pipe sleepers, with clear spaces of 50 ft width from equipment to equipment.

For tankage areas, each storage tank located in an individual bund or dike shall be considered as a single fire zone. Where multiple tanks are located inside of a common bund then the entire bund shall be considered as a single fire zone and firewater demand corresponding to tank involved in fire and exposure protection for adjacent tanks shall be considered as a design fire scenario.

Building areas will be considered as individual fire zones.

5.2 Firewater Demand Calculation Basis

The firewater demand for each zone shall be based upon a review of fire hazards (i.e. hydrocarbon type, flammable liquid volume, pressure, temperature, fire type, etc.),



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FIRE PROTECTION DESIGN BASIS

preliminary plot plans, equipment sizes, firewater application rates (density), etc. Only a single major fire event will be considered to occur at any given time.

The firewater demand scenario is based on the combined utilization rates of active fire suppression (i.e. deluge, sprinklers, monitors, foam, hoses) for the fire involved zone, and devices used for adjacent zones or nearby equipment that may be required to be cooled as identified in during the qualitative review of fire hazards.

The firewater distribution system shall be sized by calculating the worst case design firewater demand. The fire scenario resulting in the maximum firewater demand will be established as the worst case design fire scenario. This maximum demand is considered as the design firewater demand scenario.

When estimating firewater demand for fire monitors and hose lines, the following criteria shall be used in addition to manufacturer's recommended guidelines for service:

- Hose Line: 2- ½" 250 gpm
- Fire monitor: CCS - Grade 750 gpm
- Fire monitor : CCS - Elevated 1000 gpm

An additional 1000 gpm (one fire hydrant) will be added to all fire scenario firewater demands for each fire zone.

Deluge application density rates shall be as per FM Class 4930 for the cooling tower and NFPA 13 requirements for the CCS buildings/enclosures.

For sprinkler demand basis for buildings/enclosures, refer to Doc. No. M1NN-CCS-SPC-235-00010, Building Fire Detection and Protection Systems. Sprinkler demand was calculated as per NFPA 13 requirements.

A fire hazards review was completed based on the CCS Process equipment list provided to Mechanical on July 16, 2020 and is included in Attachment 1.

Preliminary worst case demand is anticipated to be the cooling tower zone. The cooling tower contains combustible fill and will require deluge water spray to meet FM approval and will also have fire monitor protection.

The FEED firewater demand calculation will be issued in a separate report, Doc. No. M1NN-CCS-RPT-HSE-00001, Firewater Demand and Hydraulic Calculations.



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6.0 FIREWATER HYDRAULIC CALCULATION

Hydraulic calculations will be performed for the various CCS fire scenarios, including the facility specific worst-case scenario to confirm the preliminary sizing of the CCS underground HDPE piping. Firewater supply will come from Burns and McDonnell, who will provide the firewater pumps and tanks which will supply the CCS firewater main.

The CCS main will consist of piping, fire hydrants, monitors, and deluge systems. The CCS underground firewater piping layout will be modeled using Pipenet Vision (Version 1.10).

The minimum battery limit supply pressure of 120 psig will be used to conduct firewater hydraulic calculations. Different hydraulic scenarios will be modeled to determine worst case demand and pressure/flow. For optimal monitor and hose stream reach, 100 psig is needed at base of riser for monitors/elevated monitors and 90 psig is needed at each deluge and building sprinkler system stub-ups to achieve required coverage.

The preliminary hydraulic calculation results will be issued in a separate report, Doc. No. M1NN-CCS-RPT-HSE-00001, Firewater Demand and Hydraulic Calculations.

7.0 FIRE AND GAS DETECTION

7.1 General

Fire and gas detection and alarm systems are intended to identify the presence of hazardous/ toxic /inert gases, abnormal heat, fire, and/or smoke.

Detection strategies and systems with alarms will minimize loss of life and property by providing an early warning to personnel allowing for the initiation of emergency response plans. All fire and gas detectors shall be FM approved.

Sufficient gas detection must be provided to:

- Determine if a release has occurred.
- To allow voting to reduce the probability of a false trip.
- To facilitate process isolation and de-inventorying of fuel.
- To reduce the probability of ignition when flammable releases are upwind of fired equipment.
- The appropriate gas, smoke, flame, and heat detectors shall be provided based on the potential hazard that exists in the area.



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7.2 Fire and Gas Detection Systems

The CCS will have a fire and gas monitoring system. This system will be used to monitor fire and gas in the process areas and buildings. Process area devices, including deluge pull stations (if any), manual call points (MCP), and flame detectors shall connect to the building FGCPs.

Combustible gas detectors, flame detectors, and carbon dioxide detectors will be utilized in the CCS facility. Process area gas detectors shall be connected to the adjacent building FGCP. Signals for "Confirmed Fire", "Confirmed Gas" and "Common Trouble" for each fire zone shall be hardwired to the DCS. The "Common Trouble" shall represent either a detector on High alarm or an FGCP panel malfunction.

The FGCP shall indicate the nature of the hazard and its general location or Fire Zone on the visual display unit (VDU) for that system. In general, the system response to a signal detecting a leak of gas or a fire shall be an alarm to the operator.

Audible notification (horns) will be provided in process areas, enclosures, and buildings to indicate a fire and gas alarm event. Beacon colors and tones are discussed in per M1NN-CCS-SPC-235-00010, Building Fire Detection and Protection Systems.

Reference also Document No. M1NN-CCS-PHL-270-00001, Control Philosophy and Design Criteria for the details of the Fire and Gas System.

7.3 Buildings

Refer to Doc. No. M1NN-CCS-SPC-235-00010, Building Fire Detection and Protection Systems, for building requirements.

7.4 Combustible Gas Detectors

Combustible gas detectors will be placed in the boiler enclosure to ensure detection of any natural gas leaks. The CCS process enclosure will have fire and gas detection and alarms as identified in safety reviews.

Alarm levels for the combustible gas detectors located inside process enclosures and outside shall be as follows:

- High alarm at 20% LEL of the combustible gas to be detected
- High-High alarm at 50% LEL of the combustible gas to be detected



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FIRE PROTECTION DESIGN BASIS

One-out-of-one (1oo1) gas detection for a High alarm (20% LEL) will initiate visual and audible alarms on the FGCP and the Distributed Control System (DCS) Console in addition to initiating a General alarm on the CCS horns.

For High-High alarm (50% LEL), 1oo1 gas detection will initiate visual and audible alarms on the FGCP and a confirmed gas alarm on the DCS Console in addition to initiating a General alarm on the CCS horns.

7.5 Gas Detectors

Carbon dioxide detectors will be utilized in the enclosures, such as the CO_2 compressor enclosure. This will ensure that operators are alerted of an oxygen deficient atmosphere in the enclosure. The detectors will be mounted near the floor, as CO_2 is heavier than air.

For CO_2 detectors, 1oo1 gas detection for a High alarm (5,000 ppm) will initiate visual and audible alarms on the FGCP and a Confirmed Gas alarm on the DCS console, in addition to initiating a general alarm on the CCS horns. For High-High alarm (10,000 ppm), 1oo1 gas detection will initiate visual and audible alarms on the FGCP and a Confirmed Gas alarm on the DCS console, in addition to initiating a general alarm over the CCS horns.

7.6 Flame Detectors

Flame detectors will be used wherever combustible compressor lube oil is present. Flame detectors will be UV/IR type and will be used primarily to detect lube oil fires.

Activation of 1oo1 flame detectors shall initiate an alarm on the FGCP and a Confirmed Fire alarm on the DCS console. A General Fire Alarm per alarm area shall also be announced through the CCS horns.

7.7 Monitoring and Control of Deluge Systems

The deluge systems will be monitored by the FGCP per MPC. Deluge systems will also be remotely activated in the control room through the FGCP. The fire and gas system shall monitor the deluge system pressure/flow, valve tamper switches, and deluge valve enclosure temperature. Sprinkler system control is addressed in Doc. No. M1NN-CCS-SPC-235-00010, Building Fire Detection and Protection Systems.

8.0 PASSIVE FIRE PROTECTION

The purpose of passive fire protection is as follows:

- To prevent the collapse of steel work supporting equipment containing flammable or toxic materials via fireproofing within a specified time in order to restrict the addition



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FIRE PROTECTION DESIGN BASIS

of fuel to the fire and to protect personnel and equipment from the effects of equipment failure or support failure during the fire.

- To protect safety critical equipment for a period sufficient to fulfill its function.

Passive fire protection (PFP) is provided in areas where other fire protection systems alone do not adequately mitigate the risk and where the inherent fire resistance of the facility is inadequate to respond to a reasonably expected hazard. The components of PFP systems include firewalls, penetration seals, structural coatings, equipment protection, fireproofing materials, and materials of construction.

Considerations for PFP applications shall take into account:

- the attributes of potential fires (e.g. size, duration, location);
- the safeguards afforded by the design (layout, active fire protection system, etc);
- the potential hazards that may be created by the application of PFP (e.g. impede ability to inspect, cracking due to flexible movement of structural members, and potential corrosion due to cracking).

Additional considerations shall be made as the design progresses in process hazard analysis (PHA) studies, P&ID reviews and fire hazard assessment studies to ascertain those areas that will be specified as “required” and to the type and extent of such protection.

Fireproofing system requirements are addressed in Section 8.1 of this document. Other common PFP systems are discussed in Sections 8.2 and 8.3 below.

8.1 Fireproofing

When properly implemented, fireproofing systems can help protect personnel and reduce potential property losses by providing additional time to control or extinguish a fire before thermal effects cause equipment or support.

Fireproofing shall be used to provide primary protection of:

- Structures directly or indirectly supporting significant hydrocarbon inventories or emergency systems.
- Structures supporting heavy loads that, if they were to fail, would lead to significant hydrocarbon release, catastrophic failure, or loss or damage to control or emergency systems.
- Emergency instrumentation and control equipment required for safe and emergency shutdown

Fireproofing for this project shall be designed based on the following:



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- Fire potential equipment (FPE)
- Dimensions of Fire Scenario Envelope
- Fire resistance rating

The major fire hazard considered in fireproofing design will occur from the ignition of accidental leakage of flammable products. The leaked product may spread as a liquid pool, and when ignited will result in a pool fire continuously sustained by the leaking source, and produces a flame height in excess of the pool diameter.

The extent of fireproofing zones and duration of fire resistance shall be based on pool fire scenarios specified in in API RP 2218 Fireproofing Practices in Petroleum and Petrochemical Processing Plants and applicable building codes.

8.2 Types of Fireproofing/Firewalls

Fireproofing for structural members is typically dense concrete or intumescent coating (sprayed on fireproofing). Structures and supports protected by fireproofing materials of any type, except concrete, shall have a minimum rating per UL 1709 of two (2) hours. If concrete is used for fireproofing, its minimum thickness should be 2 inches. All firewalls shall be rated for two (2) hours, as with fireproofing. See Section 8.4 below for more information regarding firewalls.

8.3 Containment and Drainage

Adequate containment and proper drainage are essential components with regards to limiting the damage from exposure to fire as the result of the spread of a liquid from its immediate spill area to other sections of a facility or even outside the facility areas. See Doc. No. M1NN-CCS-SPC-210-00001, Civil Design Criteria, for more information.

The correct combination of containment and drainage will minimize the size of a potential fire, reduce the exposure to the surroundings, localize the need for fire protection and minimize the response requirements for extinguishment.

8.4 Firewalls

Firewalls are used to prevent the spread of fire and limit thermal radiation exposure to occupied building areas and adjacent equipment. Possible applications for firewalls would be where spacing guidelines between transformers and electrical building cannot be met or between compressors housed in shelters.

Firewalls are constructed of steel, concrete, masonry or other non-combustible material, and have a fire protection rating depending on the severity of the hazard exposure. However,



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FIRE PROTECTION DESIGN BASIS

firewalls can also impede natural ventilation, thereby providing the opportunity for gas releases to accumulate and be subjected to potential explosion. Due consideration shall be given to the issues of gas accumulation and entrapment and substrate corrosion and monitoring as well as, inherent endurance time before providing firewalls.

Firewalls used to limit control areas, fire areas, or to separate occupancies of a building, shall meet the applicable building codes for building use and occupancy classification.



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ATTACHMENT 1 – PRELIMINARY FIRE HAZARDS REVIEW

COLUMNS

Unit	Equipment Number	Equipment Name	Insulation Req'd?	Fireproof Insulation Protection	Significant Chemicals Contained	Phase	Major Component	Flammable, Combustible, Toxic	Flashpoint (°F)	Autoignition Temp (°F)	ACTIVE FIRE PROTECTION				
											FIREWATER MONITOR		WATER SPRAY		
											Requires Monitor Coverage (Y/N)	Hydrant/Hose Reel Coverage (Y/N)	Contains Significant Amount of O2 (Y/N)	Requires Waterspray System (Y/N)	Basis of Waterspray Requirement
CCS	CCS-C-101	Direct Contact Cooler (DCC)	Y	N	CO2	G	Nitrogen	N/A	N/A	N/A	N	Y	N	N	-
CCS	CCS-C-201	Absorber	Y	N	Solvent	L,G	Solvent	Non-combustible	N/A	N/A	N	Y	N	N	-
CCS	CCS-C-301	Stripper	Hot	N	Solvent	L,G	Water	Non-combustible	N/A	N/A	N	Y	N	N	-

Notes:
1) This Fire Hazards Review is based on Process Equipment List, M1NN-CCS-LST-225-00001_Rev A, Issued to Mechanical on 16-JUL-20

VESSELS

Unit	Equipment Number	Equipment Name	H or V	Insulation Req'd?	Significant Chemicals Contained	Phase	Major Component	Flammable, Combustible, Toxic	Flashpoint (°F)	Autoignition Temp (°F)	ACTIVE FIRE PROTECTION				
											FIREWATER MONITOR	FIREWATER HYDRANT	WATER SPRAY		
											Requires Monitor Coverage (Y/N)	Has Hydrant/Hose Reel Coverage (Y/N)	Contains Significant Amount of O2 (Y/N)	Requires Waterspray System (Y/N)	Basis of Waterspray Requirement
CCS				Hot	Solvent	L,G	Water	Non-combustible	N/A	N/A	N	Y	N	N	N/A
CCS	CCS-V-302	Overhead Accumulator	Horizontal	None	N/A	L	Water	None	N/A	N/A	N	Y	N	N	N/A
CCS	CCS-V-303	Reboiler Condensate Drum	Horizontal	Hot	N/A	L	Water	None	N/A	N/A	N	Y	N	N	N/A
CCS	CCS-V-601	CO_2 Product Compressor Suction KO Drum	Vertical	None	N/A	L	Water	None	N/A	N/A	N	Y	N	N	N/A

Notes:
1) This Fire Hazards Review is based on Process Equipment List, M1NN-CCS-LST-225-00001_Rev A, Issued to Mechanical on 16-JUL-20

TANKS

Unit	Equipment Number	Equipment Name	Insulation Req'd?	Significant Chemicals Contained	Phase	Major Component	Flammable, Combustible, Toxic	ACTIVE FIRE PROTECTION					
								FIREWATER MONITOR	FIREWATER HYDRANT	WATER SPRAY (DELUGE)		FOAM SYSTEM	
								Requires Monitor Coverage (Y/N)	Has Hydrant/Hose Reel Coverage (Y/N)	Requires Waterspray System (Y/N)	Basis of Waterspray Requirement	Tanks >50,000 gallons capacity storing flammable liquids (Y/N)	Requires Semi-Fixed Foam System (Y/N)
CCS	CCS-TK-401	Spent Solvent Tank	No	Solvent	L	Solvent	Non-combustible	N	Y	N	N/A	N	N
CCS	CCS-TK-501	Solvent Storage Tank	No	Solvent	L,G	Solvent	Non combustible	N	Y	N	N/A	N	N
CCS	CCS-TK-502	Solvent Recovery Tank	No	Solvent	L	Solvent	Non-combustible	N	Y	N	N/A	N	N
CCS	CCS-TK-503	50 wt% NaOH Storage Tank	No	NaOH	L	NaOH	Corrosive	N	Y	N	N/A	N	N
CCS	CCS-TK-504	20 wt% NaOH Storage Tank	No	NaOH	L	Water	Corrosive	N	Y	N	N/A	N	N
CCS	CCS-TK-505	TEG Storage Tank	No	TEG (Triethylene Glycol)	L	TEG	None	N	Y	N	N/A	N	N

Notes:
1) This Fire Hazards Review is based on Process Equipment List, M1NN-CCS-LST-225-00001_Rev A, Issued to Mechanical on 16-JUL-20

S & T EXCHANGERS

Unit	Equipment Number	Equipment Name	Duty (MMBtu/hr)						ACTIVE FIRE PROTECTION				
									FIREWATER MONITOR	FIREWATER HYDRANT	WATER SPRAY		
				Phase	Major Substance at Shell Side	Flammable, Combustible, Toxic	Flashpoint (°F)	Autoignition Temp (°F)	Requires Monitor Coverage (Y/N)	Has Hydrant/Hose Reel Coverage	Contains Significant Amount of O2 (Y/N)	Requires Waterspray System (Y/N)	Basis of Waterspray Requirement
CCS	CCS-E-101 A-F	DCC Water Cooler		L,G	Water	None	N/A	N/A	N	Y	N	N	-
CCS				L	Water	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-E-202	Wash Water Cooler		L	Water	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-E-203	Lean Solvent Cooler		L	Solvent	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-E-301	Solvent Cross Exchanger		L	Solvent	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-E-302	Reboiler		L	Water	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-E-303	Condenser		L	Water	Water	N/A	N/A	N	Y	N	N	-
CCS				L	Solvent	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-E-601	CO_2 Product Compressor Aftercooler		L,G	CO2	None	N/A	N/A	N	Y	N	N	-

Notes:

1) This Fire Hazards Review is based on Process Equipment List, M1NN-CCS-LST-225-00001_Rev A, Issued to Mechanical on 16-JUL-20

COMPRESSORS

Unit	Equipment Number	Equipment Name	Compressor Type & CODE	Capacity (Rated-ACFM)	Phase	Major Component	Flammable, Combustible, Toxic	ACTIVE FIRE PROTECTION				
								FIREWATER MONITOR	FIREWATER HYDRANT	WATER SPRAY		
								Requires Monitor Coverage (Y/N)	Hydrant/Hose Reel Coverage	Compresses Flammable Gases (Y/N)	Requires Waterspray System (Y/N)	Basis of Waterspray Requirement
CCS	*CCS-BL-201*	Blower	Axial Fan		G	Air	none	N	Y	N	N	-
CCS		Blower Lube Oil Unit			L	Lube Oil	Combustible	N	Y	N	N	
CCS					G	Water	none	N	Y	N	N	-
CCS			-		L	Lube Oil	Combustible	N	Y	N	N	-
CCS	*CCS-K-601*	C02 Product Compressor	Intregrally Geared Centrifugal		G	CO2	Asphyxiant	N	Y	N	N	-
CCS		CO2 Compressor Lube Oil Unit	-		L	Lube Oil	Combustible	N	Y	N	N	-

Notes:

1) This Fire Hazards Review is based on Process Equipment List, M1NN-CCS-LST-225-00001_Rev A, Issued to Mechanical on 16-JUL-20

PUMPS

Unit	Equipment Number	Equipment Name	Type	Rated Flow Rate gpm	Discharge Pressure psig	Significant Chemicals Contained	Phase	Major Component	Flammable, Combustible, Toxic	Operating Temp (°F)	ACTIVE FIRE PROTECTION: FIREWATER MONITOR: Requires Monitor Coverage (Y/N)	ACTIVE FIRE PROTECTION: FIREWATER HYDRANT: Has Hydrant/Hose Reel Coverage	ACTIVE FIRE PROTECTION: WATER SPRAY: Handling flammable or combustible liquids with rated capacity of 20 gpm or more (Y/N)	ACTIVE FIRE PROTECTION: WATER SPRAY: Requires Waterspray System (Y/N)	ACTIVE FIRE PROTECTION: WATER SPRAY: Basis of Waterspray Requirement
CCS	CCS-P-101A/B	DCC Water Pump	Centrifugal			-	L	Water	None	250	N	Y	N	N	N/A
CCS	CCS-P-102A/B	DCC Scrubbing Solution Pump	Centrifugal			-	L	Water	None	250	N	Y	N	N	N/A
CCS						-	L	Water	None	250	N	Y	N	N	N/A
CCS	CCS-P-202A/B	Wash Water Pump	Centrifugal			-	L	Water	None	250	N	Y	N	N	N/A
CCS	CCS-P-203A/B	Rich Solvent Pump	Centrifugal			-	L	Solvent	None	250	N	Y	N	N	N/A
CCS	CCS-P-301A/B	Lean Solvent Pump	Centrifugal			-	L	Solvent	None	310	N	Y	N	N	N/A
CCS	CCS-P-302A/B	Reflux Pump	Centrifugal			-	L	Water	None	250	N	Y	N	N	N/A
CCS	CCS-P-303A/B	Reboiler Condensate Pump	Centrifugal			-	L	Water	None	0	N	Y	N	N	N/A
CCS	CCS-P-501	Solvent Make-Up Pump	Centrifugal			-	L	Solvent	None	250	N	Y	N	N	N/A
CCS	CCS-P-502	Solvent Recovery Pump	Vertical			-	L	Solvent	None	310	N	Y	N	N	N/A
CCS	CCS-P-503A/B	50 wt% NaOH Pump	Centrifugal			NaOH	G	NaOH	Corrosive	250	N	Y	N	N	N/A
CCS	CCS-P-504A/B	DCC NaOH Injection Pump	Metering (PD)			NaOH	L	NaOH	Corrosive	250	N	Y	N	N	N/A
CCS	CCS-P-505	TEG Make-Up Pump	Metering (PD)			TEG (Triethylene Glycol)	L	TEG	Irritant	250	N	Y	N	N	N/A
CCS	CCS-P-601	Process Condensate Pump	Centrifugal			-	L	Water	None	250	N	Y	N	N	N/A
CCS	CCS-P-701A-C	Cooling Water Pumps	Centrifugal			-	L	Water	None	150	N	Y	N	N	N/A

Notes:

1) This Fire Hazards Review is based on Process Equipment List, M1NN-CCS-LST-225-00001_Rev A, Issued to Mechanical on 16-JUL-20

FILTERS

Unit	Equipment Number	Equipment Name	Capacity	Significant Chemicals Contained					ACTIVE FIRE PROTECTION				
					Phase	Major Component	Flammable, Combustible, Toxic	Flashpoint (°F)	Requires Monitor Coverage (Y/N)	Hydrant/Hose Reel Coverage (Y/N)	Contains Significant Amount of O2 (Y/N)	Requires Waterspray System (Y/N)	Basis of Water Spray Requirement / Comments
CCS	CCS-F-101A/B	DCC Water Filter		None	L	Water	None	N/A	N	Y	N	N	-
CCS	CCS-F-201	Lean Solvent Filter		Solvent	L	Solvent	None	N/A	N	Y	N	N	-
CCS	CCS-F-501	Solvent Recovery Filter		Solvent	L	Solvent	None	N/A	N	Y	N	N	-

Notes:
1) This Fire Hazards Review is based on Process Equipment List, M1NN-CCS-LST-225-00001_Rev A, Issued to Mechanical on 16-JUL-20

MISCELLANEOUS EQUIPMENT

Unit	Equipment Number	Equipment Name							ACTIVE FIRE PROTECTION				
			Significant Chemicals Contained	Phase	Major Component	Flammable, Combustible, Toxic	Flashpoint (°F)	Autoignition Temp (°F)	FIREWATER MONITOR Requires Monitor Coverage (Y/N)	HYDRANT/HOSE REEL Has Hydrant/Hose Reel Coverage	Contains Significant Amount of O2 (Y/N)	Requires Water Spray (Y/N)	Basis of Water Spray Requirement
CCS	CCS-DM-101	Unit 1 CCS Isolation Damper	None	G	N/A	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-DM-102	Unit 2 CCS Isolation Damper	None	G	N/A	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-DU-101	DCC Inlet Ducting System	None	G	Air	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-DU-102	DCC Outlet Duct	None	G	Air	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-PK-201	Impurity Removal Package	None	L,G	N/A	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-DU-201	Absorber Inlet Duct	None	G	Air	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-DM-201	Absorber Stack Damper	None	G	N/A	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-DS-301	Reboiler Steam Desuperheater	None	L	Steam	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-PK-401	Solvent Maintenance System	None		N/A	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-H-401	Spent Solvent Tank Heater	None	G	N/A	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-MX-501	NaOH Dilution Mixer	NaOH	L	NaOH	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-H-501	Solvent Storage Tank Heater	None	G	N/A	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-H-502	Solvent Recovery Tank Heater	None	G	N/A	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-H-503	50 wt% NaOH Storage Tank Heater	None	G	N/A	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-H-504	20 wt% NaOH Storage Tank Heater	None	G	N/A	None	N/A	N/A	N	Y	N	N	-

MISCELLANEOUS EQUIPMENT

Unit	Equipment Number	Equipment Name	Significant Chemicals Contained	Phase	Major Component	Flammable, Combustible, Toxic	Flashpoint (°F)	Autoignition Temp (°F)	ACTIVE FIRE PROTECTION: FIREWATER MONITOR Requires Monitor Coverage (Y/N)	ACTIVE FIRE PROTECTION: HYDRANT/HOSE REEL Has Hydrant/Hose Reel Coverage	ACTIVE FIRE PROTECTION: Contains Significant Amount of O2 (Y/N)	ACTIVE FIRE PROTECTION: Requires Water Spray (Y/N)	ACTIVE FIRE PROTECTION: Basis of Water Spray Requirement
CCS	CCS-PK-601A/B	CO_2 Dehydration Package	CO2	G	CO2	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-VS-601	CO_2 Vent Stack	CO2	G	CO2	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-CT-701	Cooling Tower	None	L	Water	None	N/A	N/A	Y	Y	N	Y	Water spray required on fan decks to meet FM approval
CCS	CCS-X-701	Cooling Tower Basin	None	L	Water	None	N/A	N/A	N	Y	N	N	-
CCS	CCS-PK-701	Cooling Tower Chemical Injection Package	Sulfuric Acid	L	Water	Toxic/Corrosive	N/A	N/A	N	Y	N	N	-
CCS	CCS-PK-702	Boiler Package	Methane	G	Methane	Flammable	N/A	N/A	N	Y	N	N	-
CCS	CCS-PK-703	Plant and Instrument Air Package	None	G	Air	None	N/A	N/A	N	Y	N	N	-
		Compressor Lube Oil Unit		L	Lube Oil	Combustible	-	-	N	Y			
CCS	CCS-X-801	Building Elevator	None	N/A	N/A	None	N/A	N/A	N	Y	N	N	-
	CCS-X-802	Absorber Elevator	None	N/A	N/A	None	N/A	N/A	N	Y	N	N	-

Notes:

1) This Fire Hazards Review is based on Process Equipment List, M1NN-CCS-LST-225-00001_Rev A, Issued to Mechanical on 16-JUL-20

ATTACHMENT 12 – FIREFIGHTING EQUIPMENT SPECIFICATION

Minnkota Power Cooperative

Project Tundra Carbon Capture and Sequestration Project

FIRE PROTECTION SPECIFICATION - EQUIPMENT

DOCUMENT NUMBER:
M1NN-CCS-SPC-653-00001

Fluor Project No: M1NN

						Jayesh Patel	
C	26Aug2020	22	Issued for Design	JST	SB	JP	
B	27Jul2020	23	Issued for Client Review	JST	SB	JP	
A	16Jul2020	22	Issued for Internal Review	JST	SB	JP	
REV	**DATE**	**PAGES**	**DESCRIPTION**	**ORIG.**	**CHKD**	**Fluor**	**CLIENT**
						APPROVED BY	

FIRE PROTECTION SPECIFICATION - EQUIPMENT

RECORD OF REVISIONS

Revision No.	Date	Description
A	16Jul2020	Issued for Internal Review
B	27Jul2020	Issued for Client Review
C	26Aug2020	Issued for Design

FIRE PROTECTION SPECIFICATION - EQUIPMENT

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7.0 BUILDING FIRE PROTECTION 22

FIRE PROTECTION SPECIFICATION - EQUIPMENT

1.0 GENERAL

1.1 Purpose

The purpose of this document is to specify the design requirements for firefighting systems and equipment for the Minnkota Project Tundra Carbon Capture and Sequestration (CCS) scope. This document also identifies the interfaces and responsibilities as they apply to the design of fire protection systems.

1.2 Scope

The scope of this Fire Protection Specification covers the general design requirements for the active fire protection systems and equipment for the Minnkota Project Tundra scope.

This document is intended to complement Doc. No. M1NN-CCS-DBD-653-00001, Fire Protection Design Basis.

The plant fire and gas system design is generally excluded from of the scope of this Fire Protection Specification. Fire and Gas system design is covered in documents M1NN-CCS-SPC-235-00010 Building Fire Detection & Protection Systems and M1NN-CCS-PHL-270-00001 Control Philosophy and Design Criteria.

1.3 Definitions

All technical definitions herein are to be interpreted as defined by applicable NFPA standards. The following terms are included for quick reference:

Definition	Description
Approved	Approved by the AHJ, shall mean written approval. This approval does not relieve the supplier from contractual requirements.
Authority Having Jurisdiction (AHJ)	The organization, office, or individual responsible for approving equipment, an installation, or a procedure
Combustible Liquid	Any liquid that has a flash point at or above 100°F (37.8°C).
Fire Protection System	Any fire alarm device or system or fire-extinguishing device or system, or combination thereof, which is designed and installed for detecting, controlling, or extinguishing a fire or otherwise alerting occupants, or the fire department, or both, that a fire has occurred.
Fire Zone	A fire area that has the potential to impact hazardous equipment within the vicinity such that the combined areas should be considered a single fire area. Fire zones may be separated from each other by means of firewalls or adequate separation distances such that the fire is expected to be contained within the area thus minimizing the extent of the fire zone.



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Definition	Description
Flammable Liquid	Any liquid that has flash point below 37.8°C (100°F), and vapor pressure not exceeding 40 psig at 37.8°C (100°F).
Flash Point	The minimum temperature of a liquid at which sufficient vapor is given off to form an ignitable mixture with air, near the surface of the liquid or within the vessel as determined by ASTM D 56 or ASTM D 93.

1.4 Abbreviations

Abbreviation	Term
AR-AFFF	Alcohol Resistant Aqueous Film Forming Foam
AHJ	Authority Having Jurisdiction
CCS	Carbon Capture and Sequestration
CO_2	Carbon Dioxide
FM	Factory Mutual
FT/SEC	Feet per Second
GPM	Gallons per Minute
HDPE	High Density Polyethylene
NFPA	National Fire Protection Association
NHT	National Hose Thread
PIV	Post Indicator Valve
UL	Underwriters Laboratories

1.5 Statutory Approvals

The Authority Having Jurisdiction (AHJ) for fire protection system approvals is currently assumed to be the State of North Dakota Fire Marshal.

2.0 REFERENCES

Applicable requirements in the referenced industry codes and standards shall be considered an integral part of this specification. For Project Specifications and References, the revision in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 Project Documents

Document No.	Title
M1NN-CCS-SPC-235-00010	Building Fire Detection & Protection Systems
M1NN-CCS-DBD-653-00001	Fire Protection Design Basis
M1NN-CCS-SPC-250-50001	Piping Design Layout Specification



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Document No.	Title
M1NN-CCS-PHL-270-00001	Control Philosophy and Design Criteria
M1NN-CCS-SPC-210-00002	Civil and Structural Plant Data Sheet
M1NN-CCS-SPC-210-00003	Civil and Structural Project Data Sheet
M1NN-CCS-SPC-210-00001	Civil Design Criteria

2.2 American Water Works Association (AWWA)

Document No.	Document Title
C502	Dry Barrel Fire Hydrants
C550	Protective Interior Coatings for Valves and Hydrants
C906	Polyethylene (PE) Pressure Pipe and Fittings, 4 in. through 65 in.

2.3 National Fire Protection Association (NFPA)

Document No.	Document Title
NFPA 10	Standard for Portable Fire Extinguishers
NFPA 11	Standard for Low-, Medium-, and High-Expansion Foam
NFPA 12	Standard on Carbon Dioxide Extinguishing Systems
NFPA 13	Standard for Installation of Sprinkler Systems
NFPA 14	Standard for the Installation of Standpipe and Hose Systems
NFPA 15	Standard for Water Spray Fixed Systems for Fire Protection
NFPA 16	Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems
NFPA 17	Standard for Dry Chemical Extinguishing Systems
NFPA 17A	Standard for Wet Chemical Extinguishing Systems
NFPA 22	Standard for Water Tanks for Private Fire Protection
NFPA 24	Standard for the Installation of Private Fire Service Mains and Their Appurtenances
NFPA 25	Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems
NFPA 30	Flammable & Combustible Liquids Code
NFPA 70	National Electric Code
NFPA 72	National Fire Alarm and Signalling Code
NFPA 101	Life Safety Code



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Document No.	Document Title
NFPA 750	Standard on Water Mist Fire Protection Systems
NFPA 780	Standard for the Installation of Lightning Protection Systems
NFPA 850	Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations
NFPA 1961	Standard on Fire Hose
NFPA 1963	Standard for Fire Hose Connections
NFPA 1903	Standard for Mobile Water Supply Fire Apparatus
NFPA 2001	Standard on Clean Agent Fire Extinguishing Systems

2.4 Factory Mutual (FM)

Reference list is not intended to be complete compilation of FM standards. Where firewater service listing is specified, the applicable FM approval is preferred.

Document No.	Document Title
FM Class 1510	Approval Standard for Fire Hydrants (Dry Barrel Type) for Private Fire Service
FM Class 2111	Approval Standard for Fire Hose
FM Data Sheet 4-1N	Fixed Water Spray Systems for Fire Protection
FM Data Sheet 3-10	Private Fire Service Mains
FM Data Sheet 4-5	Portable Extinguishers
FM Data Sheet 1-6	Cooling Towers
FM Class 4930	Approval Standard for Cooling Towers

3.0 FIREWATER SYSTEM

3.1 General

The objective of the firewater system is to provide firewater to CCS unit buildings and equipment for fire protection, cooling of exposed equipment, control of burning, and fire extinguishment.

In general, the firewater system consists of the following sections:

- Firewater supply and storage (not part of Fluor scope)
- Firewater pumps and firewater jockey pumps (not part of Fluor scope)
- Underground firewater main distribution network
- Strategically placed sectional isolation valves (PIVs)



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FIRE PROTECTION SPECIFICATION - EQUIPMENT

- Downstream fire protection appliances, consisting of, but not limited to: hydrants, monitors, deluge systems for process equipment (where required), and any foam systems as required by the fire hazards identified within the CCS facility.

Fire protection systems are required to comply with applicable FM Data Sheets and NFPA standards. Fire protection equipment shall be FM approved and listed for fire protection service (e.g. Factory Mutual). Should a required fire protection device not be listed by an accredited third party laboratory, such equipment if utilized shall be reviewed and approved by the AHJ.

Water-filled system components where the potential for freezing exists shall be designed and protected against such condition. Winterization may take the form of heat tracing, heated buildings, or calculated flow through winterizing lines.

The basis of design for the OSBL firewater supply and distribution is defined in Doc. No. M1NN-CCS-DBD-653-00001, Fire Protection Design Basis.

3.2 Firewater System Engineering Company Interfaces and Deliverables

3.2.1 The underground firewater ring main and loops around CCS unit area will be designed by Fluor.

3.2.2 Fluor will supply the hydrants, monitors, sectional isolation valves, deluge systems (if any), and building sprinklers take offs on that loop.

3.2.3 Burns & McDonnell is responsible for sizing the firewater supply piping connected to the CCS unit area underground firewater main and any scope related to additional firewater pumps.

3.2.4 Fluor will provide firewater pressure and flow rate required to supply CCS underground firewater main to Burns & McDonnell.

3.2.5 Fluor is responsible for verifying required flows and pressures are achieved at the point of delivery.

3.2.6 The CCS underground firewater ring main piping starting at the plant supply tie-in points by Burns & McDonnell will be hydraulically analyzed by Fluor to ensure that:

- The minimum residual pressure is provided such that the required flow is achieved at the hydrant, monitor, foam system, water spray system, etc. farthest from the firewater pumps.
- The maximum velocity through a single path in the firewater mains does not exceed manufacturer's piping specification requirements.



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- The flushing velocity in any section of the fire main is not less than 10 ft/sec, (per NFPA 24), which is necessary for cleaning/flushing the pipe and for lifting foreign material to an aboveground flushing outlet.

3.3 Underground Firewater Main Distribution Network

3.3.1 An integrated underground firewater ring main piping network shall be provided as a gridded system to ensure that a firewater supply loop encompasses each of the CCS units/buildings.

3.3.2 All firewater lines, mains, branches, and laterals will be installed underground for protection during abnormal events. The underground firewater distribution network shall be configured in such a manner that every loop and every grid shall have a dual supply from separate sources unless valve configurations are set up in such a way that continuous supply is ensured to the area affected when a problem occurs in the feeding section.

3.3.3 As per NFPA 24, underground firewater piping will be approved for firewater service use (FM approved).

3.3.4 Firewater main piping and piping components, including isolation valves, pressure relief devices, waste cone sight glasses, and others shall be FM approved for use in firewater service.

3.3.5 Underground piping material will be HDPE Class 200 piping.

3.3.6 The transition material between the HDPE piping and above ground hydrants, monitors and system manifolds will be externally coated and wrapped, internally galvanized ASTM A53 carbon steel. Piping material engineer shall confirm that material grade satisfies minimum design material temperature.

3.3.7 The minimum size of firewater main loops shall be NPS 12 (12” ID). Supply lines to hydrants, monitors, and buildings with low fire risk are allowed to be 6 inches minimum (ID).

3.3.8 Design limitations and installation requirements of the selected pipe shall conform to manufacturer’s recommendations

3.3.9 The CCS firewater mains shall be sized assuming that Burns and McDonnell can provide 120 psi at the battery limits in order to meet the minimum residual pressure requirement of 100 psig at the hydraulically most remote location at the CCS (furthest from the battery limits tie-ins), and at the maximum design firewater demand flow rate.



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3.3.10 Pipe used for the firewater main and branch lines to hydrants shall be sized according to hydraulic calculations illustrating that the selected pipe size will accommodate the required flow rate at a specific discharge pressure.

3.3.11 Hydraulic calculations shall be performed using pipe inside diameter dimensions. Maximum pipe velocity allowed in hydraulic calculations should be less than 20 ft/s per FM DS 3-10 requirements.

3.3.12 All hydrant and monitor risers shall be a minimum of 6” or at least one size larger than the largest outlet.

3.3.13 Bury requirements for underground firewater main pipe shall be as per NFPA 24. Depth of cover of underground firewater mains shall be determined by the maximum depth of frost penetration at the site. The top of the pipe shall be buried not less than 1 ft (0.3 m) below the frost line. See Doc. No. M1NN-CCS-SPC-210-00002, Civil and Structural Plant/Project Site Data, for site conditions.

3.3.14 Wet vertical riser segments connecting above and below ground piping shall be protected from freezing by an approved means. This will be accomplished either with the use of a drain hole, or by electric heat tracing and insulation of the wet riser segments.

3.3.15 Where bury depth does not protect against freezing, lateral piping to the downstream hydrants, monitors etc. will be designed for dry conditions by using self-draining piping to address the potential for freezing during the winter months. Therefore, these pipelines/equipment will be supplied with drain ports, flushing systems, and insulation as required.

3.4 Sectional Isolation Valves

3.4.1 As per NFPA 24, sectional isolation valves are necessary to allow isolation of piping sections to limit the number of fire protection connections impaired in event of a break or for repairs or extensions to the system. PIV type sectional isolation valves shall be strategically placed in the fire-water ring main such that no more than no more than five (5) take-off connections for appliances (hydrants, monitors, deluge, sprinklers, etc.) serving a single fire area are out of service at any one time in the event of a partial outage of the firewater mains.

3.4.2 Isolation or sectional isolation valves and cross connections shall be provided as necessary such that an outage of any single part of the piping will not affect the overall requirement to provide the most demanding firewater portion of the CCS unit. A sufficient number of isolation valves shall be provided so that any section of the grid can be taken out of service and the grid can still supply water through adjacent sections to protect plant areas.



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3.4.3 The firewater system shall be hydraulically designed such that the worst case firewater demand can be met with one section out of service, which is typically at one of the supply feeds at the battery limits from the firewater source.

3.4.4 All isolation valves used in the firewater system shall provide for positive, valve-position indication that is readily visible at all times.

3.4.5 All valves shall be capable of being locked or sealed in the open position.

3.4.6 FM approved gate valves shall be used on underground firewater loop for isolation.

3.4.7 PIVs for firewater piping supplying buildings shall be located as per NFPA 24.

3.5 Firewater Hydrants

Fire hydrants will be placed in accordance with NFPA 24, as well as with consideration to hazards they are protecting utilizing a performance based design. Hydrants shall be provided in strategic positions within the plant to enable fire trucks to access firewater supply and spaced so that the firewater demands for the area can be met.

3.5.1 Hydrants shall be 6” dry barrel self-draining type with a design pressure of 175 psig. Industrial high performance hydrant or equivalent will be selected. Hydrant design shall be as per FM DS 3-10, such that a small drain hole will open once the hydrant valve is closed to prevent freezing.

3.5.2 Hydrants shall be FM approved for fire protection service.

3.5.3 Hydrants shall have a gate valve (PIV) between the inlet and the firewater main.

3.5.4 Hydrants will have two 2 ½ inch threaded connection ports and one (1) 6” 150 lb flange by 5” brass Storz pumper connection. All connections shall be equipped with cap and chain. Pumper connections shall face roadway or access way with vehicle impact guarding provided where applicable.

3.5.5 Hose threads shall be NH standard in accordance with NFPA 1963, Screw Threads and Gaskets for Fire Hose Connections.

3.5.6 Hydrants shall be installed such that the outlets are a minimum of 24 inches above grade.

3.5.7 Hydrants should be installed a minimum of 50 ft and a maximum of 100 ft from the area to be protected.



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3.5.8 Hydrants around the CCS unit shall be spaced at a maximum of 300 ft apart from each other.

3.5.9 Hydrants shall be accessible from at least two opposing directions for use during emergencies in the event that visibility is obstructed in a fire event due to smoke/ wind direction.

3.5.10 A level working area shall be provided around hydrants, hydrant/monitors, and monitors for ease of maintenance and operation.

3.5.11 Hydrants located alongside CCS access roads shall be a minimum distance of 3.5 ft from the edge of the road or shoulder.

3.5.12 Hydrants located within 6 feet of any road or vehicle access way or other areas where mechanical damage could occur from impacts shall be protected against mechanical damage with guard posts.

3.5.13 Mechanical damage protection for hydrants shall be constructed in a manner that does not obstruct attachment of hoses to the hydrant.

3.5.14 Each building/enclosure will have at least one (1) hydrant located a minimum of 50 ft,from it.

3.6 Firewater Monitors

Fixed, manually operated firewater monitors shall be provided at strategic locations around and inside the CCS areas, where required. Process area requirements should be evaluated to determine the need for monitor coverage of structures, equipment, and large vessels.

Firewater monitors shall be located such that fire hazard equipment in process areas can be reached by at least two (2) monitor streams. Where process equipment and pipe racks affect the coverage by monitor streams, other means of protection such as fixed water spray systems (deluge) should be used to supplement monitor coverage.

3.6.1 Where possible, monitor coverage shall be considered for areas and equipment as follows:

- Installed to disperse/dilute potential gaseous releases from equipment and piping;
- Installed at loading/off-loading facilities in the absence of a fixed foam-water spray system;
- Installed around hydrocarbon storage tanks <60 feet in diameter and/or diked areas in the absence of fixed foam protection systems as foam type monitors;



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- Installed for the protection of pumps handling flammable/combustible product;
- Hot equipment such as boilers will be provided with firewater coverage such that fire exposed faces of the equipment can be reached by monitor streams.

3.6.2 Firewater monitors shall be placed according to NFPA 24 requirements, as well as based on hazards they are protecting utilizing a performance based design approach. Criteria for spacing and placement of monitors are provided below:

- Firewater monitors shall be placed in a graded area to prevent any hydrocarbon spill from flowing toward the monitor and shall be sized with consideration given to type and height of equipment to be protected, location and inlet water pressure.
- Monitors must be positioned to provide proper water throw and capacity to cover the designated surface areas.
- Monitors shall be installed around all fire hazardous envelopes such that the spray pattern of each monitor will overlap that of an adjacent monitor.
- Maximum spacing for firewater monitors from a tank being protected shall be 100 feet.
- Monitors shall be mounted a minimum of 50 feet horizontally from the equipment being protected and a minimum of 5 feet from the shoulder of any road.
- Monitors located within 6 feet of any road or vehicle access way or other areas where mechanical damage could occur from impacts shall be protected against mechanical damage.
- Monitors should be safely accessible from at least two (2) opposing directions. If this is not possible then automatic oscillating monitors or remote operated monitors may be considered.

3.6.3 Firewater monitor design requirements are as follows:

- Monitors shall be of the lever or gear operated type, having full 360° rotation and locking device and being capable of one-man operation. Monitors shall have ANSI flat-faced flange bases.
- Monitors shall be provided with isolation valve (PIV), which will be normally closed such that underground riser portion is not wet during winter. Bottom of riser will be provided with drain hole so that riser portion does not freeze in winter.



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- Monitors shall be FM approved for fire protection service.
- Monitors shall be designed for minimum 100 psig industrial high pressure firewater.
- Monitor design flows shall be 750 gpm for process areas. For the purposes of determining firewater coverage, monitors shall not be considered effective beyond 120 feet unless selected monitor manufacturer has demonstrated performance in excess of this value.
- Water-foam type monitors (where used) shall be provided with an approved foam compound supply container suitably protected against all weather conditions by means of a protective cover and supplied with either a dip tube or hard piping of sufficient length to ensure effective functionality.
    - The type and dosage rate of foam concentrate must be matched to the type of flammable product.
    - The quantity shall be sufficient to sustain first response firefighting until the emergency response team arrives to take over firefighting activities.
    - The design parameters for the use of foam monitors and hose line nozzles to protect tanks containing hydrocarbons shall be in accordance with Table 5.2.4.2.2 of NFPA 11.
    - The foam supply provided should not be less than the applicable volumes prescribed in NFPA 11.
- Elevated monitors may be required for elevated equipment coverage and should be used only after careful consideration, since these monitors require extensive maintenance to ensure reliability. Design requirements for elevated monitors are as follows:
    - Elevated fire monitors shall be stand-alone fire monitor type.
    - Standalone elevated monitor design flows shall be 1000 gpm. For the purposes of determining firewater coverage, stand-alone elevated monitors shall not be considered effective beyond 150 feet unless selected monitor manufacturer has demonstrated performance in excess of this value.
    - Elevated monitors shall be FM approved for fire protection service.
    - Elevated monitors may be fixed to cover a specific risk area or remotely operated to cover multiple risks within a specified area.
    - Fixed elevated monitors shall be manually activated by PIV. PIVs for elevated monitors will be located outside of the fire/danger zone. Where this cannot be achieved consideration shall be given to providing remote activation.

- Where the water table does not allow for draining of below ground portion of riser then aboveground activation valve may be required. Freeze protection shall be required for wet portion located above the frost line.
- Elevated monitors shall be free draining to grade.
- Low temperature grease will be utilized for cable operators for elevated monitors

3.6.4 Monitor nozzle design requirements are as follows:

- Monitor nozzles shall be sized with consideration given to type and height of equipment to be protected, location, and inlet water pressure.
- Fire monitors can be equipped with either water nozzle or foam nozzle, depending on the fire hazard. Adjustable nozzles (full fog to straight stream) shall be provided and rated 750 gpm (1000 gpm for elevated monitors) capacity at 100 psi. Monitor nozzle shall have fixed or swivel 2 ½ Inch NST female connection.
- Nozzles shall be FM approved for fire protection service.
- Foam nozzles shall have fixed or swivel 2½ inch NST female connection with foam concentrate pickup tube 1 ½ inch by 12 feet hose plus drum pickup valve for 3 % proportioning.

3.7 Fixed Water Spray/Deluge Systems

The objective of the deluge system is to provide firewater protection to equipment by reducing the effects of heat radiation. Deluge should not be considered as a substitute for passive fire protection. Detail design of the fixed water spray systems/deluge systems will be performed by competent third-party contractors licensed to design fire protection systems in the state of North Dakota and will be finalized during detailed engineering.

Design of deluge systems is as per FM Data Sheet 4-1N and NFPA 15. All sprinkler and deluge system valves and shall be Viking brand, unless approved by AHJ. The piping, deluge control valve, and deluge nozzles shall be FM approved and listed.

3.7.1 In addition to the criteria listed below selection of equipment requiring protection shall be in accordance with FM Data Sheet 4-1N and NFPA 15 requirements. Deluge shall be considered for the following applications:

- Pumps handling flammable liquids or combustible liquids at temperatures elevated above their flash points. Fixed water spray system should be considered for pumps when the following conditions exist:
  - The fluid being handled is at a temperature that is significantly (40ºF or more) above its flash point, and



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- The considered pump is in close proximity to other equipment (including adjacent pumps) or structures that could be quickly damaged by the pump fire, and
- The pump is located where protection by monitors or hose streams would be difficult or impractical.
- Large engine or turbine driven compressors and lube oil consoles and lube oil pumps. This is required due to large volumes of hot lubricating oils being handled under pressure in the driver, transmission, and lubrication systems.

3.7.2 Deluge system hydraulics calculations shall apply the following:

- The water supply pressure, for calculation purposes, shall be based on a minimum 100 psig residual pressure at the water supply flanged riser connection upstream of the deluge control valve from which point all pressure losses through the isolation valve and water spray piping will be subtracted.
- For preliminary hydraulic calculation purposes, flow-rates of the water spray systems can be hand calculated, plus a 20% design factor. The 20% design factor is to account for the overlap, wind loss, and hydraulic imbalance of the water spray system.
- A Hazen-Williams coefficient of 120 shall be used for hydraulic calculations in designing water spray deluge system, assuming use of hot dipped galvanized steel piping.
- Deluge application rates shall be as per NFPA 15 and applicable FM Global datasheets.

Deluge valve design considerations are summarized below. The deluge activation valves shall be positioned to allow for safe and easy access by emergency response personnel and unit operators.

- Sprinkler/deluge systems control valves shall be protected from the effects of cold weather (freeze protection).
- Wet deluge piping and deluge activation valves not housed in a heated building shall be heat traced and insulated.
- Should deluge firewater systems be installed in heated shelters/ buildings, the wet aboveground portion of the system located in the building will be insulated. Heated buildings housing wet deluge piping/valves must have low temperature alarms to the CCS control room.
- Deluge system actuation valves shall be located at least 50 feet from the equipment or area to be protected.



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- Deluge valves may be grouped up to a maximum of five (5) deluge valves per manifold header.
- Deluge valves for protection of storage tanks shall be located outside of the respective tank dike and protected against fire exposure for deluge system activation. Such deluge valves shall be located at least 50 ft. from protected tank.
- Activation of deluge systems shall be automatic. All deluge systems shall also be capable of being activated remotely from the CCS control room and manually at the deluge system manifold.
- Manual activation by emergency responders shall be in accordance with NFPA 11, 15, and 16. A manual activation station is to be provided at the deluge valve manifold.
- Deluge systems designed to be activated automatically during a fire scenario will activate via the pilot heads in the field. The water spray deluge system activates when pilot heads fail, releasing the air pressure from the airline, which prompts the deluge valve to open.

3.8 Foam Systems

3.8.1 3% AR-AFFF fixed and semi-fixed foam systems shall be installed in full compliance with NFPA 11 where identified as required within the CCS Unit.

3.8.2 A fixed or semi-fixed foam fire extinguishing system may be required for atmospheric tanks located in an area where there is limited firefighting access or the tank presents a serious fire exposure threat to adjacent process facilities. NFPA 30 provides applicable fire protection requirements for atmospheric tanks.

- Where fixed foam discharge outlets are used for fixed roof tanks containing hydrocarbons, the minimum discharge times and application rates shall be in accordance with NFPA 11.
- Fixed foam systems shall be permitted to be actuated automatically or manually.
- An automatic system shall be activated by automatic detection equipment (e.g. flame detectors) and operation shall be controlled by listed or approved actuation method.

3.8.3 Automatic detection equipment and any auxiliary electric equipment shall be rated for hazardous areas if located in such areas.

3.8.4 Manually actuated systems shall be permitted to be manually actuated by local or remote manual pull stations located at a location removed from the hazard zone



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to permit them to be operated in an emergency, yet close enough to ensure operator knowledge of fire conditions.

3.8.5 The detection system shall activate a local alarm, as well as alarm at a constantly manned location. The detection system's alarms also shall be actuated when the system is operated manually.

4.0 Firewater System Installation and Acceptance Testing

4.1 Underground Firewater System

4.1.1 All underground piping, before connecting to lead-in connections to firefighting equipment or fire protection systems, shall be flushed per NFPA 24 requirements at a rate sufficient to produce a velocity of 10 feet per second per in the piping or at the water demand rate of the system, whichever is greater.

4.1.2 All piping shall be hydrostatically tested at a minimum pressure of 200 psig or 50 psig in excess of the system working pressure and shall maintain a pressure at ±5 psig for a period of 2 hours. Leakage rates for underground piping shall not exceed the limits as shown in NFPA 24.

4.1.3 All firefighting equipment and valves shall be fully opened and closed under system pressure, with drainage devices checked during operation.

4.1.4 All testing shall be conducted in accordance with NFPA 24 and NFPA 25, with all required documentation completed and submitted in accordance with local and state requirements.

4.2 Deluge System

4.2.1 A field acceptance test shall require a full flow discharge test of the deluge system piping as a means of checking the nozzle layout, discharge patterns, and determination of relation between design criteria and actual performance. The discharge pressure at the highest most remote nozzle shall be recorded and shall be at least equal to that for which the system was designed. All operating parts of the system shall be fully tested to ensure that they are in operating condition.

4.2.2 Alarm switches and deluge release stations shall be tested for correct operation.

4.2.3 The test shall be conducted in accordance with NFPA 13, 15, and 25 with all required documentation completed and submitted in accordance with local and state requirements.



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5.0 Special Hazard Extinguishing Systems

5.1 Clean Agent Fire Extinguishing Systems

5.1.1 Automatic clean agent extinguishing systems shall be provided to protect the rack room inside the Multipurpose Building.

5.1.2 Other areas where water systems would otherwise cause damage to facility equipment may require Clean Agent system protection. Additional areas of concern may include emergency generator enclosures/rooms, battery storage areas, electrical rooms, control rooms, computer rooms, telecommunications room, etc.

5.1.3 The selection, design, and use of fixed Clean Agent fire extinguishing systems shall be in accordance with NFPA 2001, “Standard on Clean Agent Fire Extinguishing Systems” and local codes. An acceptance test, including measurement of vapor concentration during and after discharge, shall be conducted.

5.2 Fixed Chemical Agent Systems

5.2.1 Fixed installed total-flooding local application systems or pre-engineered dry chemical extinguishing systems are not anticipated to be required for the project unless determined otherwise. However, an automatic wet-chemical fire extinguishing system may be required to protect commercial cooking equipment as applicable. Fixed chemical agent extinguishing systems shall meet NFPA 17A and local code requirements.

5.3 Fixed Carbon Dioxide (CO_2) Systems

5.3.1 Fixed CO_2 systems shall only be used when no alternative solutions are available. Total flooding systems shall not be capable of automatic discharge while persons are within the enclosure.

5.3.2 Fixed systems protecting equipment enclosures and/or compartments may be provided with the equipment being protected (usually gas turbine packages and gas compressor enclosures).

5.3.3 Applications include transformer rooms, engine control centers, enclosed machinery areas, combustible oil-filled switchgear rooms, under floor areas, etc. Each system shall meet NFPA 12.

5.4 Fine Water Mist Systems



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5.4.1 Fine water mist systems are effective in extinguishing pressurized hydrocarbon fires in enclosures (e.g. engine rooms, pump rooms, gas turbines) and on pumps in open locations. Use of fine water mist systems, is determined based on suitability for the fire hazard. Systems shall meet NFPA 750 and local code requirements.

6.0 PORTABLE FIREFIGHTING EQUIPMENT

6.1 Fire Hose Cabinets and Hose Reels (Industrial)

6.1.1 Hose cabinets will be provided adjacent to fire hydrants in CCS unit areas. Hose from hose cabinets can be used to combat incipient fires if a site or external fire brigade is not available or if response by the fire brigade is expected to be too slow and if fire control/extinguishing capacity cannot be provided by other means. Fire hose cabinets should be positioned near hydrants in the vicinity of areas where fires may occur.

6.1.2 Hose cabinets shall be manufactured of steel or GRP material and fitted with a locking or latching door, ventilation grills and the necessary storage racks to contain the equipment specified in Section 6.1.3 below.

6.1.3 Where specified, hose cabinets shall contain the following equipment:

- Fire Hose – 50 ft sections of 1 ½ inch and 2 ½ inch diameter with 2 ½ inch NHT hose couplings (where applicable type of fire hose coupling and connector shall be able to connect with external fire brigade firefighting equipment)
- Fire Hose rack (shelf)
- Spray nozzle(s) - adjustable from straight stream to full fog
- Hydrant wrenches

6.1.4 Fixed hose reel systems should be specified in process areas in very limited applications. This equipment requires training and should only be considered to address specific needs for hose streams that must be readily available for small, incipient fire scenarios.

6.2 Portable and Wheeled Fire Extinguishers

6.2.1 Portable Fire Extinguishers

- At least one 30 lb. dry chemical fire extinguisher for every 1000 ft^2 of floor area but not more than 75 feet apart in process facilities including



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transformer bays, platforms and landings, provided that such platforms and landings are used for operating equipment, and containing valves.

- In high hazard areas, the minimum distance between fire extinguishers may be reduced to 50 feet.
- Extinguishers for fires other than in ordinary combustibles should be located close to the hazard to be protected (at least within 50 ft) where they will be accessible during a fire
- A portable dry chemical fire extinguisher shall be located on each level near the stairway landing of multi-level structures and elevated platforms. Fire extinguishers are not required for tanks, vessels or towers.
- At least one 15 lb or one 20 lb carbon dioxide fire extinguisher for every 2150 ft^2 or part thereof floor area in substation buildings and, placed at each entrance of the substation should placement at other locations not negatively affect the width of the escape/ emergency route.
- The top of each fire extinguisher shall be installed no higher than 5 ft above the floor or ground surface. Building fire extinguishers will be enclosed in a cabinet, outdoor extinguishers will have a cover to protect from the elements. Fire extinguishers shall include corrosion control coatings and suitable mounting devices.

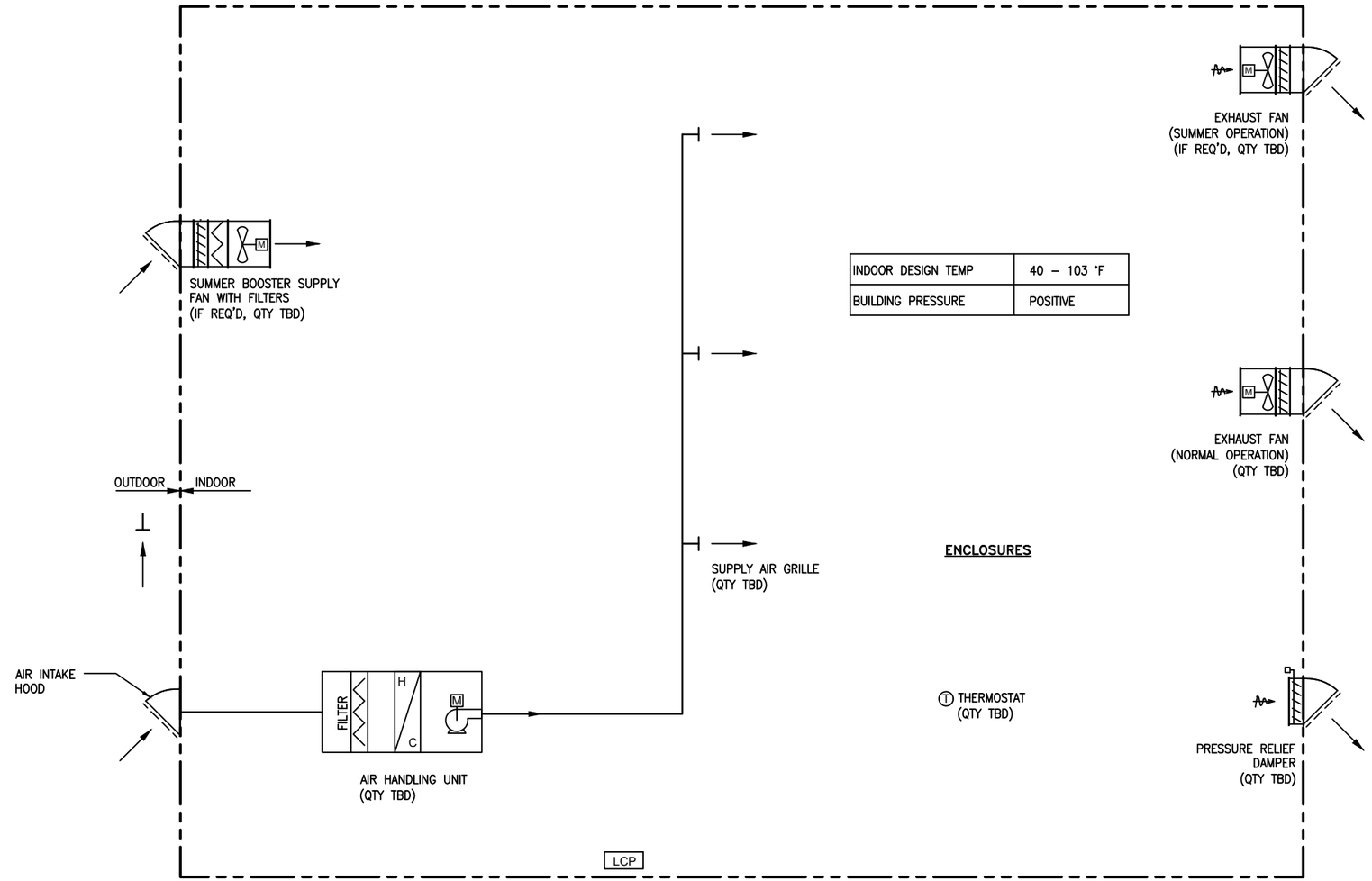
6.2.2 Wheeled Fire Extinguishing Equipment

- Wheeled, dry chemical extinguishers can be located at strategic points throughout the facility in areas near hazardous equipment such as compressors, lube oil units and process heaters.
- Extinguishers for fires other than in ordinary combustibles should be located close to the hazard to be protected (at least within 50 ft) where they will be accessible during a fire.
- CO_2 wheeled extinguishers should be considered in or near electrical substations or switchgear rooms operating voltages greater than 600v and near emergency diesel generators.

7.0 BUILDING FIRE PROTECTION

Non-process buildings such as multipurpose buildings and substations shall be adequately protected against fire through the use of sprinkler systems, standpipes, clean agent systems, and/or hydrants as per applicable building codes and NFPA standards. See specification M1NN-CCS-SPC-235-00010, Building Fire Detection & Protection Systems, for CCS building fire protection requirements. In addition to the requirements of this specification, the process area enclosures, including the process enclosure, boiler enclosure, and utility enclosure fire protection systems shall meet the applicable building code requirements.

ATTACHMENT 13 – HVAC CONCEPTUAL AIRFLOW SCHEMATIC



GENERAL NOTE:

1. THIS DRAWING REPRESENTS A CONCEPTUAL PLAN. THIS DRAWING IS A SCHEMATIC DIAGRAM TO INDICATE SCHEME. THIS DRAWING IS NOT REPRESENTATIVE OF ACTUAL EQUIPMENT LAYOUT AND SHALL NOT BE USED AS SUCH. THIS DRAWING SHOULD NOT BE UNDERSTOOD TO INDICATE ACTUAL QUANTITIES OF EQUIPMENT AND DEVICES.
2. THIS DRAWING IS APPLICABLE TO THE FOLLOWING ENCLOSURES:
   - BOILER ENCLOSURE (CCS–BOE–001)
   - COMPRESSOR ENCLOSURE (CCS–COE–001)
   - PROCESS ENCLOSURE (CCS–PRE–001)
3. THE AIR HANDLING UNIT FOR THE BOILER ENCLOSURE SHALL BE LOCATED OUTDOORS.

LEGEND:

- FAN WITH MOTOR
- BACKDRAFT DAMPER
- BAROMETRIC PRESSURE RELIEF AIR DAMPER
- T TEMPERATURE SENSOR
- M AHU FAN WITH MOTOR
- LCP LOCAL HVAC CONTROL PANEL
- H/C HEATING COIL

REV	DATE	REVISION DESCRIPTION	BY	CHK	APPV
A	16SEP2020	ISSUED FOR INTERNAL REVIEW	DK	LT	NS
B	21SEP2020	ISSUED FOR CLIENT REVIEW	DK	LT	NS
0	020CT2020	ISSUED FOR DESIGN	DK	LT	NS

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CONTRACT M1NN

CONTRACT	M1NN	
DESIGNED BY	D. KONG	
CHECKED BY	L. THREATT	
SUPERVISOR	L. THREATT	APP DATE
LEAD ENGR/SPEC.	N. SWAMY	APP DATE
FLUOR	J. PATEL	APP DATE
CLIENT	D. WOLF	APP DATE

MINNKOTA POWER COOPERATIVE
PROJECT TUNDRA
CARBON CAPTURE AND SEQUESTRATION

HVAC
ENCLOSURES
CONCEPTUAL AIRFLOW SCHEMATIC

SCALE	DRAWING NUMBER	REV
NTS	M1NN-CCS-SKT-235-00001	0

CAD FILE NAME M1NN–CCS–SKT–235–00001_0.dwg

F–B.DWG 01JUL09

PLOT DATE: Z:\CAD\235_HVAC\DWG_XX\01–HVAC\01_Working\M1NN–CCS–SKT–235–00001_0.dwg 10–02–20 1:09 pm Printed By: kon2377G

ATTACHMENT 14 – BASIS OF COST ESTIMATE

Project Tundra

Basis of Estimate
Fluor Class 3 Estimate
February 26, 2020

Fluor Contract No. M1NN

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7.0 Home Office Costs, Engineering and Office Expenses

8.0 Other Costs and Fees

8.01 Sales and Use Tax (Direct & Indirect)
8.02 Escalation
8.03 Cost Contingency
8.04 Event Contingency
8.05 Warranty
8.06 Licensor and Royalty Fees
8.07 Management Fees
8.08 Late Changes
8.09 Actual Costs Incurred to Date

9.0 Below the Line Costs

9.01 Client Furnished Materials – Fluor Scope
9.02 Non-Fluor Scope
9.03 Taxes and Incentives
9.04 Owner's Costs

10.0 Project Work Breakdown Structure (WBS)

11.0 Estimate Disclaimer

12.0 Attachments

1.0 Executive Summary

Purpose

The purpose of the Basis of Estimate is to provide an overview of how the Class 3 estimate values were developed and compiled into the finished deliverable.

This BoE is not the governing scope document. Refer to the Scope of Facilities (SOF) and Scope of Services (SOS) documents issued separately.

2.0 Estimate Content and Scope

Fluor has contracted with Minnkota Power Cooperative (Client), to perform Front End Engineering Design (FEED) for a new carbon capture facility at the Client's existing Milton R. Young Power Station located in Center, North Dakota. This FEED estimate encompasses engineering, procurement, fabrication and construction (EPFC) for the facility.

The estimating deliverable is a Class 3 end of FEED estimate. The estimate was developed utilizing propriety estimating systems owned and licensed by Fluor including the Estimator, and MS Office™ products. This estimate is non-binding.

3.0 Key Milestones and Schedule Dates

Begin Proposal Phase:	03/2021
Begin LNTP Phase	09/2021
Full Notice to Proceed (FNTP)	01/2022
Begin Civil Work / Site Prep	06/2022
Begin Effective Construction	04/2023
Mechanical Completion	05/2025
Substantial Completion	11/2025

4.0 General Estimate Overview

4.01 General Assumptions and Qualifications

- All labor, material and equipment costs have been estimated as of 4th Qtr 2020.
- The construction schedule and productivity assume normal weather conditions for the site location.
- Material and equipment pricing is based upon an international slate of approved vendors and manufactures for Fluor's Econamine FG+ projects as previously submitted to MPC.
- Engineering, Procurement and Construction services will utilize Fluor's domestic and international offices.
- Please see attached list for additional clarifications.

4.02 Exclusions

- Demolition has been excluded from the project scope as the basis is a site clear or obstructions. In addition, all contaminated soils and other existing hazardous materials are excluded.
- Two year or Operating Spares
- Currently no space or provisions for MPC or MPC's representatives have been included in Fluor's trailers or temporary facilities.
- Relocation of Existing Power Lines is by MPC.
- Additional interface points not defined on the IFF interface list. Tie-ins to existing facilities are by MPC.
- Future contractual, performance and schedule penalties/risks are excluded as they are not yet defined or agreed

4.03 Basis of Estimate Documentation

The estimate is based on the following key documentation issued as "Basis of Estimate" for this project.

The estimate is based on the following documentation:

Equipment List(s): M1NN-CCS-LST-255-00001

Plot Plan(s): M1NN-CCS-PLN-250-00001, M1NN-CCS-PLN-250-00002-0001/2/3/4/5

Project PFDs

Project P&IDs

Other (see attached Project Document Register)

- Piping Specialty Items
- Electrical one-lines, load list, area classifications
- Instrument index
- Electrical Equipment List
- Project Specifications & Standards

5.0 Estimate Details and Direct Field Costs (DFC)

5.01 Quantification & Allowances

Engineering provided neat, installed and purchased quantification by discipline.

Fluor assessed and included the required allowances for mechanical & specifications (mech and spec) design development, construction cut and waste and a material take off (MTO) allowance for bulk materials.

5.02 Subcontract and Material Pricing Basis

Selected pricing was provided to Estimating by Supply Chain team. See attached summary of contract pricing for further details.

Pricing is categorized into the following groups:

1. Formal Packages: Formal RFQ or RFP with technical and commercial evaluations, and high level clarifications completed, however no negotiations performed.
2. In-House: Pricing based on recent projects or reference data.

5.03 Labor Hours, Productivity & Craft Labor Costs

5.03.1 Fluor Self Perform Direct Field Work

The estimate is based on Fluor self-performing Concrete, Structural Steel, Mechanical, Piping, Electrical, Control Systems, Painting and Insulation scopes of work. The self-perform construction cost estimate is developed using Fluor's Construction Unit Effort Hours with local wage rates applied per hour.

Wage rates used in the direct field cost are bare rates that include spot overtime and premium time which are based upon an open shop execution strategy. Benefits and burdens, and per diem are included in the Indirect Field Cost. The standard construction work week will be 55 hours with premium paid on all hours over 40. Gross up of per diems is excluded.

	Composite Crew Rates For a 55 Hour Week
Civil	
Concrete	
Structures	
Mechanical	
Piping	
Electrical	
Instruments	
Paint	
Insulation	
Scaffolding	

5.03.2 Module Yard Fabrication

The construction execution is stick built. However, the design of selected piperacks incorporates onsite pre-assembly at a designated pre-assembly area.

5.03.3 Subcontract Scope of Work

Budgetary estimates were provided by specialty contractors based on formal RFPs.

These include:

- Civil / Earthwork – K011
- Field Fabricated Columns and Vessel – K001
- Column Internals – K002
- Buildings – K004
- Cooling Tower – K005
- Heavy Haul/ Heavy Lift – K009

5.04 Earthwork and Civil Site Works (Account-00)

Piling was quantified as Cast in-drilled hole (CIDH). Subcontract pricing was provided by subcontractors.

5.05 Marine and Heavy Civil Works (Account-05)

N/A

5.06 Concrete (Account-10)

Engineering provided quantities for concrete for all site requirements, except for form work which were quantified by Estimating.

Unique aspect of project scope include elevated concrete table top which will be pre-cast in sections and shipped to site for installation.

5.07 Structural Steel (Account-20)

The estimate includes quantities for site, and pre-assembly module steel for the selected piperacks.

5.08 Architectural and Buildings (Account-30)

All pricing for the Architectural and Building scope of work was included in the K004 contract pricing provided by Fluor's Contract Group.

The subcontractor is responsible for the foundation associated with the building, but not the slab or any other civil scope associated with the buildings.

5.09 Machinery and Equipment (Account-40)

The mechanical equipment list consists of 304 tagged items including turnkey subcontracts for the field fabricated Columns, Tanks, Vessel and Cooling Tower.

A budgetary estimate from the design contractor (Nels) was provided as part of their ductworks study and used to price out the procurement, freight and construction installation of the inlet and outlet ducting system.

The estimate includes vendor reps, capital spares, and a construction and commissioning and startup spares allowance based on a percentage of the mechanical equipment pricing.

5.10 Piping (Account-50)

Pricing Basis

- Material pricing is based on in-house reference data.
- The pricing for fabrication of spools is based on in-house fabricator unit pricing.
- NDE and bolt tensioning pricing is based on in-house sub-contractor unit rates.

Assumptions and Clarifications

- Standard pipe supports, guides and hangers were quantified on the engineering material take-off (MTO).
- Nuts, bolts and gaskets were quantified on the engineering material take-off (MTO).
- Hydro-testing temporary material was factored from pipe and fittings material pricing.
- Provision and disposal of the testing mediums is included in the construction indirects cost.
- All painting of shop fabricated piping is included in the estimate as shop applied and is included in the piping shop fabrication account. An allowance is included by Estimating for the painting of field welds and touchup painting in the field.
- All labor activities, shop fabrication, testing, paint and insulation were provided by engineering.

5.11 Pipelines (Account-55)

Not Applicable

5.12 Electrical (Account-60)

Electrical Engineering provided a basis of estimate equipment and bulks MTO.

Major electrical equipment includes:

- (2) Prefabricated substations
- MV and LV switchgears
- MV and LV MCCs
- HV and MV transformers
- MV VFDs

- UPS
- Panelboards

Foundations for electrical equipment were provided by CSA Engineering and are included in the concrete account.

The estimate includes cost for electrical heat tracing based on in-house pricing.

The estimate includes cost for 480V feeders for cathodic protection.

5.13 Control Systems (Account-70)

Control Systems Engineering provided a basis of estimate MTO, including tagged instruments, instrument bulks, DCS package and analyzer shelter package. The DCS was issued as a formal package to Emerson as the single source bidder. Pricing for remaining items including the analyzer package was based on in-house pricing. Installation hours for field instruments include device installation, testing and loop check only. Calibration will be performed in the shop.

5.14 Communications and Security (Account-75)

The material cost estimate for Communications and Security is based on in-house pricing. A cost allowance for installation is included based on a historical percentage of the Direct Field Material Cost.

5.15 Modularization (Account-83)

NA

5.16 Demolition and Environmental Works (Account-84)

Not applicable

5.17 General Requirements (Account-87)

5.17.1 Scaffolding

Scaffolding is included as a percentage of Direct Field man-hours excluding civil, earthworks and concrete. Scaffolding costs associated with fabrication and erection of Tanks, Columns, Cooling Tower, Ducting and Buildings are included in the turnkey subcontract pricing for each scope of work. Material cost is included in the DFC with the scaffolding labor as rental materials.

5.17.2 Freight / Logistics

The Logistics group provided a detail estimate of the Domestic and Ocean freight cost.

5.17.3 Freight Related Duties and Fees

Freight related duties and fees are included in the estimate cost.

5.17.4 Brokerage and Agent Fees

Brokerage and Agent Fees are included in the estimate cost.

5.17.5 Port Terminal Charges

Port Terminal Charges are included in estimate cost.

5.17.6 Import Duties

Import Duties have been evaluated. None were identified at time of estimate.

5.17.7 Import Taxes

Import Taxes have been evaluated. None were identified at time of estimate.

5.18 Startup and Commissioning (Account-88)

5.18.1 Pre-Commissioning, Commissioning, and Start Up

Commissioning and start-up is based on Fluor performing commissioning and start-up service and being responsible for initial plant operations through completion of commissioning and Performance Testing. The Commissioning Team provided a detailed estimate based on PFD's, plot plans and the EPCC schedule. The scope includes the following stages of the start-up and commissioning process:

- Pre-commissioning
- Commissioning
- Startup
- Validation/Performance Test

5.19 Spare Parts

5.19.1 Capital Spares

Engineering provided the list of Capital Spares:

- K-601A/B CO2 Product Compressor
  1. Spare pinions / impellers (including witnessed rotor mechanical run test) including spare rotor storage container
  2. Spare bullgear
- BL-201 Blower

1. Spare rotor, including storage container

- XV-0512 Warehouse spare valve
- FV-0367 Warehouse spare valve
- XV-0734 Warehouse spare valve

5.19.2 Construction Spares

Estimating included an allowance for all construction spares based on (1) percentage of Mechanical Equipment material.

5.19.3 Startup and Commissioning Spares

Estimating included an allowance for all startup and commissioning spares based on (1) percentage of Mechanical Equipment material.

5.19.4 Two Year / Operating Spares

Excluded from the Estimate (Owner's Cost)

5.20 Vendor Representatives and Consultants

5.20.1 Vendor Reps During Construction

Engineering provided a list of vendor reps required for the Mechanical, Electrical and Control Systems equipment including durations and number of people. Procurement provided the cost for rates, airfare and per diems based upon the formal quotes obtained during FEED.

5.20.2 Vendor Reps During Startup & Commissioning

Included in the Commissioning and Startup Estimate.

5.21 Allowances

An allowance has been included in the estimate for procurement and installation of the relief valve associated with the Duct work.

6.0 Construction Indirect Field Costs (IFC)

An Indirect Field Cost (IFC) estimate was developed by Construction and Estimating to align with and support the project and construction execution plans, and is based on Fluor's Standard Construction Indirect Cost Template.

6.1 Temporary Facilities (Account-90)

Requirements for temporary buildings are based on construction requirements. Pricing is based on in-house data.

The estimate includes the following temporary facilities:

- Office Trailers
- Warehouse Facilities
- Rental Property
- Equipment Preservation

- The parking lot area contains geogrid, crushed concrete surfacing, temporary fencing, and lighting, and appropriate parking space.
- Temporary power requirements have been identified.
- Temporary utility bill electrical consumption is based on unit rate pricing ($0.0975/KWh) provided by Construction and consumption requirement calculated by Construction and Engineering.
- Temporary construction and silt fencing requirements are based on quantities provided by construction and engineering.

The following items were all developed by estimating using historical data from recent projects:

- Warehouse Racks and Shelving
- Foundations for Trailers
- Maintenance of Temporary Buildings
- Protection for Weather (Wind Breaks, Rain Protection, etc.)
- Sewage Haul off
- Maintenance, including relocation of lighting and temporary power cables, plus cable testing
- Temporary Roads (Including Haul Roads)
- Temporary Signage, Signals & Striping, Barriers and Barricades (Install, relocate & removal)
- Temporary Drainage
- Dunnage and Miscellaneous Lumber
- Dust Control (Periodic watering roads)
- Maintenance of Roads and Laydown Areas including Steel Plates for Road Crossings

6.2 Construction Camps (Account-91)

Not Applicable

6.3 Construction Services (Account-92)

Construction services cost was based on Fluor historical ratios.

Construction services includes the following:

- Firewatch / Holewatch
- Job Cleanup, Janitorial, & Dumpster services
- Warehouse & Site Services
- Work Stoppages. Show Up Pay and Dewatering activities
- Health & Safety services & supplies, craft training, craft testing
- Construction contractor site security personnel
- Monthly IT charges, Office Supplies
- Misc. Professional services, such as soil testing, pest control, weed control,

6.4 Field Staff (Account-93)

Fluor Site Staff is based on a staffing plan developed by Construction and priced by Fluor Commercial Estimating using current office rates and assignment policy.

6.5 Field Craft (Account-94)

Field Craft Burdens & Benefits and Per Diem costs are based on input from Fluor's Industrial Relations Group.

6.6 Construction Equipment & Small Tools (Account-95)

A construction equipment plan was developed to quantify the various types of equipment required for the construction activities and associated durations based on the EPC Schedule. Monthly equipment rental rates were internally developed.

The cost for Small Tools and Consumables was included in the estimate at a rate per direct field work hours.

The Heavy Haul/ Heavy Lift scope of work was estimated based on a budgetary quote based upon a formal RFP formal logistics study from K009 supplied by Fluor's Contracts Group.

6.7 Insurance, Bonds, Permits, & Fees (Account-96)

Insurance has been included for Worker's Comp., Commercial General Liability, and Auto Insurance in accordance with the attached key contractual principles. Builder's Risk insurance is provided by Owner.

Permit costs are considered Owner's Cost. An allowance is included for a permit consultant to assist with the development of a permit matrix.

Management fee is included. Licensor fee is considered an Owner's Cost.

7.0 Home Office Costs, Engineering and Office Expenses

The Home Office Estimate has been priced on a 40 hour work week basis with the work split between Fluor's US based offices and non-US offices. Escalation was excluded in the Home Office Cost Estimate and included in the project escalation calculation. Business travel was developed based upon a detailed buildup of required travel.

The overall workshare content is estimated to be approximately 40%.

The estimate includes 3rd party studies for the following services;

- Noise Study
- Geotechnical Field Investigation
- Topographic Survey
- Laser Scanning
- Route Study

Both Construction and Commissioning and Startup support, which will occur in the Home Office, are included in the Home Office Estimate.

The proposal phase has been excluded from the estimate.

8.0 Other Costs and Fees

8.01 Sales and Use Tax (Direct & Indirect)

Excluded from the estimate (Owner's Cost, if applicable)

8.02 Escalation

The estimate has been prepared with a fourth quarter 2020 pricing basis. Forward escalation has been applied in accordance with the attached project schedule.

8.03 Cost Contingency

The estimate cost contingency is based on a risk analysis model with variables that are project specific. The contingency value was calculated utilizing a computerized Monte Carlo simulation with the risk variables determined by the project team. A P85 level of confidence has been selected for the recommended contingency value, as per Fluor recommended practice.

8.04 Event Contingency

A project execution event risk allowance has been included with the estimate contigency cost. This execution event risk allowance deos not include commercial, contractual, or performance risks currently since they are not yet defined or agreed. For information, the commercial / contractual / performance risks which typically range from 1.5 to 3 percent of the total installed cost, depending on the allocation of contractual risk and the value of the LD's and performance guarantees.

8.05 Warranty

Warranty has been included as 0.5% of TFOC cost.

8.06 Licensor and Royalty Fees

Licensor Fees have been excluded as these are considered Owner's Costs.

8.07 Management Fees

Management fees are included in the project cost.

8.08 Late Changes

Fluor has included MPC's decision to utilize FM Compliant cooling tower as a late change in the other costs portion of the Estimate Summary Sheet.

8.09 Actual Costs Incurred to Date

Not Applicable

9.0 Below the Line Costs

9.01 Client Furnished Materials – Fluor Scope

None provided

9.02 Non-Fluor Scope

Not Applicable

9.03 Taxes and Incentives

Taxes are excluded and considered an Owner's Cost if applicable.

9.04 Owner's Costs

Owner's costs have not been estimated, nor included. Owner's cost items include:

- Owner staff and staff expenses at site and home office
- Owner staff personal protective equipment cost
- Owner staff and staff expenses for equipment inspection, witness testing and other travel
  by owner if required
- Temporary facilities and site services for Owner's staff, consultants and engineers
- Owner consultants / engineer costs
- All permit Costs
- Owner's business risk/contingency
- Plant vehicles and fuel costs (HO, CM, operations, maintenance, etc.)
- Operation and Maintenance spare parts
- Facility equipment, including maintenance, shop, lab, mobile lifting equipment, and emissions testing
- Licensor fees and Licensor representatives' costs
- Costs for Land and acquisition of property and leases
- Permanent office equipment, furniture, computers, and business systems for multipurpose building
- Owner's Staff Transportation (HO & CM)
- Infrastructure upgrades and improvements to facilitate transportation
- Operator Costs
- Demolition costs, including hazardous material removal (if any)
- Owner's cost for utilities during commissioning and start-up (water, gas, elec., etc.)
- Removal of Buried Obstructions including assessment, removal, abatement and/or disposal of potential landfills and hazardous materials
- Relocation of existing above ground and underground utilities
- Permanent signage (entrance and throughout the site)
- Property taxes
- Feedstock to support commissioning and start-up
- Cost of any contracts or subcontracts that are not contracted by Fluor
- Scopes designed by non-Fluor entities including water treatment, CO2 pipeline, natural gas pipeline, etc.
- Scope Changes

- Impurity Removal Package Testing
- Cost associated with recommendations of icing study and emissions/dispersion study not shown on the basis of estimate documents
- All state, county, local and other North Dakota taxes

10.0 Project Work Breakdown Structure (WBS)

The estimate was compiled according to the project work breakdown structures, with all quantities and costs organized accordingly into the level of detail for the WBS structure.

BP00	Civil Balance of Plant
BPBE	Boiler
BPCT	Cooling Tower
BPHH	Roads
BPMB	Multipurpose Building
BPPR	Balance of Plant Pipe Rack
BPSS	Substation
BPTF	Temporary Facilities
BPUT	Utilities
CC00	Civil – Carbon Capture
CCAB	Absorber/ DCC
CCCE	Compressor
CCDB	Duct and Blower
CCPE	Process
CCPR	Pipe Rack
CCST	Stripper
CCWP	Impurity Removal Package

11.0 Estimate Disclaimer

This report was prepared for Minnkota Power Cooperative by Fluor Enterprises and other independent consultants and is based in part on information not within the control of either Fluor or the consultants. Neither Fluor nor the consultants have made an analysis, verified, or rendered an independent judgment of the validity of the information provided by others. While it is believed that the information contained herein will be reliable under the conditions and subject to the limitations set forth herein, neither Fluor nor the consultants guarantee the accuracy thereof. Use of this report or any information contained therein shall constitute a release and agreement to defend and indemnify Fluor and such consultants from and against any liability (including but not limited to liability for special, indirect or consequential damages) in connection with such use. Such release from and indemnification against liability shall apply in contract, tort (including *negligence* of Fluor or those consultants, whether active, passive, joint or concurrent), strict liability, or other theory of legal liability; provided, however, such release, limitation and indemnity provisions shall be effective to, and only to, the maximum extent, scope or amount allowable by law.

Notwithstanding the above, neither the Final Report nor any information contained therein or

otherwise supplied by Fluor in connection with the Study and the Services shall be released by Company or used in connection with any proxy, proxy statement, proxy soliciting materials, prospectus, Securities Registration Statement or similar document without the express written consent of Fluor, except as may be required by law.

12.0 Attachments

- Estimate Unit Summaries

ATTACHMENT 15 – ESTIMATE SUMMARIES

Client:	Minnkota Power Cooperative	**USD**
Client's Project Name:	M1NN_Project Tundra	TJS
Location:	Center, North Dakota	10-Feb-2021
Estimate Purpose:	Carbon Capture and Sequestration	**Area:**
Reference Plant Type	12,978 STPD	**Carbon Capture**

Account	Description	TotalCost / Price
	Direct Field Cost - Site	
00	Earthwork & Civil	19,071,256
05	Marine & Heavy Civil Works	
10	Concrete	30,080,300
20	Structural Steel	20,114,695
30	Architectural & Buildings	18,028,683
40	Machinery & Equipment (Tag Count)	240,526,037
50	Piping Avg dia inch = 5.5"	52,472,883
55	Pipelines Avg dia inch = 10"	-
60	Electrical	19,360,585
70	Control Systems (Fluor + Vendor Tag Count)	4,173,100
75	Aux Systems (Communications & Security)	-
81	Painting & Coatings	1,645,026
82	Insulation & Refractory	9,990,857
83	Modularization - Rigging & Setting (# of Modules)	-
84	Demolition and Environmental Work	-
8705	Scaffolding	7,458,763
8710-8720	Int'l Shipping, Logistics & Related Duties & Fees	12,492,606
8810-8830	Pre-Comm., Comm. & SU (Excl Fld Staff Labor)	
8840	Validation (Excl Field Staff Labor)	
	TOTAL DIRECT FIELD COST - SITE	435,414,790
	Sub-Total Direct Field Costs (DFC)	435,414,790
	Sub-Indirect Field Costs (IFC)	135,007,351
	Total Field Costs (TFC)	**570,422,141**
	Sub-Total Home Office Costs (HOC)	51,277,878
	Total Field & Office Costs (TFOC)	**619,891,618**
	Other Costs & Fees	-
9910	Escalation	44,228,049
9920	Contingency & Warranty	61,486,225
9930	Fees - Overhead & Profit	71,541,549
9940	Sales and Use Taxes (Direct & Indirect)	-
9950	Licensor & Royalty Fees	-
N/A	Late Changes	1,180,011
	Sub-Total Other Costs	178,435,835
	Indicated Total Cost (ITC)	**798,327,453**
	Client Costs:	
COA TBD	Owner Furnished Material / Non-Fluor Scope (OFM)	
COA TBD	Other (TBD by Project)	

798,327,453

Client:	Minnkota Power Cooperative	**USD**
Client's Project Name:	M1NN_Project Tundra	TJS
Location:	Center, North Dakota	10-Feb-2021
Estimate Purpose:	Carbon Capture and Sequestration	**Area:**
Reference Plant Type	12,978 STPD	**Compression**

Account	Description	TotalCost / Price
	Direct Field Cost - Site	
00	Earthwork & Civil	289,487
05	Marine & Heavy Civil Works	
10	Concrete	8,370,406
20	Structural Steel	1,813,043
30	Architectural & Buildings	10,452,703
40	Machinery & Equipment (Tag Count)	31,773,000
50	Piping Avg dia inch = 5.5"	9,525,466
55	Pipelines Avg dia inch = 10"	-
60	Electrical	3,444,289
70	Control Systems (Fluor + Vendor Tag Count)	379,301
75	Aux Systems (Communications & Security)	-
81	Painting & Coatings	73,437
82	Insulation & Refractory	436,393
83	Modularization - Rigging & Setting (# of Modules)	-
84	Demolition and Environmental Work	-
8705	Scaffolding	1,035,465
8710-8720	Int'l Shipping, Logistics & Related Duties & Fees	114,727
8810-8830	Pre-Comm., Comm. & SU (Excl Fld Staff Labor)	
8840	Validation (Excl Field Staff Labor)	
	TOTAL DIRECT FIELD COST - SITE	67,707,718
	Sub-Total Direct Field Costs (DFC)	67,707,718
	Sub-Indirect Field Costs (IFC)	18,839,663
	Total Field Costs (TFC)	**86,547,381**
	Sub-Total Home Office Costs (HOC)	7,142,778
	Total Field & Office Costs (TFOC)	**93,325,299**
	Other Costs & Fees	-
9910	Escalation	6,658,577
9920	Contingency & Warranty	9,256,812
9930	Fees - Overhead & Profit	10,770,651
9940	Sales and Use Taxes (Direct & Indirect)	-
9950	Licensor & Royalty Fees	-
N/A	Late Changes	177,652
	Sub-Total Other Costs	26,863,692
	Indicated Total Cost (ITC)	**120,188,992**
	Client Costs:	
COA TBD	Owner Furnished Material / Non-Fluor Scope (OFM)	
COA TBD	Other (TBD by Project)	

120,188,992

Client:	Minnkota Power Cooperative	**USD**
Client's Project Name:	M1NN_Project Tundra	TJS
Location:	Center, North Dakota	10-Feb-2021
Estimate Purpose:	Carbon Capture and Sequestration	**Area:**
Reference Plant Type	12,978 STPD	**Balcance of Plant**

Account	Description	TotalCost / Price
	Direct Field Cost - Site	
00	Earthwork & Civil	23,717,208
05	Marine & Heavy Civil Works	
10	Concrete	4,005,816
20	Structural Steel	1,036,135
30	Architectural & Buildings	20,980,816
40	Machinery & Equipment (Tag Count)	23,165,412
50	Piping Avg dia inch = 5.5"	13,055,134
55	Pipelines Avg dia inch = 10"	
60	Electrical	3,451,036
70	Control Systems (Fluor + Vendor Tag Count)	7,016,581
75	Aux Systems (Communications & Security)	5,598,860
81	Painting & Coatings	45,026
82	Insulation & Refractory	428,280
83	Modularization - Rigging & Setting (# of Modules)	-
84	Demolition and Environmental Work	112,385
8705	Scaffolding	1,321,825
8710-8720	Int'l Shipping, Logistics & Related Duties & Fees	3,195,869
8810-8830	Pre-Comm., Comm. & SU (Excl Fld Staff Labor)	15,600,144
8840	Validation (Excl Field Staff Labor)	
	TOTAL DIRECT FIELD COST - SITE	122,730,526
	Sub-Total Direct Field Costs (DFC)	122,730,526
	Sub-Indirect Field Costs (IFC)	39,321,293
	Total Field Costs (TFC)	**162,051,819**
	Sub-Total Home Office Costs (HOC)	14,931,559
	Total Field & Office Costs (TFOC)	**176,983,378**
	Other Costs & Fees	
9910	Escalation	12,137,193
9920	Contingency & Warranty	16,873,233
9930	Fees - Overhead & Profit	19,632,645
9940	Sales and Use Taxes (Direct & Indirect)	
9950	Licensor & Royalty Fees	
N/A	Late Changes	323,822
	Sub-Total Other Costs	48,966,893
	Indicated Total Cost (ITC)	**226,644,706**
	Client Costs:	
COA TBD	Owner Furnished Material / Non-Fluor Scope (OFM)	
COA TBD	Other (TBD by Project)	

226,644,706

Client:	Minnkota Power Cooperative	**USD**
Client's Project Name:	M1NN_Project Tundra	TJS
Location:	Center, North Dakota	10-Feb-2021
Estimate Purpose:	Carbon Capture and Sequestration	**Area:**
Reference Plant Type	12,978 STPD	**Utilities**

Account	Description	TotalCost / Price
	Direct Field Cost - Site	
00	Earthwork & Civil	2,610,844
05	Marine & Heavy Civil Works	
10	Concrete	18,781,913
20	Structural Steel	2,190,820
30	Architectural & Buildings	12,282,848
40	Machinery & Equipment (Tag Count)	36,300,706
50	Piping Avg dia inch = 5.5"	5,569,380
55	Pipelines Avg dia inch = 10"	
60	Electrical	32,759,448
70	Control Systems (Fluor + Vendor Tag Count)	3,067,266
75	Aux Systems (Communications & Security)	1,021,096
81	Painting & Coatings	182,261
82	Insulation & Refractory	433,947
83	Modularization - Rigging & Setting (# of Modules)	-
84	Demolition and Environmental Work	
8705	Scaffolding	1,475,505
8710-8720	Int'l Shipping, Logistics & Related Duties & Fees	3,609,772
8810-8830	Pre-Comm., Comm. & SU (Excl Fld Staff Labor)	
8840	Validation (Excl Field Staff Labor)	
	TOTAL DIRECT FIELD COST - SITE	120,285,807
	Sub-Total Direct Field Costs (DFC)	120,285,807
	Sub-Indirect Field Costs (IFC)	43,892,931
	Total Field Costs (TFC)	**164,178,738**
	Sub-Total Home Office Costs (HOC)	16,667,557
	Total Field & Office Costs (TFOC)	**180,846,295**
	Other Costs & Fees	
9910	Escalation	13,548,308
9920	Contingency & Warranty	18,834,977
9930	Fees - Overhead & Profit	21,915,209
9940	Sales and Use Taxes (Direct & Indirect)	
9950	Licensor & Royalty Fees	
N/A	Late Changes	361,471
	Sub-Total Other Costs	54,659,965
	Indicated Total Cost (ITC)	**236,985,069**
	Client Costs:	
COA TBD	Owner Furnished Material / Non-Fluor Scope (OFM)	
COA TBD	Other (TBD by Project)	

236,985,069

ATTACHMENT 16 – EPCC LEVEL 1 SCHEDULE

Minnkota Project Tundra EPC
Level 1 Schedule

16-Dec-21
Rev L

2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027

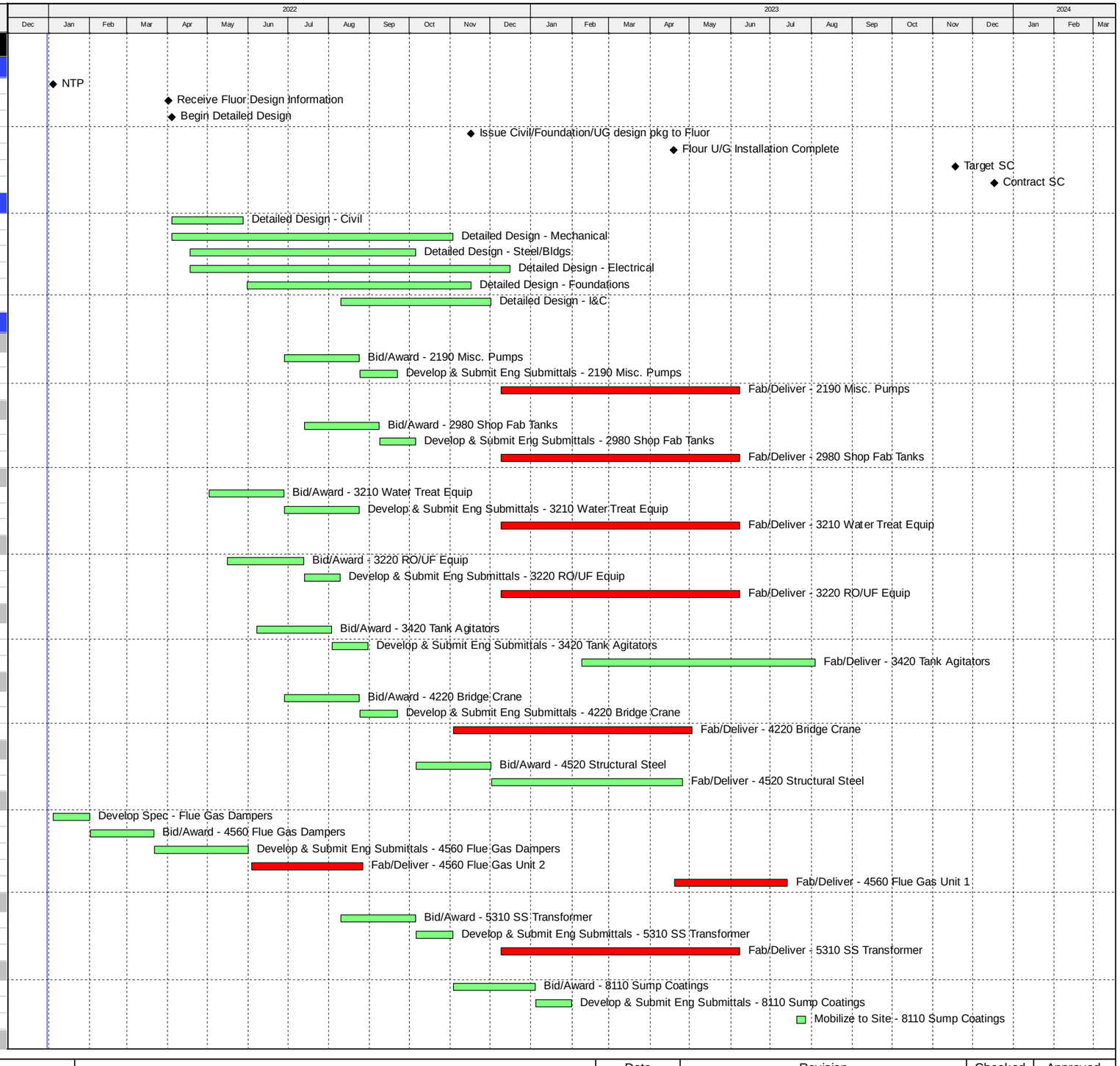
FEED Update / Proposal LNTP
Detailed Engineering
Procurement
Heavy Civil / Site Prep / Piling
Effective Construction
Commissioning / Start-up
Schedule Contingency
Client FID
Receive LNTP
Begin FEED Update / Proposal
Receive NTP
95% Engineering Complete
Mechanical Completion
Substantial Completion
Model Development to U/G MR1
Dvlp & Issue U/G ISOs
U/G MR / Incorp Comments
FEED Update / Proposal Development
Develop Site Prep Drawings
HAZOP VD
Dvlp & Issue P&IDs - IFH
Perform HAZOP / Incorp Comments
Dvlp & Issue P&IDs - IFC1
Dvlp & Issue P&IDs - IFC2
Dvlp & Issue Plot Plan - IFC
Dvlp & Issue Area Class - IFC
MR1 VD
MR2 VD
MR3 VD
Model Develop MR1
Model Develop MR2
Model Develop MR3
MG2 MG4 MG6
MG1 MG3 MG5
MR1 / Comments
MR2 / Comments
MR3 / Comments
Dvlp & Issue Misc FDNs & Paving Dwgs
RFQ / Bid Cycle / Eval - Geo / Topo / Noise
Dvlp & Issue Main FDN Dwgs
Dvlp & Issue E&I Dwgs
Geo / Topo / Noise
Dvlp & Issue LB ISOs
Dvlp & Issue SB ISOs
Dvlp & Issue Piling Dwgs
Dvlp & Issue Tertiery Steel
RFQ / Bid Cycle / Eval - Group 1 POs
Dvlp & Issue Main FDN Dwgs
Dvlp & Issue Primary & Secondary Steel
Refresh - Group 1 POs
Award Group 1 POs
RFQ / Bid Cycle / Eval - Group 2 POs
Award Group 2 POs
Refresh - Group 2 POs
Eval / Award Group 3 & 4 POs
Fab & Del Strucutral Steel
Eval / Award Group 5 POs
Tech RFQ / Data Sheets - Group 5 POs
Fab & Del Materials
Clean & Ready Site Available
CO2 Pipeline Relocation Complete
N/S FW Tie-Ins Avail
SS Ready for Pwr
Plant Ready for NG
Transmission Line Relocation
NG Tie-in Avail
Perm Power Avail
Freeze Window #1
Freeze Window #2
Freeze Window #3
Freeze Window #4
Mobilize to Site
Award Group 3 Contracts
RFQ / Bid Cycle / Eval - Subcontracts
Award Heavy Civil Contract
CT & MPB
UT
PE
Impurity Removal Package
Heavy Civil
Fab & Del Bulk U/G Pipe
Fab & Del U/G Pipe Spools
UT & PE Loops
Loops
Utilities
Blower
U/G Pipe
RFP / Bid Cycle / Award Group Contracts
Piling
PE
CE
AB
CT & BE
Concrete
DB& Impurity Removal Package Concrete
RFQ / Bid Cycle / Eval
Refresh
Award Civil / Piling Contract
3rd Party Procurement
ST, AB, & BE
DB
WP
Area Paving
PE North
BE
Buildings
RFQ / Bid Cycle / Eval
Refresh
Award Vessels Contract
3rd Party Procurement
Prefab Vessel Cans
DCC
Vessel Erection
Vessel Internals
UT
PE CE
CT
WP
AB BE ST
Mechanical
UT
CE
PE
AB
CT
BL WP
ST
Structral Steel
Fab & Del Bulk A/G Pipe
Fab & Del A/G Pipe Spools
BE, CE
UT PE, CT
AB
BL, WP
ST
Piping
Painting & Insulation
UT, CT, CE
WP
PE, ST
AB
Control Systems
SS
UT, CT
PE, DB
AB, WP
ST
Electrical
Receive Vendor Data
RFQ / Bid Cycle / Eval
Refresh
Award Cooling Tower EPC Contract
3rd Party Engineering / Procurement
Cooling Tower Erection
RFQ / Bid Cycle / Eval
Refresh
Award MPB EPC Contract
3rd Party Engineering / Procurement
Multi Purpose Building Installation
DCS Installation & SAT
Schedule Contigency
O&M Training
Comm & Start-up IA, CT, & CW
Commissioning / Start-up
Comm & Start-up Substation
Comm & Start-up Utilities

PE - Process Enclosure
AB - Absorber Area
ST - Stripper Area
CE - Compressor Enclosure

DB - Duct & Blower Area
UT - Utility Area
CT - Cooling Tower
SS - Substation
MPB - Multi Purpose Building

ATTACHMENT 17 – WATER TREATMENT L1 SCHEDULE

Activity ID	Activity Name	OD	Start	Finish
Project Tundra Water Treatment				
Milestones				
A1090	NTP	0	04-Jan-22*	
A1100	Receive Fluor Design Information	0		01-Apr-22*
A1110	Begin Detailed Design	0	04-Apr-22	
A1390	Issue Civil/Foundation/UG design pkg to Fluor	0		16-Nov-22
A1420	Flour U/G Installation Complete	0		18-Apr-23
A1270	Target SC	0		17-Nov-23
A1550	Contract SC	0		17-Dec-23
Engineering & Permitting				
A1030	Detailed Design - Civil	40	04-Apr-22	27-May-22
A1060	Detailed Design - Mechanical	150	04-Apr-22	02-Nov-22
A1050	Detailed Design - Steel/Bldgs	120	18-Apr-22	05-Oct-22
A1070	Detailed Design - Electrical	170	18-Apr-22	15-Dec-22
A1040	Detailed Design - Foundations	120	31-May-22	16-Nov-22
A1080	Detailed Design - I&C	80	10-Aug-22	01-Dec-22
Procurement				
2190 - Misc. Pumps				
A1000	Bid/Award - 2190 Misc. Pumps	40	28-Jun-22	23-Aug-22
A1010	Develop & Submit Eng Submittals - 2190 Misc. Pumps	20	24-Aug-22	21-Sep-22
A1020	Fab/Deliver - 2190 Misc. Pumps	125	09-Dec-22	07-Jun-23
2980 - Shop Fab Tanks				
A1130	Bid/Award - 2980 Shop Fab Tanks	40	13-Jul-22	07-Sep-22
A1120	Develop & Submit Eng Submittals - 2980 Shop Fab Tanks	20	08-Sep-22	05-Oct-22
A1140	Fab/Deliver - 2980 Shop Fab Tanks	125	09-Dec-22	07-Jun-23
3210 - Water Treatment Equip				
A1160	Bid/Award - 3210 Water Treat Equip	40	02-May-22	27-Jun-22
A1150	Develop & Submit Eng Submittals - 3210 Water Treat Equip	40	28-Jun-22	23-Aug-22
A1170	Fab/Deliver - 3210 Water Treat Equip	125	09-Dec-22	07-Jun-23
3220 - RO/UF Equipment				
A1190	Bid/Award - 3220 RO/UF Equip	40	16-May-22	12-Jul-22
A1180	Develop & Submit Eng Submittals - 3220 RO/UF Equip	20	13-Jul-22	09-Aug-22
A1200	Fab/Deliver - 3220 RO/UF Equip	125	09-Dec-22	07-Jun-23
3420 - Tank Agitators				
A1220	Bid/Award - 3420 Tank Agitators	40	07-Jun-22	02-Aug-22
A1210	Develop & Submit Eng Submittals - 3420 Tank Agitators	20	03-Aug-22	30-Aug-22
A1230	Fab/Deliver - 3420 Tank Agitators	125	08-Feb-23	03-Aug-23
4220 - Bridge Crane				
A1250	Bid/Award - 4220 Bridge Crane	40	28-Jun-22	23-Aug-22
A1240	Develop & Submit Eng Submittals - 4220 Bridge Crane	20	24-Aug-22	21-Sep-22
A1260	Fab/Deliver - 4220 Bridge Crane	125	03-Nov-22	02-May-23
4520 - Structural Steel				
A1280	Bid/Award - 4520 Structural Steel	40	06-Oct-22	01-Dec-22
A1290	Fab/Deliver - 4520 Structural Steel	100	02-Dec-22	25-Apr-23
4560 - Flue Gas Dampers				
A1640	Develop Spec - Flue Gas Dampers	20	04-Jan-22	31-Jan-22
A1560	Bid/Award - 4560 Flue Gas Dampers	35	01-Feb-22	21-Mar-22
A1570	Develop & Submit Eng Submittals - 4560 Flue Gas Dampers	50	22-Mar-22	31-May-22
A1580	Fab/Deliver - 4560 Flue Gas Unit 2	60	03-Jun-22	26-Aug-22
A1630	Fab/Deliver - 4560 Flue Gas Unit 1	60	19-Apr-23	13-Jul-23
5310 - Station Service Transformer				
A1310	Bid/Award - 5310 SS Transformer	40	10-Aug-22	05-Oct-22
A1300	Develop & Submit Eng Submittals - 5310 SS Transformer	20	06-Oct-22	02-Nov-22
A1320	Fab/Deliver - 5310 SS Transformer	125	09-Dec-22	07-Jun-23
8110 - Sump Coatings				
A1340	Bid/Award - 8110 Sump Coatings	40	03-Nov-22	03-Jan-23
A1330	Develop & Submit Eng Submittals - 8110 Sump Coatings	20	04-Jan-23	31-Jan-23
A1350	Mobilize to Site - 8110 Sump Coatings	5	21-Jul-23	27-Jul-23
8320 - A/G Structural & Mechanical				



Start Date	04-Jan-22
Finish Date	17-Dec-23
Data Date	31-Dec-21
Run Date	17-Feb-21

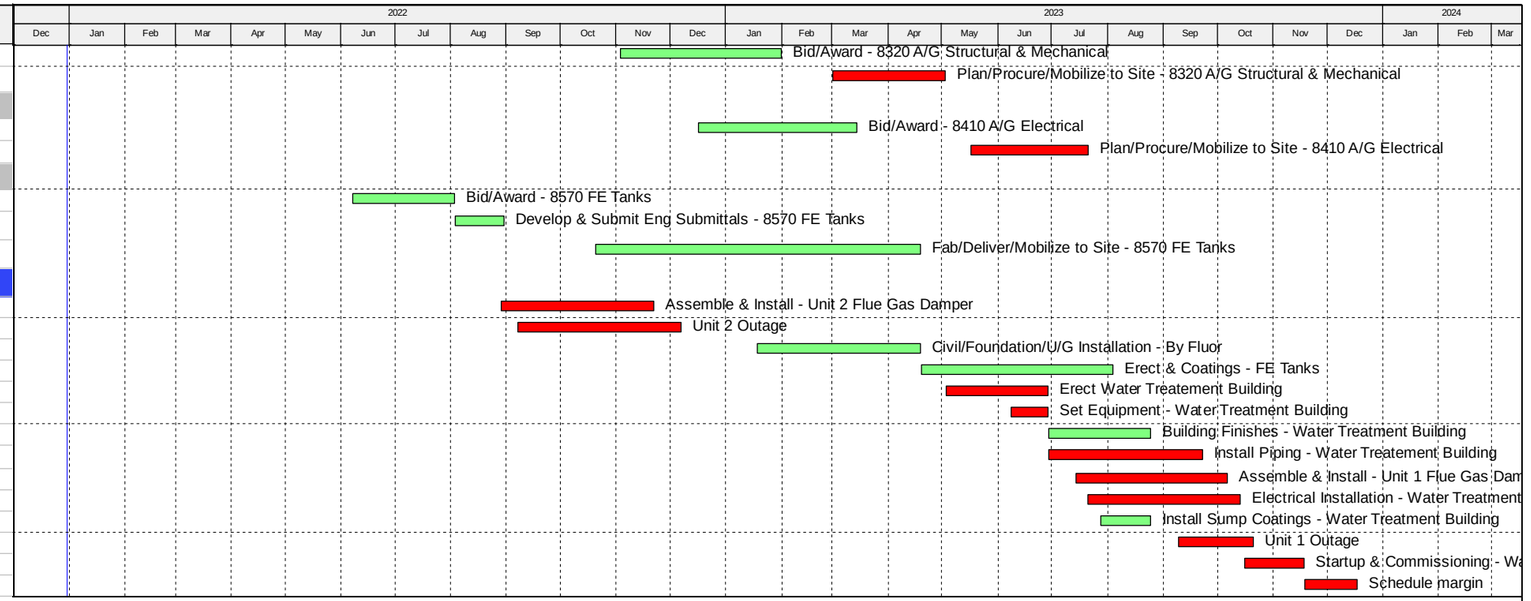
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Project Tundra Water Treatment

Project Schedule

Date	Revision	Checked	Approved

Activity ID	Activity Name	OD	Start	Finish
A1430	Bid/Award - 8320 A/G Structural & Mechanical	60	03-Nov-22	31-Jan-23
A1440	Plan/Procure/Mobilize to Site - 8320 A/G Structural & Mechanical	45	01-Mar-23	02-May-23*
8410 - A/G Electrical				
A1400	Bid/Award - 8410 A/G Electrical	60	16-Dec-22	14-Mar-23
A1410	Plan/Procure/Mobilize to Site - 8410 A/G Electrical	45	17-May-23	20-Jul-23
8570 - FE Tanks				
A1370	Bid/Award - 8570 FE Tanks	40	07-Jun-22	02-Aug-22
A1360	Develop & Submit Eng Submittals - 8570 FE Tanks	20	03-Aug-22	30-Aug-22
A1380	Fab/Deliver/Mobilize to Site - 8570 FE Tanks	125	20-Oct-22	18-Apr-23
Construction & Startup				
A1610	Assemble & Install - Unit 2 Flue Gas Damper	60	29-Aug-22	21-Nov-22
A1590	Unit 2 Outage	91	07-Sep-22*	06-Dec-22
A1450	Civil/Foundation/U/G Installation - By Fluor	65	18-Jan-23	18-Apr-23
A1460	Erect & Coatings - FE Tanks	75	19-Apr-23	03-Aug-23
A1470	Erect Water Treatement Building	40	03-May-23	28-Jun-23
A1490	Set Equipment - Water Treatment Building	15	08-Jun-23	28-Jun-23
A1480	Building Finishes - Water Treatment Building	40	29-Jun-23	24-Aug-23
A1500	Install Piping - Water Treatement Building	60	29-Jun-23	22-Sep-23
A1620	Assemble & Install - Unit 1 Flue Gas Damper	60	14-Jul-23	06-Oct-23
A1510	Electrical Installation - Water Treatment Building	60	21-Jul-23	13-Oct-23
A1520	Install Sump Coatings - Water Treatment Building	20	28-Jul-23	24-Aug-23
A1600	Unit 1 Outage	42	09-Sep-23*	20-Oct-23
A1530	Startup & Commissioning - Water Treatment Building	25	16-Oct-23	17-Nov-23
A1540	Schedule margin	30	18-Nov-23	17-Dec-23



Start Date	04-Jan-22
Finish Date	17-Dec-23
Data Date	31-Dec-21
Run Date	17-Feb-21

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Project Tundra Water Treatment

Project Schedule

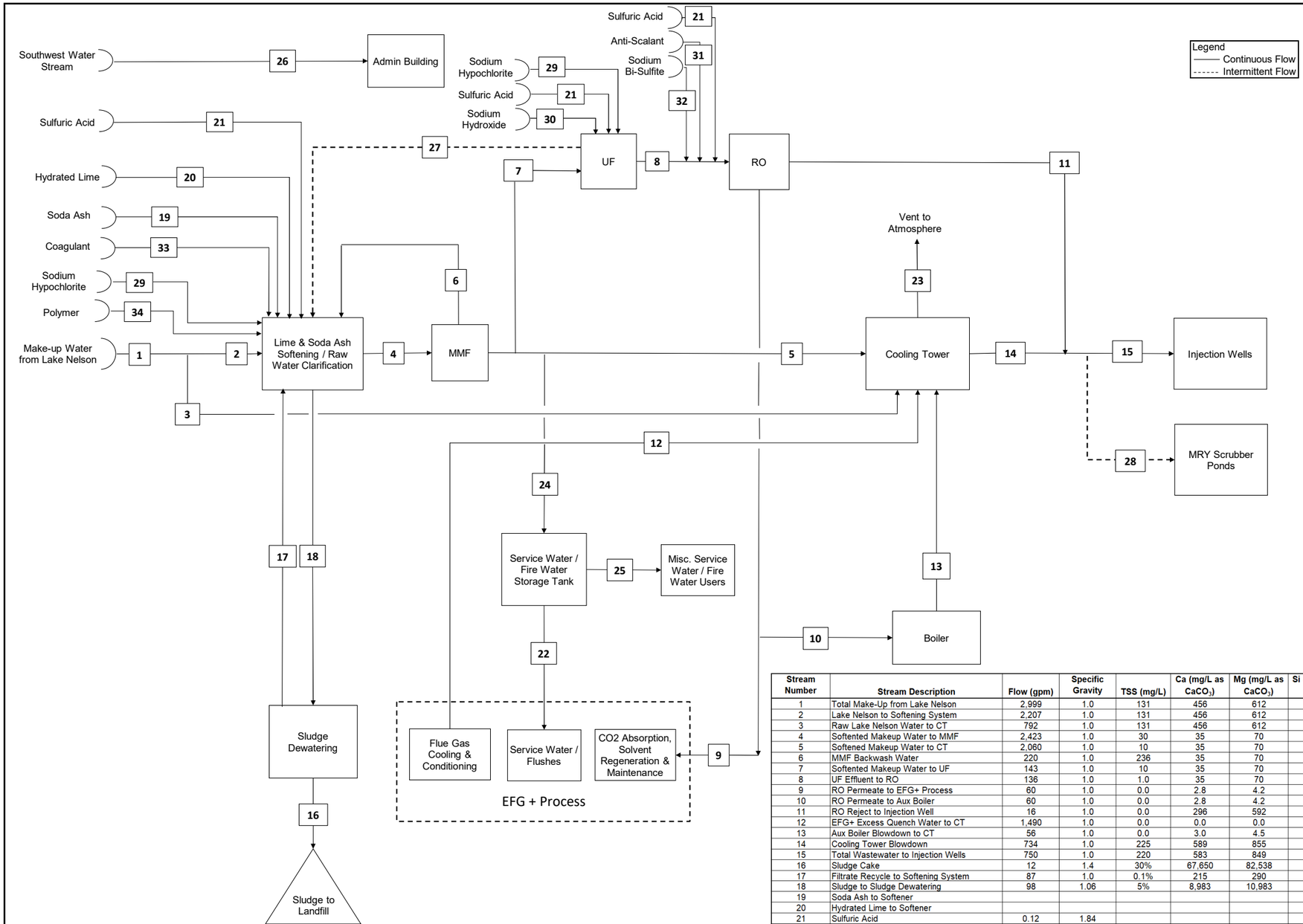
Date	Revision	Checked	Approved

ATTACHMENT 18 – DESIGN BASIS SCOPE MATRIX

		Y/N	% Unit Capacity	Total Number for Plant	Notes
GENERAL PROJECT INFORMATION					
Project Description					
	Project Location				Minnkota's Milton R. Young Site
	Site Description				Site is adjacent to the existing Milton R. Young site providing post-combustion carbon capture for Unit 2's flue gas (and Unit 1 when Unit 2 is not operating)
	Contracting Approach				Project will be based on an EPC approach.
	Labor				Non-Union
	Project L/Ds				TBD
	Project Bonding /LOC				Yes / Yes
	Project COD Date				2026
MECHANICAL EQUIPMENT					
Water Supply					
	Size for further expansion	N			
	Raw Water/Cooling Tower Makeup				
	Cooling Water Makeup	Y	100	2	Lake Nelson make-up + process condensate from DCC (DCC process condensate transfer pumps in Fluor's scope)
	Circualting Water Treatment				By Fluor
	EQ Tank	Y	100	1	
	Clarifier	Y	100	1	High Rate Softener/Clarifier - Includes Reaction tank and Rapid Mix Tank
	Multimedia Filtration	Y	50	2	Gravity Sand Filters
	Filter Backwash Tank	Y	100	1	
	Clearwell	Y			
	Clearwell Cooling Tower Make-Up	Y	50	3	Pumps to Fluor provided CT
	Clearwell Service Water Pumps	Y	100	2	
	Sludge Handling				
	Sludge Blowdown Pumps	Y	100	2	
	Sludge Holding Tank	Y	100	1	Sized for 2 press cycles (inclusive of agitator)
	Sludge Forwarding Pump	Y	100	2	
	Filter Press	Y	50	2	
	Solids Disposal	Y			Roller Bin, Front Loader to truck?
	Sludge Recirculation	Y	100	2	
	Filtrate/Area Trench Sump	Y	100	2	Area sump to catch building trench drains, sump pump to EQ Tank
	Service Water				
	Service Water Make-Up				Via the Raw Water Treatment system
	Service Water Treatment	N			
	Storage Service Water/Fire Water	N			
	Demineralized Water				
	UF Skids	Y	100	2	
	RO Cartridge Filter	y	100	2	
	RO Skids	Y	100	2	Each skid, 2 pass RO
	Storage Demin Water	Y	100	1	
	Clean in Place (CIP) System	Y			
	Potable Water				
	Potable Water Make-Up				Provided via the rural water district
	Potable Water Storage	N			By Fluor
Wastewater					
	Size for further expansion	N			
	Contaminated Wastewater	Y			If needed - Drains for areas around equipment that could be contaminated with oil will be directed through an oil/water separator (OWS). The OWS effluent will be pumped to recycle basin. BMcD to provide lift station to Fluor provided OWS
	RO Reject	Y			Reject water sent to cooling tower blowdown and then returned to injection wells (primary) or existing scrubber ponds (alternate)
	Waste Water Storage Tank	N			
	Sanitary	N			By Flour
Chemical Feed / Storage					
	Various Chemical Feed Pumps	Y	100	2	
	Sulfuric Acid	Y			4 Days of Storage Volume, indoor storage?
	Soda Ash	Y			
	Sodium Hypochlorite	Y			
	Anti-Scalant	Y			
	Sodium Bi-Sulfite	Y			
	Sodium Hydroxide	Y			
	Hydrated Lime	Y			
Fire Protection					
	Design Basis				By Fluor
	Insurer/special requirements				By Fluor
	Water Treatment Building	N			Entire water treatment building will be sprinkled, fire wall seperation between water treatment area and adjacent electrical room (if required). Sprinkler system provided by Fluor
	Pump supply source(s)	Y			If provided, electric motor with jockey pump and backup diesel-driven fire pump drawing from the Service Water/Fire Water Storage Tank.
	Water Supply/Storage	Y			Heated and insulated tank, 2 hour FPW storage in Service Water/Fire Water Storage Tank.
Compressed Air Type system					
	Air compressors	N			By Fluor
	Air receivers	Y	100	1	Receiver to be located in WT building - compressors by Fluor.
	Air dryers	N			By Fluor
Cathodic Protection					
	Underground Steel Piping	N			By Fluor
	Underground Steel Tanks	N			By Fluor
Eye Wash/Safety Shower					
	Type System	Y			Electric tank water heaters installed locally at each eye wash/safety shower station.
CONTROLS					
Equipment Control					
	Medium voltage Switchgear	Y			Hardwired I/O for breaker close/open command and indication. Communication via ELC for other monitoring and diagnostics.
	Motor Control Centers	Y			Hardwired I/O for breaker close/open command, indication, communication, and diagnostics.
	Low Voltage Switchgear	Y			Hardwired I/O for breaker close/open command and indication. Communication via ELC for other monitoring and diagnostics.
	Plant Distributed Control System (DCS)	Y			DCS to be provided by Fluor. Control of Water Treatment equipment to be via PLCs. Hard I/O for start/stop.
	Plant Historian	N			By Fluor
	Offsite Interfaces	Y	See Notes		Rural Water District no metering (by Water company); Natural Gas supply metering to be supplied on-site
Vibration monitoring					
Digital Bus					
	Foundation Fieldbus	N			
	Remote I/O	N			
Instrumentation					
	Redundancy	N			
	Transmitters	Y			4-20 ma as available, Rosemount or Yokogawa preferred?
	HART	Y			Instrumentation shall be HART-Smart where offered as a supplier option.
Continuous Emissions Monitoring System		N			By Fluor
Relaying Data Link		N			
Communication					
	Off site monitoring/administrations	N			By Fluor
	Internal plant	N			By Fluor
	External	N			By Fluor
NERC CIP Requirements		N			By Fluor

		Y/N	% Unit Capacity	Total Number for Plant	Notes
Security Systems		N			By Fluor
ELECTRICAL					
Auxiliary/Reserve Transformers:					
	Reserve Auxiliary Transformer	N			
	Auxiliary	N			
Generator Buses:					
	Power Island	N			
Electrical Equipment Enclosures:					
	Power Distribution Centers (PDCs)	N			Electrical Room will be provided as part of the WWT Building.
Switchgear:					
	6900 V Switchgear	N			By Fluor
	480V Switchgear	Y			Arc-Resistant 480V, 65kA Interrupting, High resistance grounded system with dedicated ground detection system, main-tie-main configuration, sufficient capacity to source main-tie-main from one main breaker, closed bus transfer, remote breaker racking, maitenance switches
Motor Control Centers:					
	480V MCCs	Y			480V, 3-Phase, 3-Wire, 65kA, NEMA Type 1 gasketed for indoor installation, arc-resistant design
CIVIL/STRUCTURAL					
Existing Facilities					By Fluor
Disposal of Spoils					By Fluor
Soils Conditions / Stability					By Fluor
Subsurface Rock					By Fluor
Subsurface water					By Fluor
Cut/Fill					By Fluor
Disposal of debris					By Fluor
Permanent Stormwater					By Fluor
Construction Stormwater					By Fluor
Roads					By Fluor
Surfacing					By Fluor
Soil Bearing Capacity					By Fluor
Foundation type					By Fluor
Enclosures					
	Water Treatment	Y			By Fluor
	Field Office	Y			Located in construction facilities area.
Access					
	Drive bays				See Equipment General Arrangements.
	Elevators	N			One elevator, serving both the HRSG (up to drum level) and as a freight elevator for the STG.
Maintenance cranes					
	Overhead	N			
	Hoists				Provided for equipment removal where mobile equipment cannot access
	Monorails				Provided for equipment removal where mobile equipment or overhead crane cannot access
CONSTRUCTION					
Utilities					
	Power				By Prime EPC
	Communication				By Prime EPC
	Construction Water				By EPC
	Potable Water				By EPC
	Sanitary				By EPC
Parking					Craft parking outside facility fence.
Gate Entry					
	Main				By Prime EPC
	Personnel/Craft				By Prime EPC
	Delivery				By Prime EPC
Construction Field Office / Trailers					
	Owner				Field Office
	Engineer				Field Office
	Vendors				Field Office
	Contractors				Field Office
	Site Services	Y			
Laydown area		Y			Per construction utilities drawing.
Warehouses					Additional non-permenent to be furnished by Contractor as needed.
OWNER COSTS / MISC.					
Permits					
	Air Permits				Minnkota/Owner
	Environmental Assessments				Minnkota/Owner
	SWPPP				Minnkota/Owner
	NPDES				Minnkota/Owner
Owner's Costs					Minnkota/Owner

ATTACHMENT 19 – WATER MASS BALANCE



Stream Number	Stream Description	Flow (gpm)	Specific Gravity	TSS (mg/L)	Ca (mg/L as $CaCO_3$)	Mg (mg/L as $CaCO_3$)	Si (mg/L as SiO_2)	Chloride (mg/L)	Flow (lb/hr)
1	Total Make-Up from Lake Nelson	2,999	1.0	131	456	612	27.5	17.4	1,498,544
2	Lake Nelson to Softening System	2,207	1.0	131	456	612	27.5	17.4	1,102,784
3	Raw Lake Nelson Water to CT	792	1.0	131	456	612	27.5	17.4	395,761
4	Softened Makeup Water to MMF	2,423	1.0	30	35	70	10	17.4	1,210,918
5	Softened Makeup Water to CT	2,060	1.0	10	35	70	10	17.4	1,029,328
6	MMF Backwash Water	220	1.0	236	35	70	10	17.4	110,083
7	Softened Makeup Water to UF	143	1.0	10	35	70	10	17.4	71,507
8	UF Effluent to RO	136	1.0	1.0	35	70	10	17.4	68,009
9	RO Permeate to EFG+ Process	60	1.0	0.0	2.8	4.2	6.1	1.0	29,982
10	RO Permeate to Aux Boiler	60	1.0	0.0	2.8	4.2	6.1	1.0	29,982
11	RO Reject to Injection Well	16	1.0	0.0	296	592	85	147	8,045
12	EFG+ Excess Quench Water to CT	1,490	1.0	0.0	0.0	0.0	0.0	0.0	744,550
13	Aux Boiler Blowdown to CT	56	1.0	0.0	3.0	4.5	6.5	1.1	27,983
14	Cooling Tower Blowdown	734	1.0	225	589	855	58	68	366,728
15	Total Wastewater to Injection Wells	750	1.0	220	583	849	59	70	374,774
16	Sludge Cake	12	1.4	30%	67,650	82,538	1,251	11	8,535
17	Filtrate Recycle to Softening System	87	1.0	0.1%	215	290	13	17.4	43,474
18	Sludge to Sludge Dewatering	98	1.06	5%	8,983	10,983	174	16.4	51,856
19	Soda Ash to Softener								974
20	Hydrated Lime to Softener								465
21	Sulfuric Acid	0.12	1.84						109
22	EFG+ Service Water / Flush Water	80	1.0	10	35	70	10	17.4	39,976
23	Cooling Tower Evaporation	3,664	1.0	0.0	0.0	0.0	0.0	0.0	1,830,893
24	SW / Fire Water Storage Tank Make-Up	HOLD	1.0	10	35	70	10	17	HOLD
25	Misc. SW / FW Users	HOLD	1.0	10	35	70	10	17	HOLD
26	SW Water Stream to PW Users In Admin Bld	HOLD	1.0						HOLD
27	UF Intermittent Backwash to Softener[1]	7	1.0	300	35	70	10	17.4	3,498
28	Total Wastewater to MRY Scrubber Ponds	Note 2	1.0	220	583	849	59	70	Note 2
29	12.5% Sodium Hypochlorite	0.10	1.2						59
30	25% Sodium Hydroxide	0.004	1.27						2.72
31	Anti-Scalant	0.0004	1.15						0.20
32	Sodium Bi-Sulfite	0.002	1.33						1.36
33	Coagulant	0.12	1.48						92
34	Polymer	0.00	1.08						2.5

Note 1: Time-Weighted Average Flow
Note 2: Intermittent flow only when Injection Well is out of service.

No.	Date	By	checked	Description
A	7/2/20	DRG	SSV	ISSUED FOR OWNER REVIEW
0	7/15/20	DRG	DKM	ISSUED FOR DESIGN
1	8/3/20	DRG	DKM	REVISED AS SHOWN
2	10/19/20	DRG	DRG	REVISED AS SHOWN
3	12/21/20	DRG	DRG	REVISED AS SHOWN
4	2/19/21	DRG	DRG	ADDED CHEMICALS
5	3/11/21	DRG	DRG	REVISED CHEMICAL USAGE

Notes:
1. Flows are shown in gallons per minute and rounded to the nearest gpm.

	Combined Makeup	Cooling Tower Blowdown (Stream 14)	Total Wastewater Blowdown (Stream 15)	Units
Barium	<0.1	<0.1	<0.1	mg/L
Strontium	0.9	3.5	3.6	mg/L
Sodium	448	1,740	1,784	mg/L
Potassium	16	62	64	mg/L
Iron (Fe+2/Fe+3)	0.25	0.97	1.00	mg/L
Zinc	<0.1	<0.1	<0.1	mg/L
Aluminum (Al+3)	0.19	0.74	0.76	mg/L
Manganese (Mn +2)	0.06	0.23	0.24	mg/L
Nitrate	0.23	0.89	0.92	mg/L
Ammonia	ND	ND	ND	mg/L
HCO3-	102	395	405	mg/L
CO3 (-2)	10.6	41.0	42.0	mg/L
CO2	ND	ND	ND	mg/L
Ortho-PO4 (-3)	ND	ND	ND	mg/L
SO4 (-2)	987	3,834	3,930	mg/L
Fluoride	ND	ND	ND	mg/L
Bromide	1.6	6.2	6.4	mg/L
Boron	0.3	1.2	1.2	mg/L
Arsenic (III & V)	ND	ND	ND	mg/L
TDS (estimated)	1,709	6,638	6,806	mg/L
Conductivity (estimated)	2,905	11,286	11,571	µS/cm
pH	7.4	8.0 - 8.3	8.0 - 8.3	
TOC	ND	ND	ND	
COD	ND	ND	ND	
BOD	ND	ND	ND	

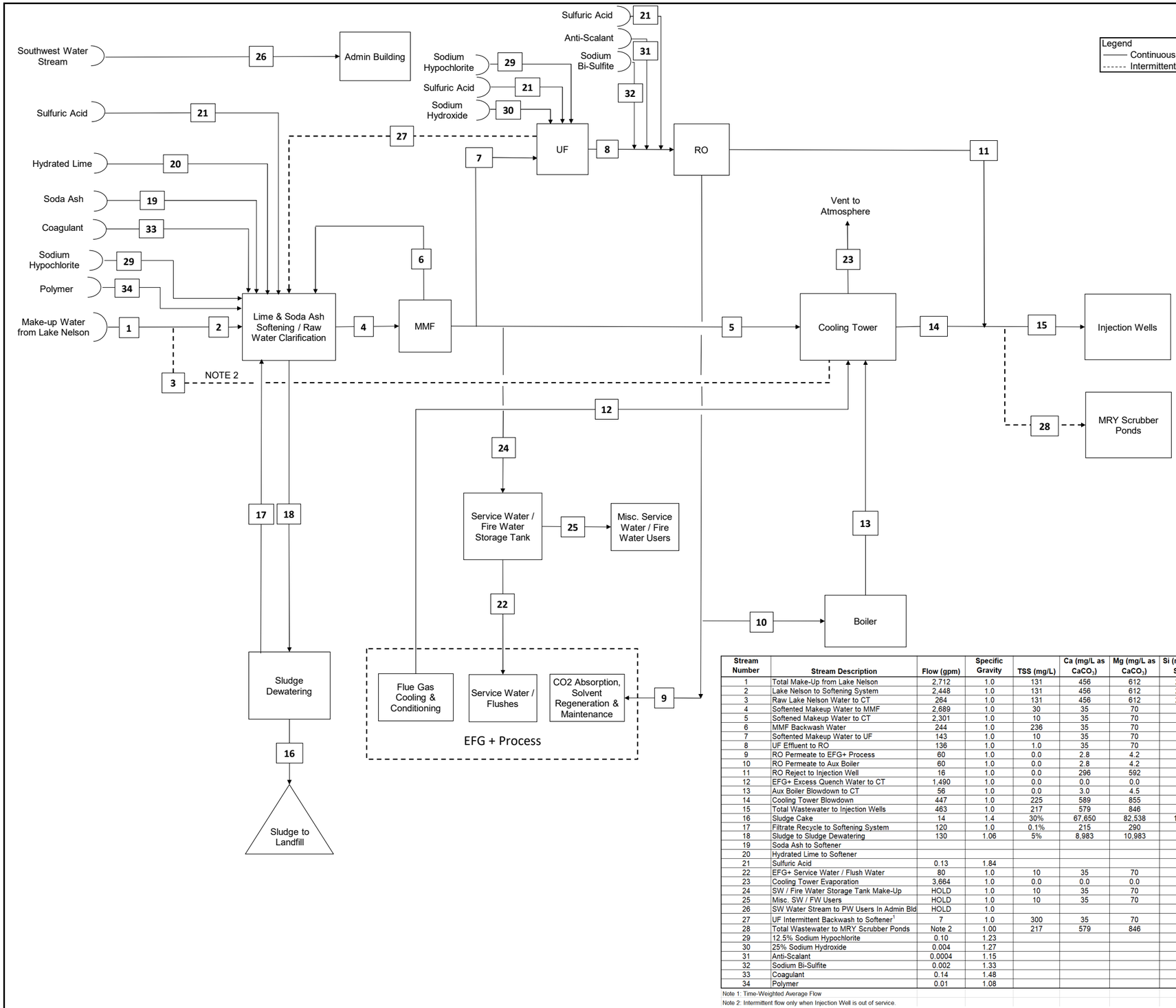
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3/11/2021	D. Guinta
designed	checked
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WATER MASS BALANCE
Minnkota Power Cooperative
Project Tundra
ANNUAL AVERAGE CASE

Project	contract	
124020		
drawing		rev.
WMB-01	**---**	**5**
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file		



Stream Number	Stream Description	Flow (gpm)	Specific Gravity	TSS (mg/L)	Ca (mg/L as $CaCO_3$)	Mg (mg/L as $CaCO_3$)	Si (mg/L as SiO_2)	Chloride (mg/L)	Flow (lb/hr)
1	Total Make-Up from Lake Nelson	2,712	1.0	131	456	612	27.5	17.4	1,354,931
2	Lake Nelson to Softening System	2,448	1.0	131	456	612	27.5	17.4	1,223,011
3	Raw Lake Nelson Water to CT	264	1.0	131	456	612	27.5	17.4	131,920
4	Softened Makeup Water to MMF	2,689	1.0	30	35	70	10	17.4	1,343,443
5	Softened Makeup Water to CT	2,301	1.0	10	35	70	10	17.4	1,149,805
6	MMF Backwash Water	244	1.0	236	35	70	10	17.4	122,131
7	Softened Makeup Water to UF	143	1.0	10	35	70	10	17.4	71,507
8	UF Effluent to RO	136	1.0	1.0	35	70	10	17.4	68,009
9	RO Permeate to EFG+ Process	60	1.0	0.0	2.8	4.2	6.1	1.0	29,982
10	RO Permeate to Aux Boiler	60	1.0	0.0	2.8	4.2	6.1	1.0	29,982
11	RO Reject to Injection Well	16	1.0	0.0	296	592	85	147	8,045
12	EFG+ Excess Quench Water to CT	1,490	1.0	0.0	0.0	0.0	0.0	0.0	744,550
13	Aux Boiler Blowdown to CT	56	1.0	0.0	3.0	4.5	6.5	1.1	27,983
14	Cooling Tower Blowdown	447	1.0	225	589	855	58	68	223,365
15	Total Wastewater to Injection Wells	463	1.0	217	579	846	59	71	231,410
16	Sludge Cake	14	1.4	30%	67,650	82,538	1,251	10	9,514
17	Filtrate Recycle to Softening System	120	1.0	0.1%	215	290	13	17.4	59,964
18	Sludge to Sludge Dewatering	130	1.06	5%	8,983	10,983	174	16.4	69,070
19	Soda Ash to Softener								1,080
20	Hydrated Lime to Softener								516
21	Sulfuric Acid	0.13	1.84						119
22	EFG+ Service Water / Flush Water	80	1.0	10	35	70	10	17.4	39,976
23	Cooling Tower Evaporation	3,664	1.0	0.0	0.0	0.0	0.0	0.0	1,830,893
24	SW / Fire Water Storage Tank Make-Up	HOLD	1.0	10	35	70	10	17	HOLD
25	Misc. SW / FW Users	HOLD	1.0	10	35	70	10	17	HOLD
26	SW Water Stream to PW Users In Admin Bld	HOLD	1.0						HOLD
27	UF Intermittent Backwash to Softener[1]	7	1.0	300	35	70	10	17.4	3,498
28	Total Wastewater to MRY Scrubber Ponds	Note 2	1.00	217	579	846	59	71	Note 2
29	12.5% Sodium Hypochlorite	0.10	1.23						64
30	25% Sodium Hydroxide	0.004	1.27						2.72
31	Anti-Scalant	0.0004	1.15						0.20
32	Sodium Bi-Sulfite	0.002	1.33						1.36
33	Coagulant	0.14	1.48						102
34	Polymer	0.01	1.08						2.7

Note 1: Time-Weighted Average Flow

Note 2: Intermittent flow only when Injection Well is out of service.

No.	Date	By	checked	Description
0	2/19/21	DRG	DRG	ISSUED FOR OWNER REVIEW
1	3/11/21	DRG	DRG	REVISED CHEMICAL USAGE

Notes:
1. Flows are shown in gallons per minute and rounded to the nearest gpm.
2. Flow will be bypassed around softener only when cooling tower cycles are limited by maximum cooling water chlorides.

	Combined Makeup	Cooling Tower Blowdown (Stream 14)	Total Wastewater Blowdown (Stream 15)	Units
Barium	<0.1	<0.1	<0.1	mg/L
Strontium	0.9	3.5	3.6	mg/L
Sodium	448	1,740	1,784	mg/L
Potassium	16	62	64	mg/L
Iron (Fe+2/Fe+3)	0.25	0.97	1.00	mg/L
Zinc	<0.1	<0.1	<0.1	mg/L
Aluminum (Al+3)	0.19	0.74	0.76	mg/L
Manganese (Mn +2)	0.06	0.23	0.24	mg/L
Nitrate	0.23	0.89	0.92	mg/L
Ammonia	ND	ND	ND	mg/L
HCO3-	102	395	405	mg/L
CO3 (-2)	10.6	41.0	42.0	mg/L
CO2	ND	ND	ND	mg/L
Ortho-PO4 (-3)	ND	ND	ND	mg/L
SO4 (-2)	987	3,834	3,930	mg/L
Fluoride	ND	ND	ND	mg/L
Bromide	1.6	6.2	6.4	mg/L
Boron	0.3	1.2	1.2	mg/L
Arsenic (III & V)	ND	ND	ND	mg/L
TDS (estimated)	1,709	6,638	6,806	mg/L
Conductivity (estimated)	2,905	11,286	11,571	µS/cm
pH	7.4	8.0 - 8.3	8.0 - 8.3	
TOC	ND	ND	ND	
COD	ND	ND	ND	
BOD	ND	ND	ND	

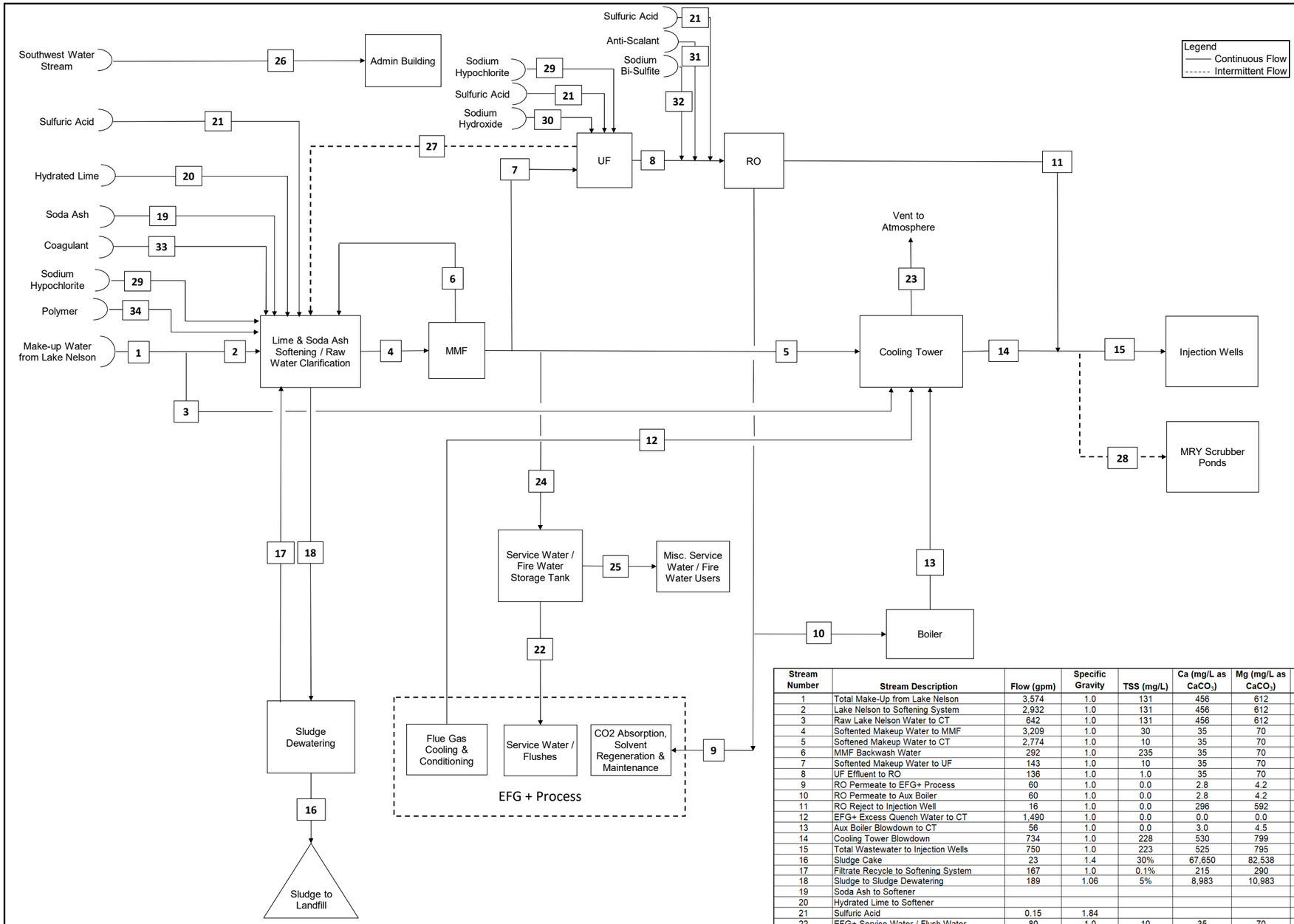
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date 3/11/2021	detailed D. Guinta
designed D. Guinta	checked D. Guinta

WATER MASS BALANCE
Minnkota Power Cooperative
Project Tundra
ANNUAL AVERAGE FULL SOFTENING CASE

Project **124020**	contract	
drawing **WMB-01**	---	rev. **1**
sheet 1 of 1 sheets		
file		



Stream Number	Stream Description	Flow (gpm)	Specific Gravity	TSS (mg/L)	Ca (mg/L as $CaCO_3$)	Mg (mg/L as $CaCO_3$)	Si (mg/L as SiO_2)	Chloride (mg/L)	Flow (lb/hr)
1	Total Make-Up from Lake Nelson	3,574	1.0	131	456	612	27.5	17.4	1,785,721
2	Lake Nelson to Softening System	2,932	1.0	131	456	612	27.5	17.4	1,464,915
3	Raw Lake Nelson Water to CT	642	1.0	131	456	612	27.5	17.4	320,806
4	Softened Makeup Water to MMF	3,209	1.0	30	35	70	10	17.4	1,603,381
5	Softened Makeup Water to CT	2,774	1.0	10	35	70	10	17.4	1,386,112
6	MMF Backwash Water	292	1.0	235	35	70	10	17.4	145,762
7	Softened Makeup Water to UF	143	1.0	10	35	70	10	17.4	71,507
8	UF Effluent to RO	136	1.0	1.0	35	70	10	17.4	68,009
9	RO Permeate to EFG+ Process	60	1.0	0.0	2.8	4.2	6.1	1.0	29,982
10	RO Permeate to Aux Boiler	60	1.0	0.0	2.8	4.2	6.1	1.0	29,982
11	RO Reject to Injection Well	16	1.0	0.0	296	592	85	147	8,045
12	EFG+ Excess Quench Water to CT	1,490	1.0	0.0	0.0	0.0	0.0	0.0	744,550
13	Aux Boiler Blowdown to CT	56	1.0	0.0	3.0	4.5	6.5	1.1	27,983
14	Cooling Tower Blowdown	734	1.0	228	530	799	63	91	366,728
15	Total Wastewater to Injection Wells	750	1.0	223	525	795	63	92	374,774
16	Sludge Cake	23	1.4	30%	67,650	82,538	1,251	11	16,370
17	Filtrate Recycle to Softening System	167	1.0	0.1%	215	290	13	17.4	83,649
18	Sludge to Sludge Dewatering	189	1.06	5%	8,983	10,983	174	16.4	100,109
19	Soda Ash to Softener								1,294
20	Hydrated Lime to Softener								618
21	Sulfuric Acid	0.15	1.84						140
22	EFG+ Service Water / Flush Water	80	1.0	10	35	70	10	17.4	39,976
23	Cooling Tower Evaporation	4,228	1.0	0.0	0.0	0.0	0.0	0.0	2,112,723
24	SW / Fire Water Storage Tank Make-Up	HOLD	1.0	10	35	70	10	17	HOLD
25	Misc. SW / FW Users	HOLD	1.0	10	35	70	10	17	HOLD
26	SW Water Stream to PW Users In Admin Bld	HOLD	1.0						HOLD
27	UF Intermittent Backwash to Softener[1]	7	1.0	300	35	70	10	17.4	3,498
28	Total Wastewater to MRY Scrubber Ponds	Note 2	1.0	0	0	0	0	0	Note 2
29	12.5% Sodium Hypochlorite	0.12	1.23						75
30	25% Sodium Hydroxide	0.004	1.27						2.72
31	Anti-Scalant	0.0004	1.15						0.20
32	Sodium Bi-Sulfite	0.002	1.33						1.36
33	Coagulant	0.16	1.48						122
34	Polymer	0.01	1.08						3.3

Note 1: Time-Weighted Average Flow
Note 2: Intermittent flow only when Injection Well is out of service.

No.	Date	By	checked	Description
A	7/2/20	DRG	SSV	ISSUED FOR OWNER REVIEW
0	7/15/20	DRG	DKM	ISSUED FOR DESIGN
1	8/3/20	DRG	DKM	REVISED AS SHOWN
2	10/19/20	DRG	DRG	REVISED AS SHOWN
3	12/21/20	DRG	DRG	REVISED AS SHOWN
4	2/19/21	DRG	DRG	ADDED CHEMICALS
5	3/11/21	DRG	DRG	REVISED CHEMICAL USAGE

Notes:
1. Flows are shown in gallons per minute and rounded to the nearest gpm.

	Combined Makeup	Cooling Tower Blowdown (Stream 14)	Total Wastewater Blowdown (Stream 15)	Units
Barium	<0.1	<0.1	<0.1	mg/L
Strontium	0.9	4.2	4.3	mg/L
Sodium	500	2,329	2,370	mg/L
Potassium	16	74	76	mg/L
Iron (Fe+2/Fe+3)	0.25	1.16	1.18	mg/L
Zinc	<0.1	<0.1	<0.1	mg/L
Aluminum (Al+3)	0.19	0.88	0.90	mg/L
Manganese (Mn +2)	0.06	0.28	0.28	mg/L
Nitrate	0.23	1.07	1.09	mg/L
Ammonia	ND	ND	ND	mg/L
HCO3-	77	357	363	mg/L
CO3 (-2)	7.1	33.2	33.8	mg/L
CO2	ND	ND	ND	mg/L
Ortho-PO4 (-3)	ND	ND	ND	mg/L
SO4 (-2)	993	4,622	4,703	mg/L
Fluoride	ND	ND	ND	mg/L
Bromide	1.6	7.4	7.6	mg/L
Boron	0.3	1.4	1.4	mg/L
Arsenic (III & V)	ND	ND	ND	mg/L
TDS (estimated)	1,675	7,797	7,933	mg/L
Conductivity (estimated)	2,848	13,256	13,488	µS/cm
pH	7.3	8.0 - 8.3	8.0 - 8.3	
TOC	ND	ND	ND	
COD	ND	ND	ND	
BOD	ND	ND	ND	

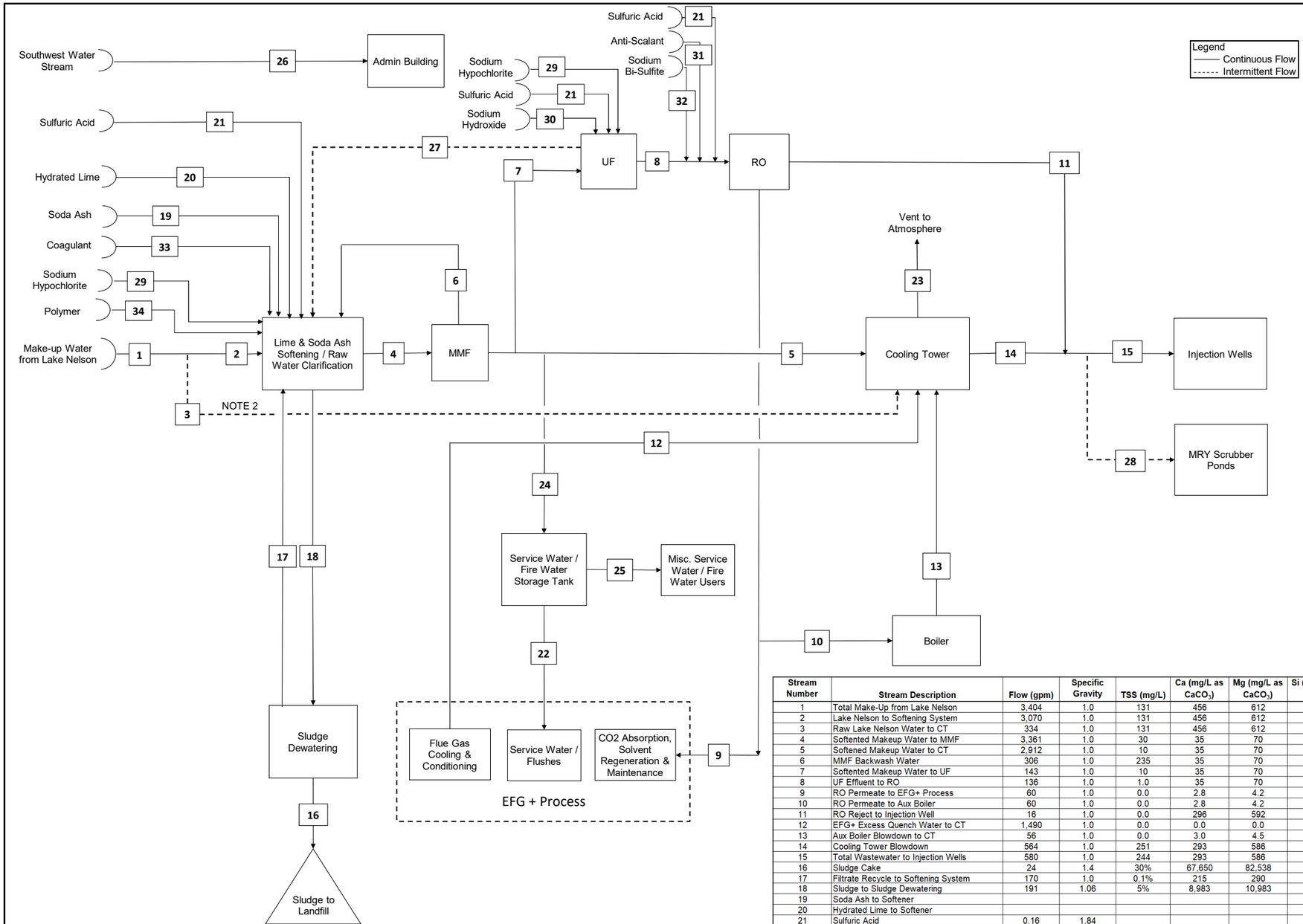
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date 3/11/2021
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WATER MASS BALANCE
Minnkota Power Cooperative
Project Tundra
SUMMER PEAK CASE

Project **124020**
contract
drawing **WMB-01**
rev. **5**
sheet 1 of 1 sheets
file



Stream Number	Stream Description	Flow (gpm)	Specific Gravity	TSS (mg/L)	Ca (mg/L as $CaCO_3$)	Mg (mg/L as $CaCO_3$)	Si (mg/L as SiO_2)	Chloride (mg/L)	Flow (lb/hr)
1	Total Make-Up from Lake Nelson	3,404	1.0	131	456	612	27.5	17.4	1,700,822
2	Lake Nelson to Softening System	3,070	1.0	131	456	612	27.5	17.4	1,533,923
3	Raw Lake Nelson Water to CT	334	1.0	131	456	612	27.5	17.4	166,899
4	Softened Makeup Water to MMF	3,361	1.0	30	35	70	10	17.4	1,679,290
5	Softened Makeup Water to CT	2,912	1.0	10	35	70	10	17.4	1,455,121
6	MMF Backwash Water	306	1.0	235	35	70	10	17.4	152,663
7	Softened Makeup Water to UF	143	1.0	10	35	70	10	17.4	71,507
8	UF Effluent to RO	136	1.0	1.0	35	70	10	17.4	68,009
9	RO Permeate to EFG+ Process	60	1.0	0.0	2.8	4.2	6.1	1.0	29,982
10	RO Permeate to Aux Boiler	60	1.0	0.0	2.8	4.2	6.1	1.0	29,982
11	RO Reject to Injection Well	16	1.0	0.0	296	592	85	147	8,045
12	EFG+ Excess Quench Water to CT	1,490	1.0	0.0	0.0	0.0	0.0	0.0	744,550
13	Aux Boiler Blowdown to CT	56	1.0	0.0	3.0	4.5	6.5	1.1	27,983
14	Cooling Tower Blowdown	564	1.0	251	293	586	85	100	281,830
15	Total Wastewater to Injection Wells	580	1.0	244	293	586	85	101	289,875
16	Sludge Cake	24	1.4	30%	67,650	82,538	1,251	11	16,580
17	Filtrate Recycle to Softening System	170	1.0	0.1%	215	290	13	17.4	84,849
18	Sludge to Sludge Dewatering	191	1.06	5%	8,983	10,983	174	16.4	101,381
19	Soda Ash to Softener								1,355
20	Hydrated Lime to Softener								647
21	Sulfuric Acid	0.16	1.84						146
22	EFG+ Service Water / Flush Water	80	1.0	10	35	70	10	17.4	39,976
23	Cooling Tower Evaporation	4,228	1.0	0.0	0.0	0.0	0.0	0.0	2,112,723
24	SW / Fire Water Storage Tank Make-Up	HOLD	1.0	10	35	70	10	17	HOLD
25	Misc. SW / FW Users	HOLD	1.0	10	35	70	10	17	HOLD
26	SW Water Stream to PW Users In Admin Bld	HOLD	1.0						HOLD
27	UF Intermittent Backwash to Softener[1]	7	1.0	300	35	70	10	17.4	3,498
28	Total Wastewater to MRY Scrubber Ponds	Note 2	1.0	0	2.8	4.2	6.1	1	Note 2
29	12.5% Sodium Hypochlorite	0.13	1.23						78
30	25% Sodium Hydroxide	0.004	1.27						2.72
31	Anti-Scalant	0.0004	1.15						0.20
32	Sodium Bi-Sulfite	0.002	1.33						1.36
33	Coagulant	0.17	1.48						128
34	Polymer	0.01	1.08						3.4

Note 1: Time-Weighted Average Flow
Note 2: Intermittent flow only when Injection Well is out of service.

No.	Date	By	checked	Description
0	10/19/20	DRG	DRG	ISSUED FOR DESIGN
1	12/21/20	DRG	DRG	REVISED AS SHOWN
2	2/19/21	DRG	DRG	ADDED CHEMICALS
3	3/11/21	DRG	DRG	REVISED CHEMICAL USAGE

Notes:
1. Flows are shown in gallons per minute and rounded to the nearest gpm.
2. Flow will be bypassed around softener only when cooling tower cycles are limited by maximum cooling water chlorides.

	Combined Makeup	Cooling Tower Blowdown (Stream 14)	Total Wastewater Blowdown (Stream 15)	Units
Barium	<0.1	<0.1	<0.1	mg/L
Strontium	0.9	5.2	5.2	mg/L
Sodium	511	2,943	2,982	mg/L
Potassium	16	92	93	mg/L
Iron (Fe+2/Fe+3)	0.25	1.44	1.46	mg/L
Zinc	<0.1	<0.1	<0.1	mg/L
Aluminum (Al+3)	0.19	1.09	1.11	mg/L
Manganese (Mn +2)	0.06	0.35	0.35	mg/L
Nitrate	0.23	1.32	1.34	mg/L
Ammonia	ND	ND	ND	mg/L
HCO3-	53	304	308	mg/L
CO3 (-2)	3.9	22.5	22.8	mg/L
CO2	ND	ND	ND	mg/L
Ortho-PO4 (-3)	ND	ND	ND	mg/L
SO4 (-2)	996	5,737	5,812	mg/L
Fluoride	ND	ND	ND	mg/L
Bromide	1.6	9.2	9.3	mg/L
Boron	0.3	1.7	1.7	mg/L
Arsenic (III & V)	ND	ND	ND	mg/L
TDS (estimated)	1,643	9,463	9,586	mg/L
Conductivity (estimated)	2,794	16,089	16,298	µS/cm
pH	7.2	8.0 - 8.3	8.0 - 8.3	
TOC	ND	ND	ND	
COD	ND	ND	ND	
BOD	ND	ND	ND	

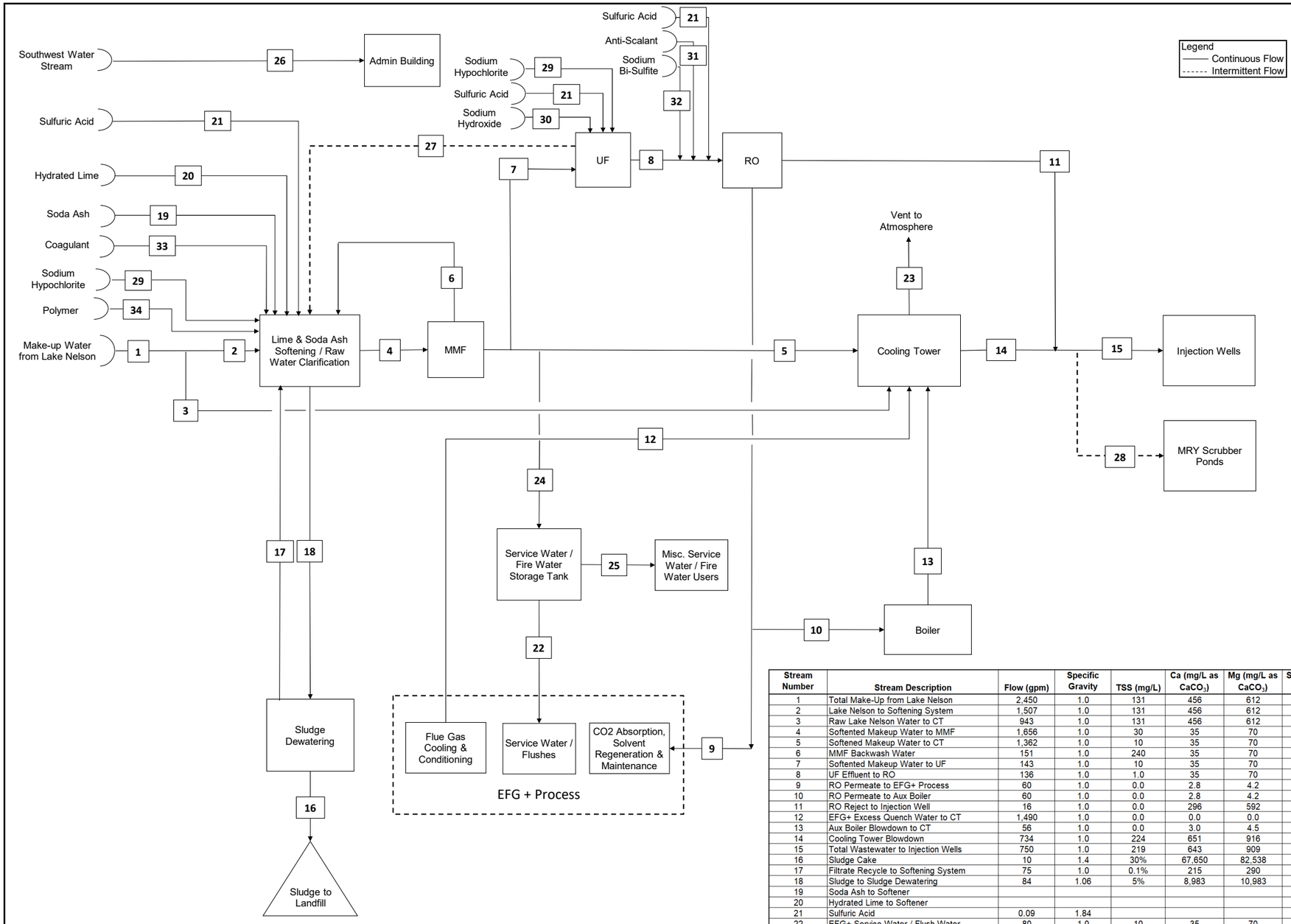
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BURNS McDONNELL

date 3/11/2021
detailed D. Guinta
designed D. Guinta
checked D. Guinta

WATER MASS BALANCE
Minnkota Power Cooperative
Project Tundra
SUMMER PEAK FULL SOFTENING CASE

Project **124020**
contract
drawing **WMB-01**
rev. **3**
sheet 1 of 1 sheets
file



Stream Number	Stream Description	Flow (gpm)	Specific Gravity	TSS (mg/L)	Ca (mg/L as $CaCO_3$)	Mg (mg/L as $CaCO_3$)	Si (mg/L as SiO_2)	Chloride (mg/L)	Flow (lb/hr)
1	Total Make-Up from Lake Nelson	2,450	1.0	131	456	612	27.5	17.4	1,224,450
2	Lake Nelson to Softening System	1,507	1.0	131	456	612	27.5	17.4	753,235
3	Raw Lake Nelson Water to CT	943	1.0	131	456	612	27.5	17.4	471,215
4	Softened Makeup Water to MMF	1,656	1.0	30	35	70	10	17.4	827,250
5	Softened Makeup Water to CT	1,362	1.0	10	35	70	10	17.4	680,539
6	MMF Backwash Water	151	1.0	240	35	70	10	17.4	75,205
7	Softented Makeup Water to UF	143	1.0	10	35	70	10	17.4	71,507
8	UF Effluent to RO	136	1.0	1.0	35	70	10	17.4	68,009
9	RO Permeate to EFG+ Process	60	1.0	0.0	2.8	4.2	6.1	1.0	29,982
10	RO Permeate to Aux Boiler	60	1.0	0.0	2.8	4.2	6.1	1.0	29,982
11	RO Reject to Injection Well	16	1.0	0.0	296	592	85	147	8,045
12	EFG+ Excess Quench Water to CT	1,490	1.0	0.0	0.0	0.0	0.0	0.0	744,550
13	Aux Boiler Blowdown to CT	56	1.0	0.0	3.0	4.5	6.5	1.1	27,983
14	Cooling Tower Blowdown	734	1.0	224	651	916	55	55	366,728
15	Total Wastewater to Injection Wells	750	1.0	219	643	909	56	57	374,774
16	Sludge Cake	10	1.4	30%	67,650	82,538	1,251	11	7,269
17	Filtrate Recycle to Softening System	75	1.0	0.1%	215	290	13	17.4	37,237
18	Sludge to Sludge Dewatering	84	1.06	5%	8,983	10,983	174	16.4	44,440
19	Soda Ash to Softener								665
20	Hydrated Lime to Softener								318
21	Sulfuric Acid	0.09	1.84						79
22	EFG+ Service Water / Flush Water	80	1.0	10	35	70	10	17.4	39,976
23	Cooling Tower Evaporation	3,117	1.0	0.0	0.0	0.0	0.0	0.0	1,557,559
24	SW / Fire Water Storage Tank Make-Up	HOLD	1.0	10	35	70	10	17	HOLD
25	Misc. SW / FW Users	HOLD	1.0	10	35	70	10	17	HOLD
26	SW Water Stream to PW Users In Admin Bld	HOLD	1.0						HOLD
27	UF Intermittent Backwash to Softener[1]	7	1.0	300	35	70	10	17.4	3,498
28	Total Wastewater to MRY Scrubber Ponds	Note 2	1.0	219	643	909	56	57	Note 2
29	12.5% Sodium Hypochlorite	0.07	1.2						43
30	25% Sodium Hydroxide	0.004	1.27						2.72
31	Anti-Scalant	0.0004	1.15						0.20
32	Sodium Bi-Sulfite	0.002	1.33						1.36
33	Coagulant	0.08	1.48						63
34	Polymer	0.00	1.08						1.7

Note 1: Time-Weighted Average Flow

Note 2: Intermittent flow only when Injection Well is out of service.

No.	Date	By	checked	Description
A	7/2/20	DRG	SSV	ISSUED FOR OWNER REVIEW
0	7/15/20	DRG	DKM	ISSUED FOR DESIGN
1	8/3/20	DRG	DKM	REVISED AS SHOWN
2	10/19/20	DRG	DRG	REVISED AS SHOWN
3	12/21/20	DRG	DRG	REVISED AS SHOWN
4	2/19/21	DRG	DRG	ADDED CHEMICALS
5	3/11/21	DRG	DRG	REVISED CHEMICAL USAGE

Notes:
1. Flows are shown in gallons per minute and rounded to the nearest gpm.

	Combined Makeup	Cooling Tower Blowdown (Stream 14)	Total Wastewater Blowdown (Stream 15)	Units
Barium	<0.1	<0.1	<0.1	mg/L
Strontium	0.9	2.8	2.9	mg/L
Sodium	418	1,311	1,358	mg/L
Potassium	16	50	52	mg/L
Iron (Fe+2/Fe+3)	0.25	0.78	0.81	mg/L
Zinc	<0.1	<0.1	<0.1	mg/L
Aluminum (Al+3)	0.19	0.60	0.62	mg/L
Manganese (Mn +2)	0.06	0.19	0.20	mg/L
Nitrate	0.23	0.72	0.75	mg/L
Ammonia	ND	ND	ND	mg/L
HCO3-	139	435	451	mg/L
CO3 (-2)	15.5	48.8	50.6	mg/L
CO2	ND	ND	ND	mg/L
Ortho-PO4 (-3)	ND	ND	ND	mg/L
SO4 (-2)	987	3,099	3,211	mg/L
Fluoride	ND	ND	ND	mg/L
Bromide	1.6	5.0	5.2	mg/L
Boron	0.3	0.9	1.0	mg/L
Arsenic (III & V)	ND	ND	ND	mg/L
TDS (estimated)	1,758	5,520	5,720	mg/L
Conductivity (estimated)	2,989	9,384	9,725	µS/cm
pH	7.7	8.0 - 8.3	8.0 - 8.3	
TOC	ND	ND	ND	
COD	ND	ND	ND	
BOD	ND	ND	ND	

ND = no data available

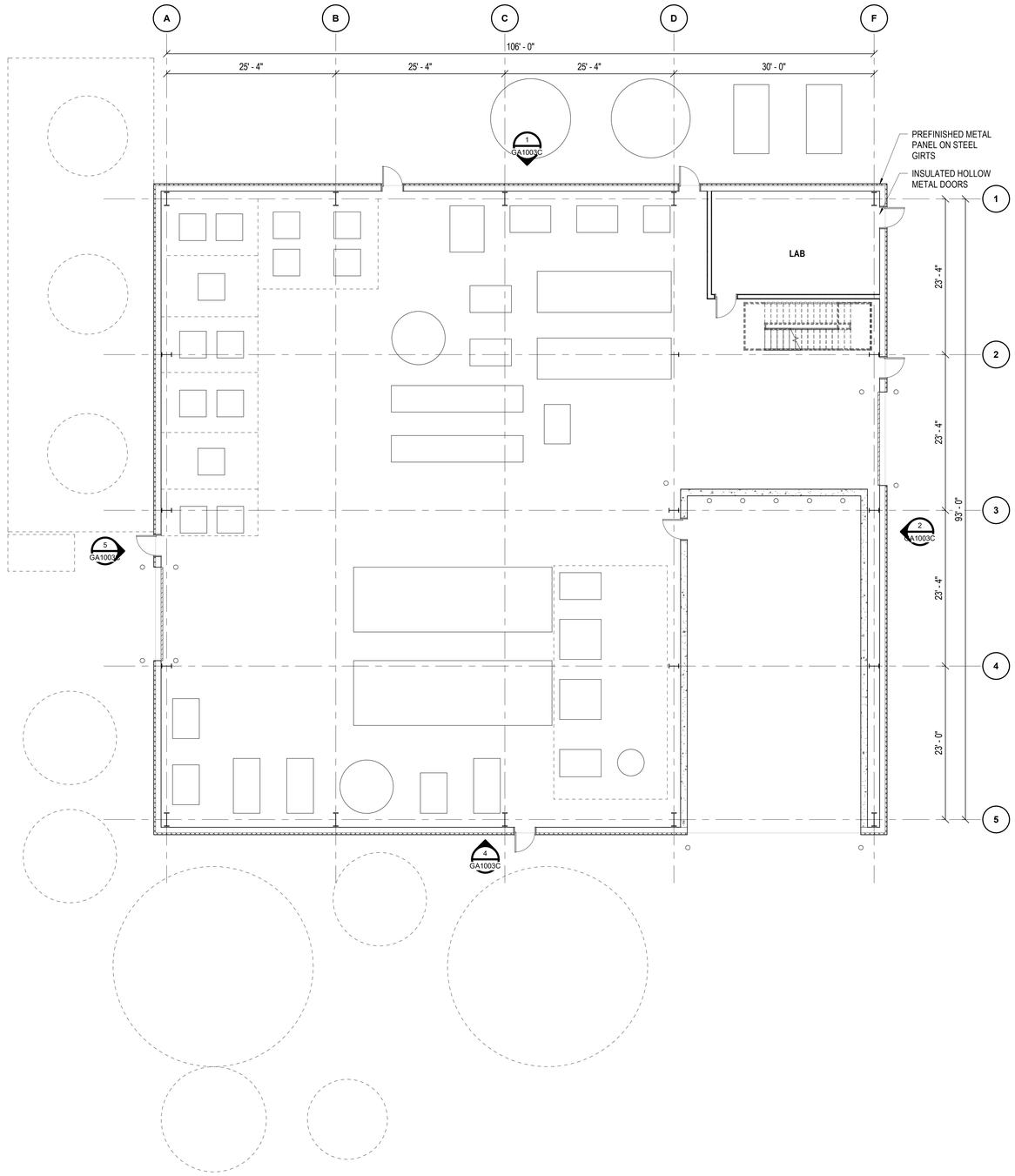
BURNS McDONNELL

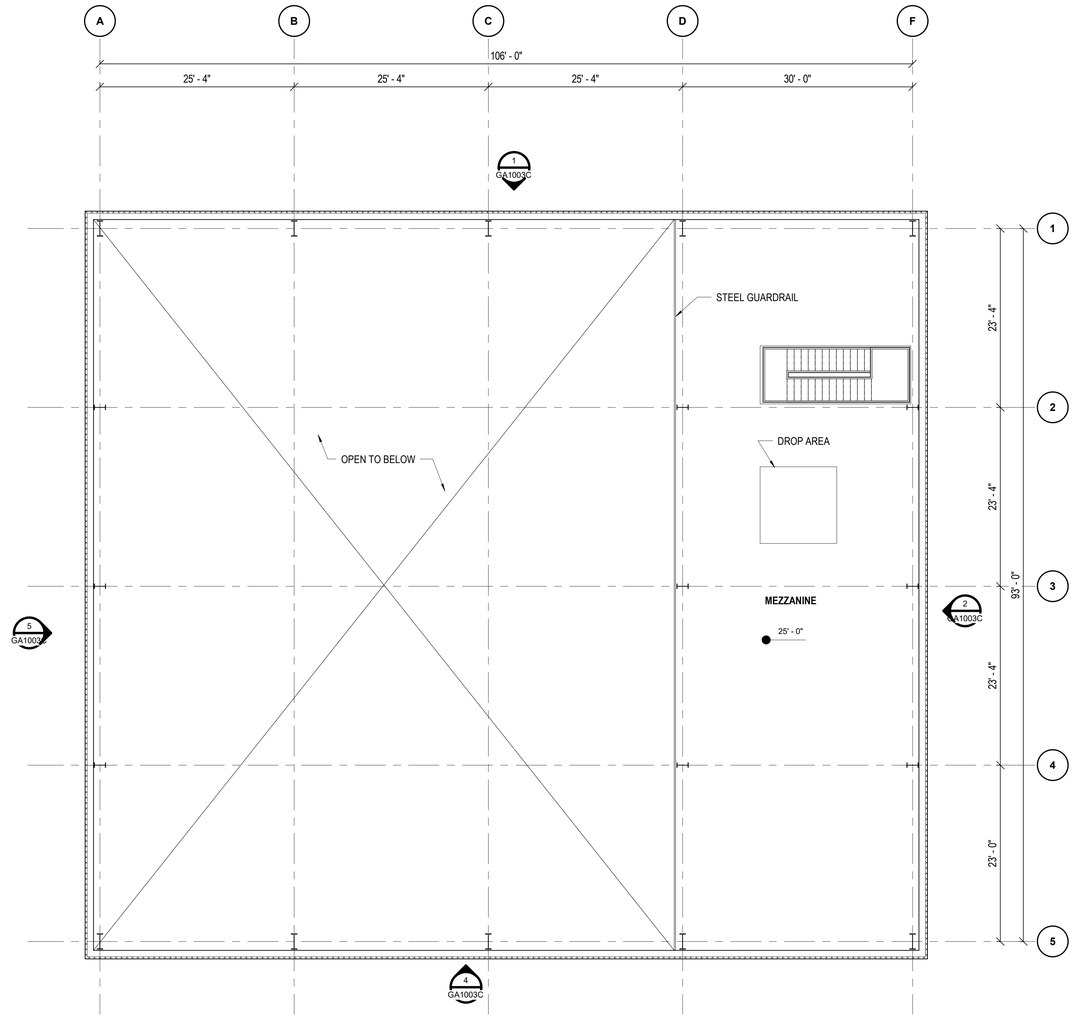
date 3/11/2021	detailed D. Guinta
designed D. Guinta	checked D. Guinta

WATER MASS BALANCE
Minnkota Power Cooperative
Project Tundra
WINTER MINIMUM CASE

Project **124020**	contract	
drawing **WMB-01**	---	rev. **5**
sheet 1 of 1 sheets		
file		

ATTACHMENT 20 – SITE AND GENERAL ARRANGEMENTS





NORTH

0 4' 8' 16'
SCALE IN FEET

TUNDRA WWT BUILDING PLAN

NORTH

0 4' 8' 16'
SCALE IN FEET

MEZZANINE FLOOR

PRELIMINARY - NOT FOR CONSTRUCTION

no.	date	by	ckd	description
A	11/04/20	RB	DF	ISSUED FOR REVIEW

BURNS McDONNELL
9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400

designed RDB | detailed RDB

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OLIVER COUNTY, ND

TUNDRA PDR
WATER TREATMENT PLANS
-

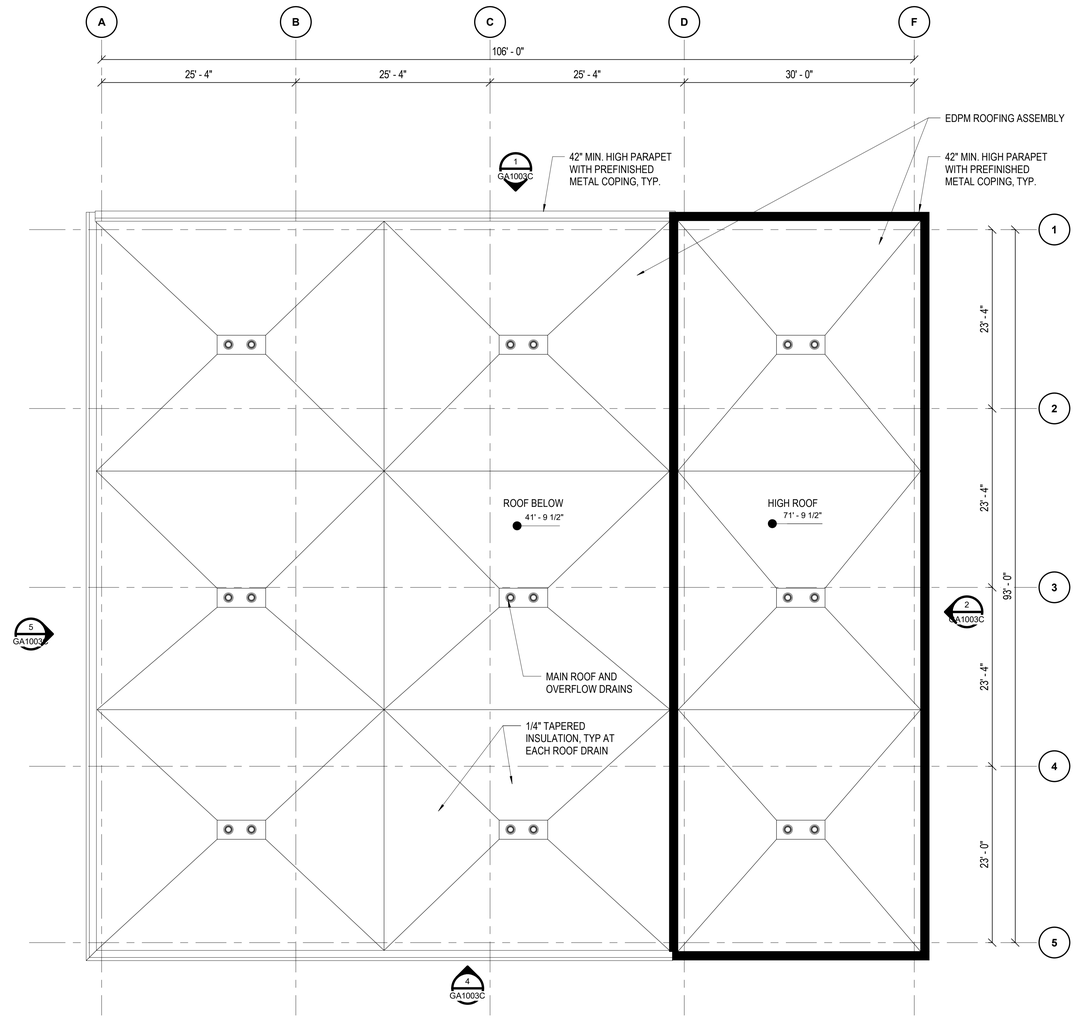
project 124020 | contract

drawing **GA1003A** | rev. **A**

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HIGH ROOF

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TUNDRA PDR
WATER TREATMENT ROOF PLAN

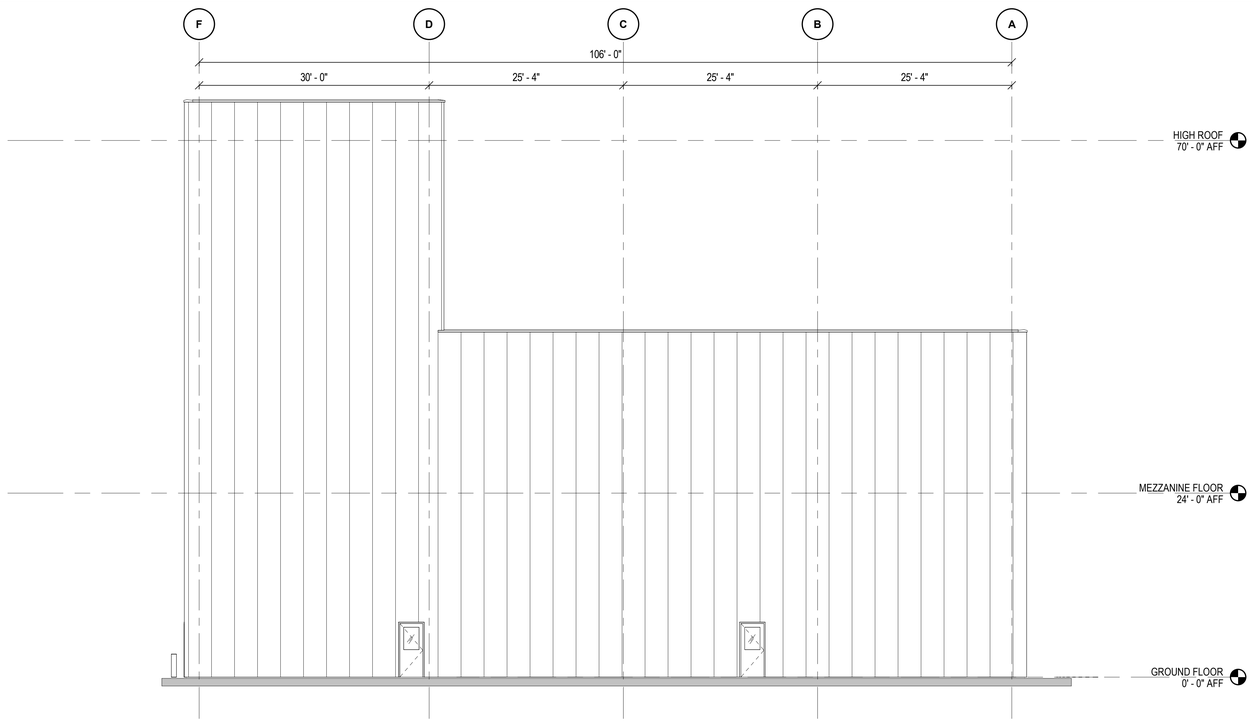
project 124020 | contract

drawing GA1003B | rev. A

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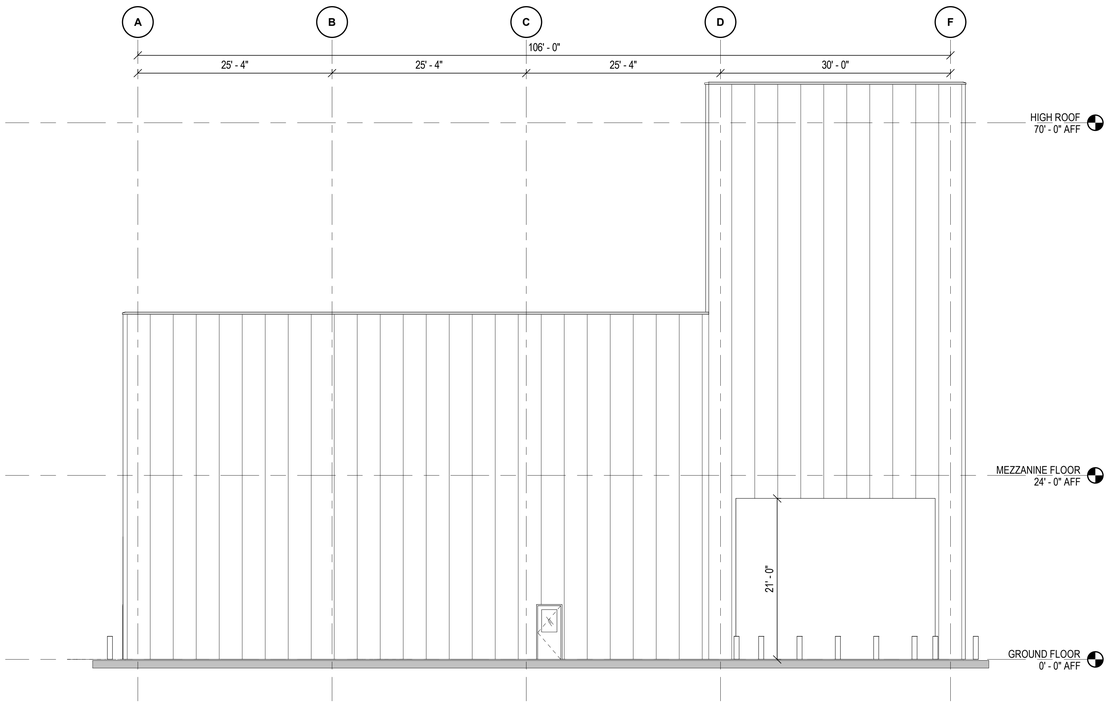
0 4' 8' 16'
SCALE IN FEET

ELEVATION 1 AE-102
WAREHOUSE NORTH ELEVATION



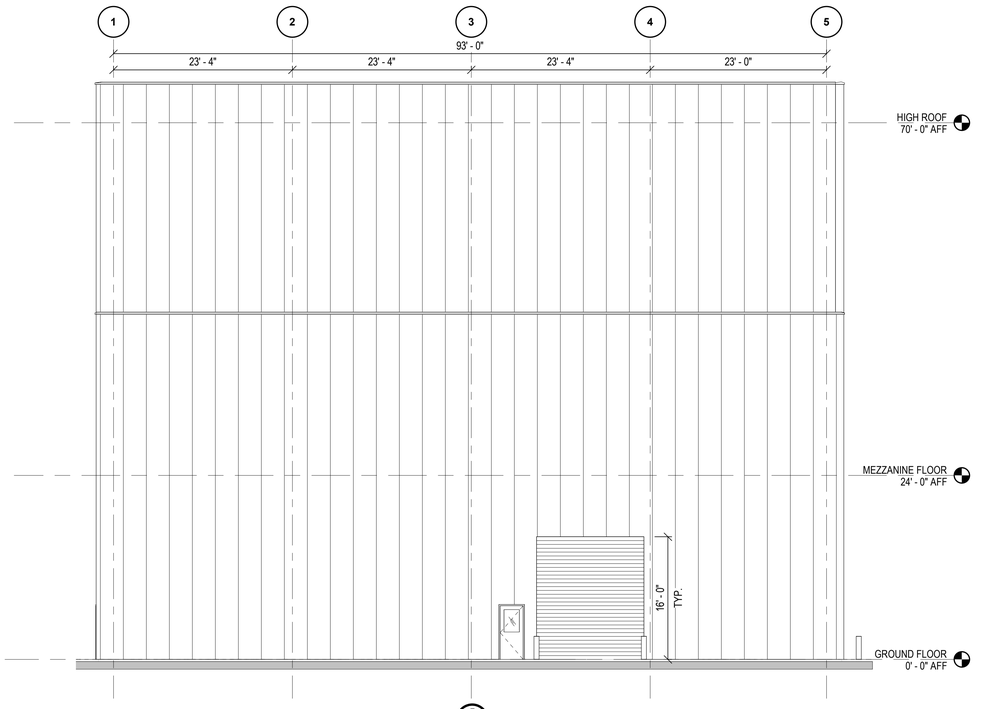
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SCALE IN FEET

ELEVATION 2 AE-102
WAREHOUSE EAST ELEVATION



0 4' 8' 16'
SCALE IN FEET

ELEVATION 4 AE-102
WAREHOUSE SOUTH ELEVATION



0 4' 8' 16'
SCALE IN FEET

ELEVATION 5 AE-102
WAREHOUSE WEST ELEVATION

PRELIMINARY - NOT FOR CONSTRUCTION

no.	date	by	ckd	description
A	11/04/20	RB	DF	ISSUED FOR REVIEW

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OLIVER COUNTY, ND

TUNDRA PDR
WATER TREATMENT ELEVATIONS

project 124020 | contract

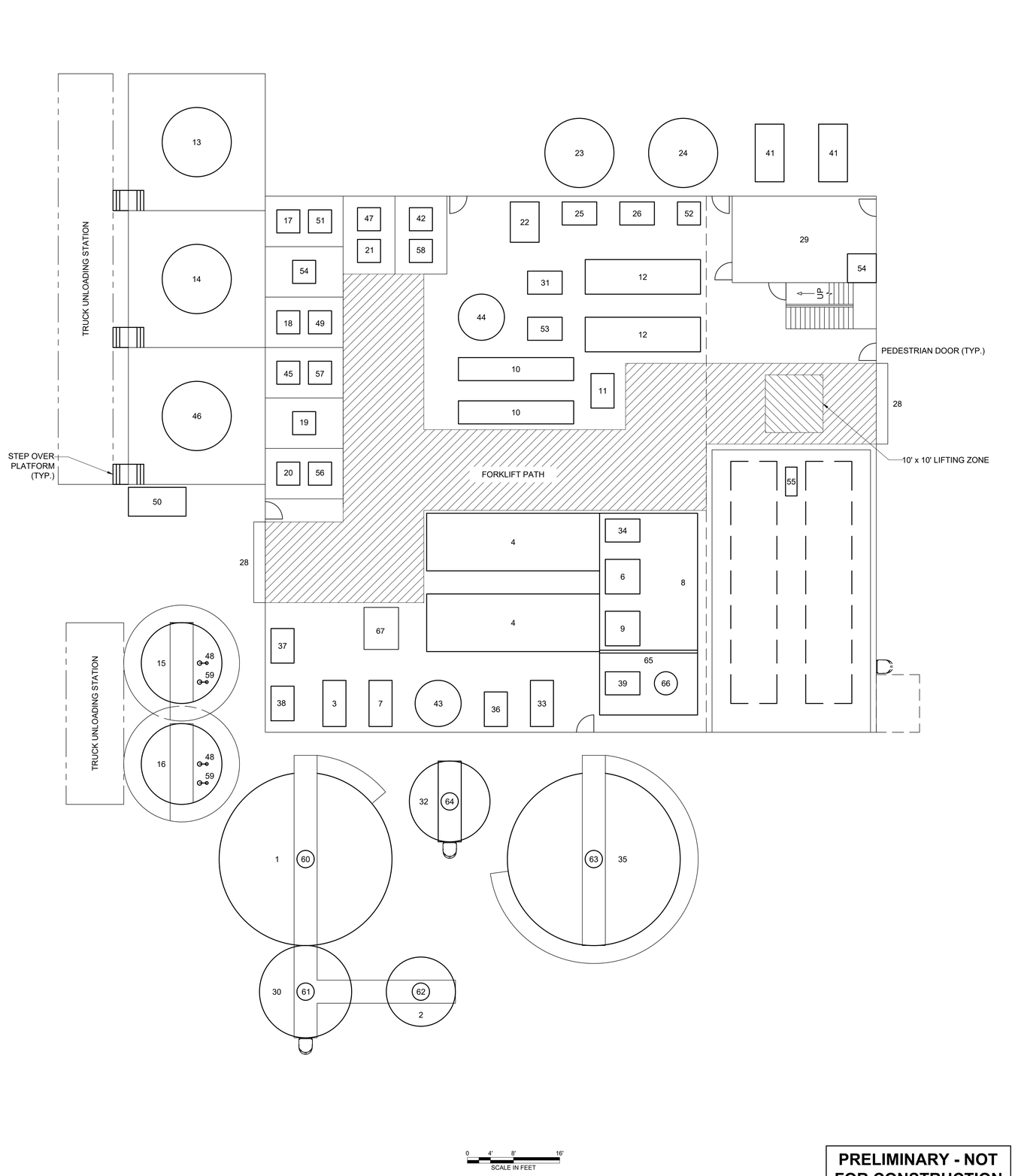
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ITEM	DESCRIPTION	QUANTITY	DIMENSIONS
1	HIGH RATE CLARIFIER	1x100%	30' DIA ~ 15' H
2	SOFTENING REACTION TANK	1x100%	12' DIA
3	CLARIFIER SLUDGE RECIRCULATING PUMP SKID	2x100% PUMPS	4'x8'
4	GRAVITY SAND FILTERS (PERMEATE TO CLEARWELL)	2x50%	30' L x10' W x10' H
5	NOT USED	-	-
6	SERVICE WATER/UF FEED PUMPS (SUBMERSIBLE PUMPS)	3x50% PUMPS	6'x6'
7	CLARIFIER SLUDGE BLOWDOWN PUMP SKID	2x100% PUMPS	4'x8'
8	CLEARWELL SUMP	1x100% PUMP	35' L x18' W x10' D
9	COOLING TOWER FEED PUMPS (SUBMERSIBLE PUMPS)	3x50%	6'x6'
10	UF SKIDS	2x100%	20' L x4' W x10' H
11	CARTRIDGE FILTER SKID	2x100% FILTERS	4'x6'
12	TWO-PASS RO SKIDS	2x100% SKIDS	20' L x6' W x10' H
13	SULFURIC ACID TANK	1x100% TANK	12' DIA x 10' H
14	SODIUM HYPOCHLORITE TANK	1x100% TANK	12' DIA x 20' H
15	SODA ASH SILO	1x100% SILO	14' DIA x 50' H
16	HYDRATED LIME SILO	1x100% SILO	14' DIA x 50' H
17	SULFURIC ACID FEED PUMP SKID	2x100% PUMPS	4'x4'
18	SODIUM HYPOCHLORITE FEED PUMP SKID	2x100% PUMPS	4'x4'
19	COAGULANT FEED PUMP SKID	2x100% PUMPS	4'x4'
20	POLYMER FEED PUMP SKID	2x100% PUMPS	4'x4'
21	ANTI-SCALANT TOTE	1x100% TOTE	4'x4'
22	UF/RO CLEAN IN-PLACE SKID	1x100% SKID	5'x7'
23	RO REJECT TANK	1x100% TANK	12' DIA x 10' H
24	RO PERMEATE TANK	1x100% TANK	12' DIA x 10' H
25	RO REJECT TRANSFER PUMP SKID	2x100% PUMPS	4' x 6'
26	RO PERMEATE TRANSFER PUMP SKID	2x100% PUMPS	4' x 6'
27	FILTER PRESS (SEE SKM-0002)	2x50% PRESS	8' W x42' L x8' H
28	OVERHEAD DOOR	2	14' W x14' H
29	WATER TREATMENT LAB	1	12' W x 25' L
30	RAPID MIX TANK	1x100% TANK	16' DIA x 10' H
31	RO FEED PUMP SKID	2x100% PUMPS	4' x 6'
32	SLUDGE HOLDING TANK	1x100% TANK	14' DIA x 16' H
33	FILTER PRESS FEED PUMP SKID	2x100% PUMPS	4' x 6'
34	FILTER BACKWASH SUMP PUMPS (SUBMERSIBLE PUMP)	2x100% PUMPS	4' x 6'
35	EQUALIZATION TANK	1x100% TANK	30' DIA x 40' H
36	CLARIFIER FEED PUMP SKID	2x100% PUMPS	4' x 6'
37	SODA ASH SLURRY PUMP SKID	2x100% PUMPS	4' x 6'
38	HYDRATED LIME SLURRY PUMP SKID	2x100% PUMPS	4' x 6'
39	FILTRATE SUMP PUMPS (SUBMERSIBLE PUMPS)	2x100% PUMPS	18' x 10' x 10'
40	WATER TREATMENT ELECTRICAL ROOM (SEE SKM-0002)	1	15' W x25' L
41	STATION SERVICE TRANSFORMERS	2	5' W x10' L
42	CAUSTIC PUMP SKID	2x100% PUMPS	4' x 4'
43	INSTRUMENT AIR RECEIVER	1x100%	8' DIA
44	UF PRODUCT TANK	1x100%	8' DIA
45	SODIUM BISULFITE PUMP SKID	2x100% PUMPS	4' x 4'
46	COAGULANT TANK	1x100% TANK	12' DIA x 10' H
47	ANTI-SCALANT FEED PUMP SKID	2x100% PUMPS	4' x 4'
48	SAFETY SHOWER / EYEWASH STATION (INDOOR)	2	1' x 2.5'
49	CEB SODIUM HYPOCHLORITE FEED PUMP SKID	2x100% PUMPS	4' x 4'
50	OUTDOOR SAFETY SHOWER/HEATER SKID	1 HEATER 1 SHOWER	5' x 10'
51	RO SULFURIC ACID FEED PUMP SKID	2x100% PUMPS	4' x 4'
52	CLOTH WASH SKID	1x100% PUMPS	4' x 4'
53	UF BACKWASH PUMP SKID	2X100% PUMPS	4' x 6'
54	INDOOR SAFETY SHOWER/HEATER SKID	1 HEATER 1 SHOWER	5' x 5'
55	BRIDGE CRANE	1x100%	
56	POLYMER TOTE	1x100%	4' x 4'
57	SODIUM BISULFITE TOTE	1x100%	4' x 4'
58	CAUSTIC TOTE	1x100%	4' x 4'
59	SAFETY SHOWER/EYEWASH STATION (OUTDOOR)	2	1' x 2.5'
60	CLARIFIER RAKE	1	
61	RAPID MIX TANK AGITATOR	1	
62	SOFTENING REACTION TANK AGITATOR	1	
63	EQUALIZATION TANK AGITATOR	1	
64	SLUDGE TANK AGITATOR	1	
65	FILTRATE SUMP	1	
66	FILTRATE SUMP MIXER	1	
67	SAND FILTER AIR SCOUR BLOWER SKID	2X100% BLOWERS	6' X 8'



PRELIMINARY - NOT FOR CONSTRUCTION

Scale For Microfilming
Millimeters
Inches

no.	date	by	ckd	description
A	08/19/20	KJM	SSV	ISSUED FOR REVIEW

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KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.

designed D. GUINTA | detailed K. MATTHEWS

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OLIVER COUNTY, ND

TUNDRA PDR
GENERAL ARRANGEMENT
WATER TREATMENT LAYOUT 1ST FLOOR

project 124020 | contract -

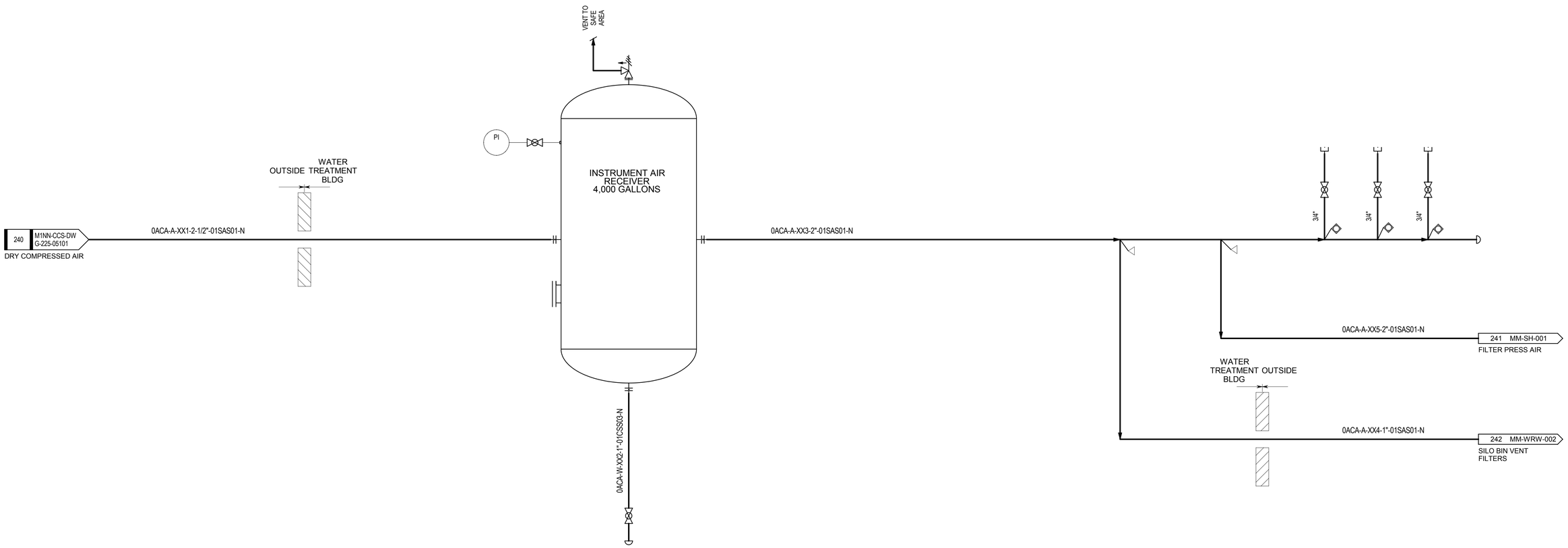
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ATTACHMENT 21 – P&IDS



Scale For Microfilming
Millimeters
Inches

PRELIMINARY - NOT FOR CONSTRUCTION

no.	date	by	ckd	description
A	03/19/21	CRF		ISSUED FOR COST ESTIMATE DEVELOPMENT

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FEED STUDY

Oliver County, ND

Piping & Instrumentation Diagram
COMPRESSED AIR

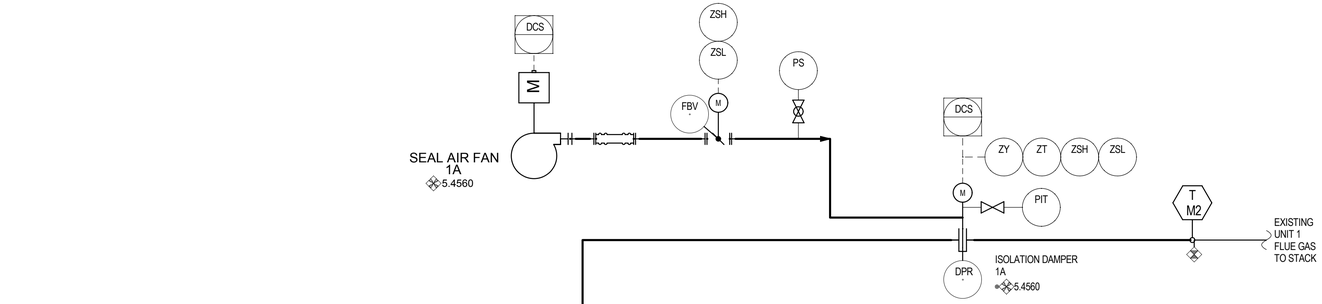
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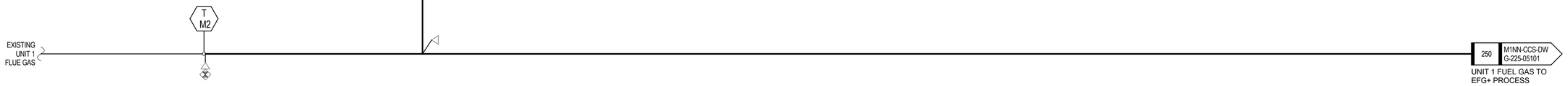
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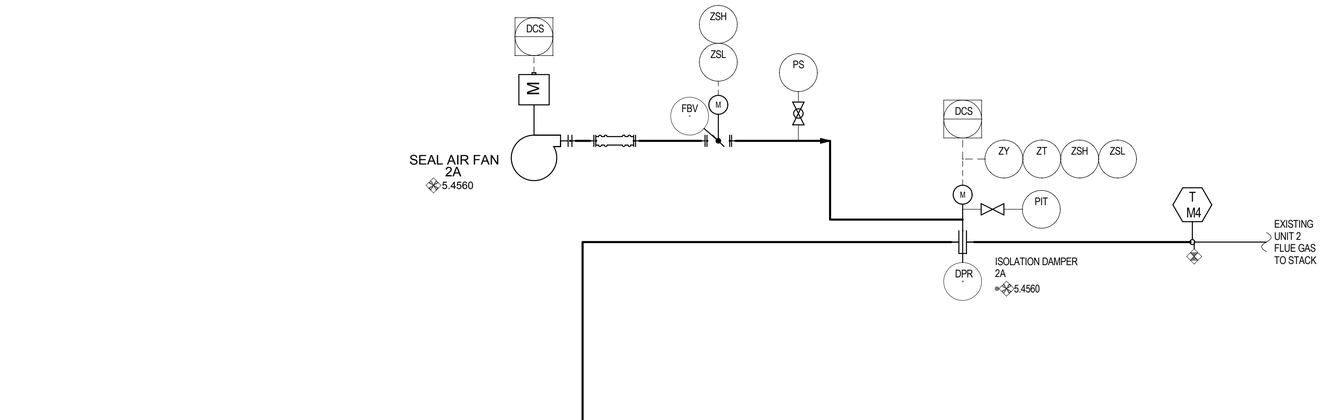
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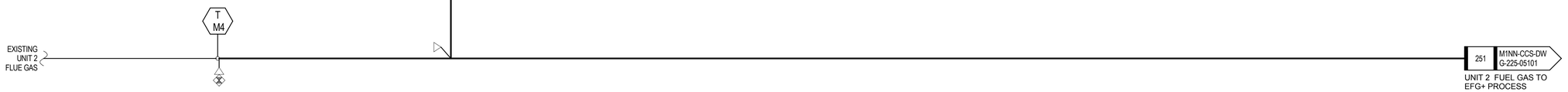
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no.	date	by	ckd	description

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FEED STUDY

Oliver County, ND

Piping & Instrumentation Diagram
BOILER AIR AND GAS

project 124020 | contract

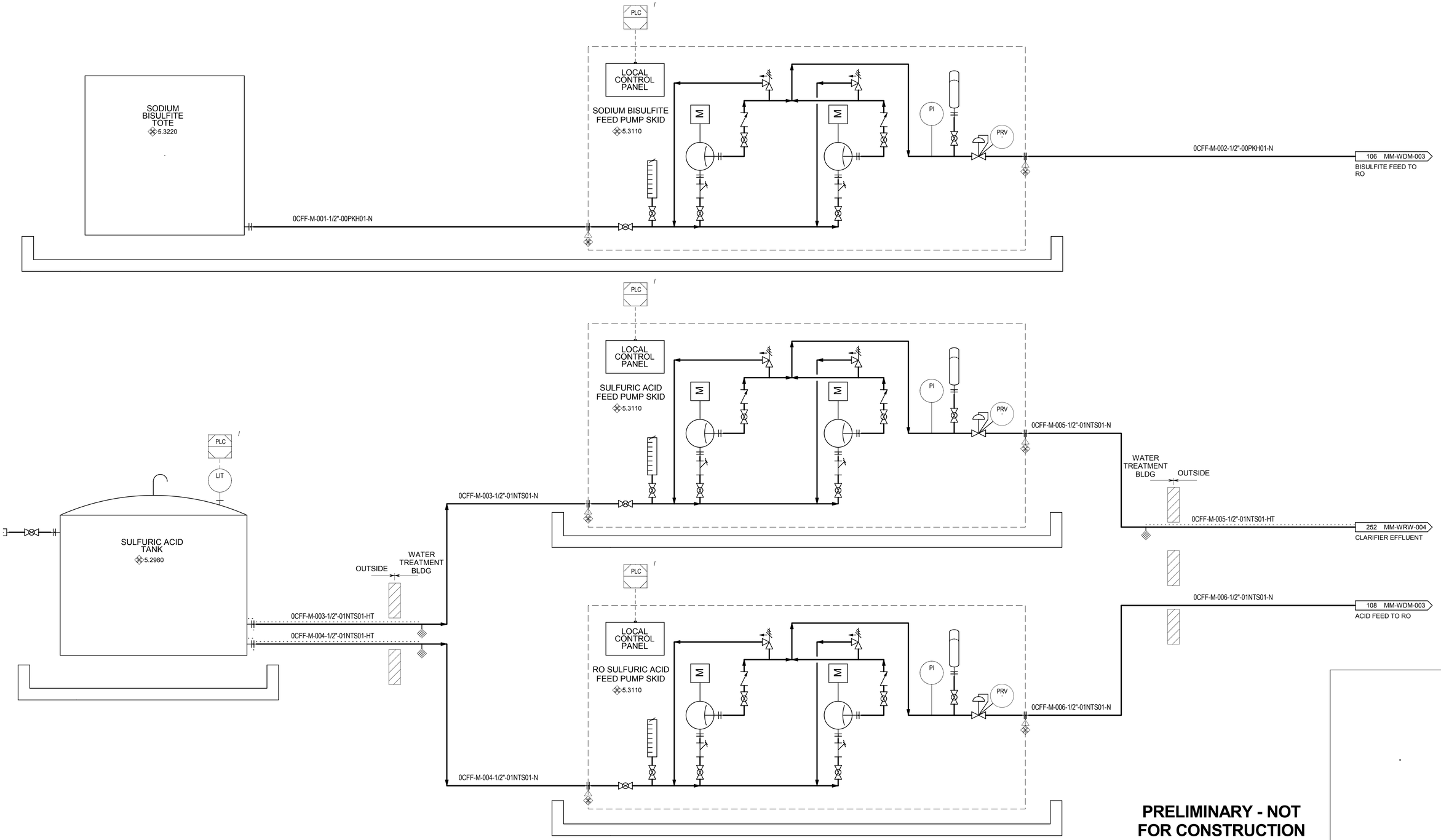
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Scale For Microfilming
Millimeters
Inches



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FEED STUDY

Oliver County, ND

Piping & Instrumentation Diagram
Chemical Feed

project 124020 | contract

drawing **MM-CFF-001** | rev. **– A**

sheet | of | sheets

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\Milton R Young Station\Common\MM-CFF-001.pid

Millimeters
Inches
Scale For Microfilming

ANTI-SCALANT TOTE
5.3220

PLC
LOCAL CONTROL PANEL
ANTI-SCALANT FEED PUMP SKID
5.3110
M
M
PI
PRV

0CFF-M-007-1/2"-00PKH01-N
0CFF-M-008-1/2"-00PKH01-N
109 MM-WDM-003
ANTI-SCALANT FEED TO RO

PLC
LOCAL CONTROL PANEL
CEB SODIUM HYPOCHLORITE FEED PUMP SKID
5.3110
M
M
PI
PRV

0CFF-M-011-1/2"-00PKH01-N
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113 MM-WDM-002
UF BACKWASH

WATER TREATMENT BLDG
OUTSIDE

PLC
LIT
SODIUM HYPOCHLORITE TANK
5.2980
5.2980

0CFF-M-010-1/2"-00PKH01-HT
111 MM-WRW-003
REACTION TANK

PLC
LOCAL CONTROL PANEL
SODIUM HYPOCHLORITE FEED PUMP SKID
5.3110
M
M
PI
PRV

OUTSIDE
WATER TREATMENT BLDG

0CFF-M-009-1/2"-00PKH01-HT
0CFF-M-009-1/2"-00PKH01-N

PRELIMINARY - NOT FOR CONSTRUCTION

no.	date	by	ckd	description
A	03/19/21	CRF		ISSUED FOR COST ESTIMATE DEVELOPMENT

no.	date	by	ckd	description

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FEED STUDY

Oliver County, ND

Piping & Instrumentation Diagram
Chemical FEed

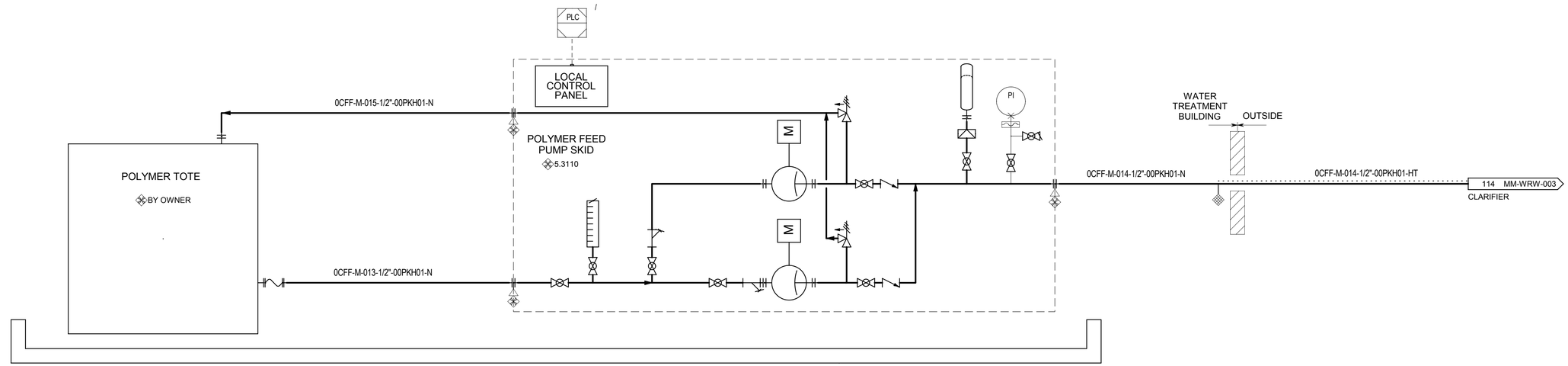
project 124020 | contract

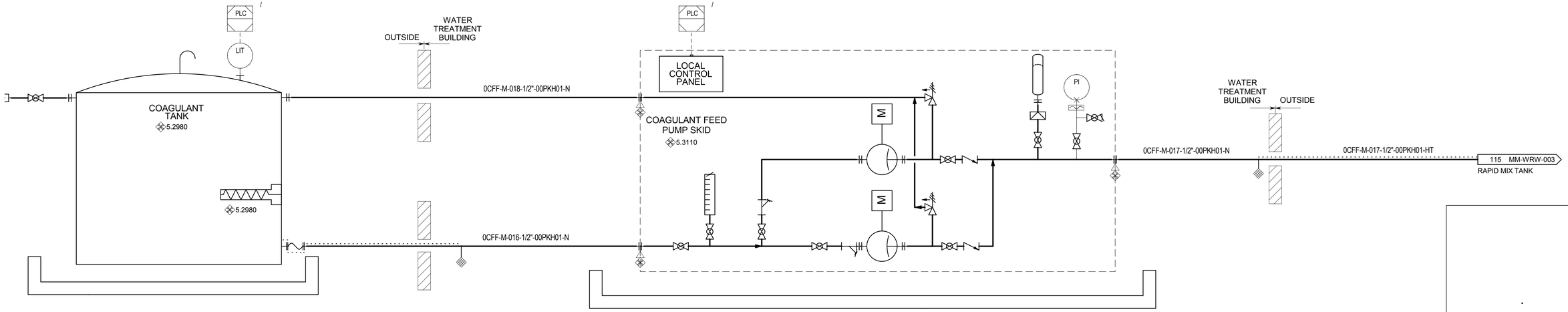
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A	03/19/21	CRF		ISSUED FOR COST ESTIMATE DEVELOPMENT

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FIRM LICENSE NO.

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FEED STUDY

Oliver County, ND

Piping & Instrumentation Diagram
Chemical Feed

project	contract
124020	

drawing **MM-CFF-003** rev. **– A**

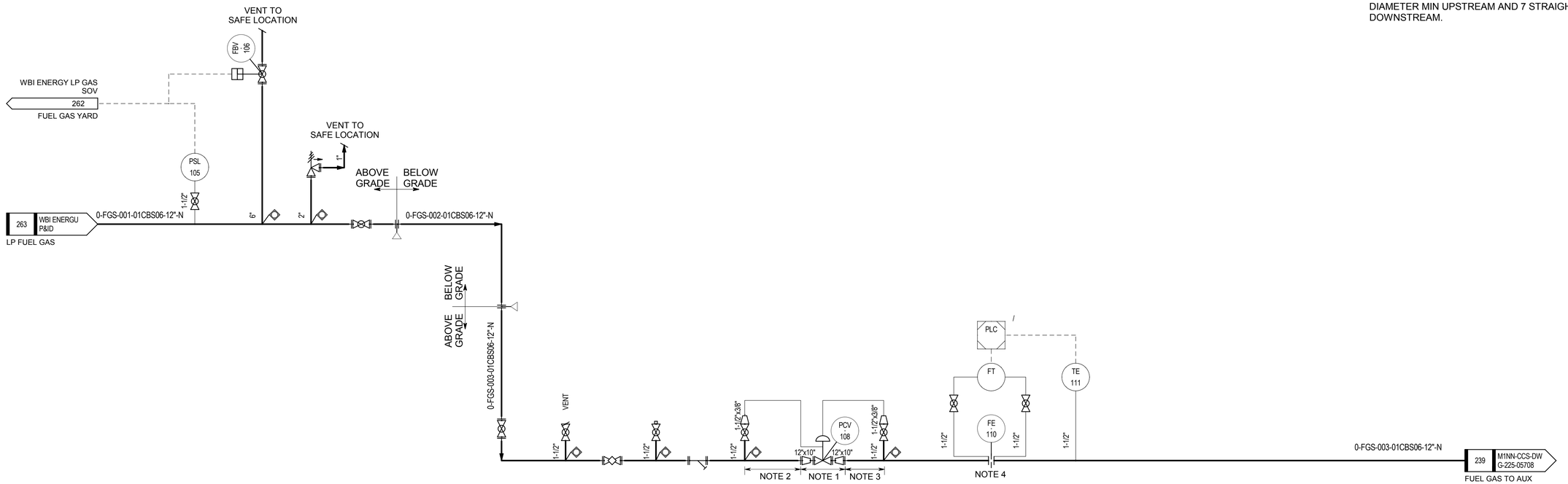
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file MM-CFF-003.pid

\Milton R Young Station\Common\MM-CFF-003.pid

NOTES:

1. PROVIDE TEMPORARY SPOOL FOR AIR BLOW.
2. LOCATE TAP 4 STRAIGHT PIPE DIAMETER MIN FROM FLANGE.
3. LOCATE TAP 10 STRAIGHT PIPE DIAMETER MIN FROM FLANGE.
4. FLOW ORIFICE REQUIRES STRAIGHT RUN OF 30 STRAIGHT PIPE DIAMETER MIN UPSTREAM AND 7 STRAIGHT PIPE DIAMETER MIN DOWNSTREAM.



Millimeters

Scale For Microfilming

Inches

PRELIMINARY - NOT FOR CONSTRUCTION

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Oliver County, ND

Piping & Instrumentation Diagram
FUEL GAS

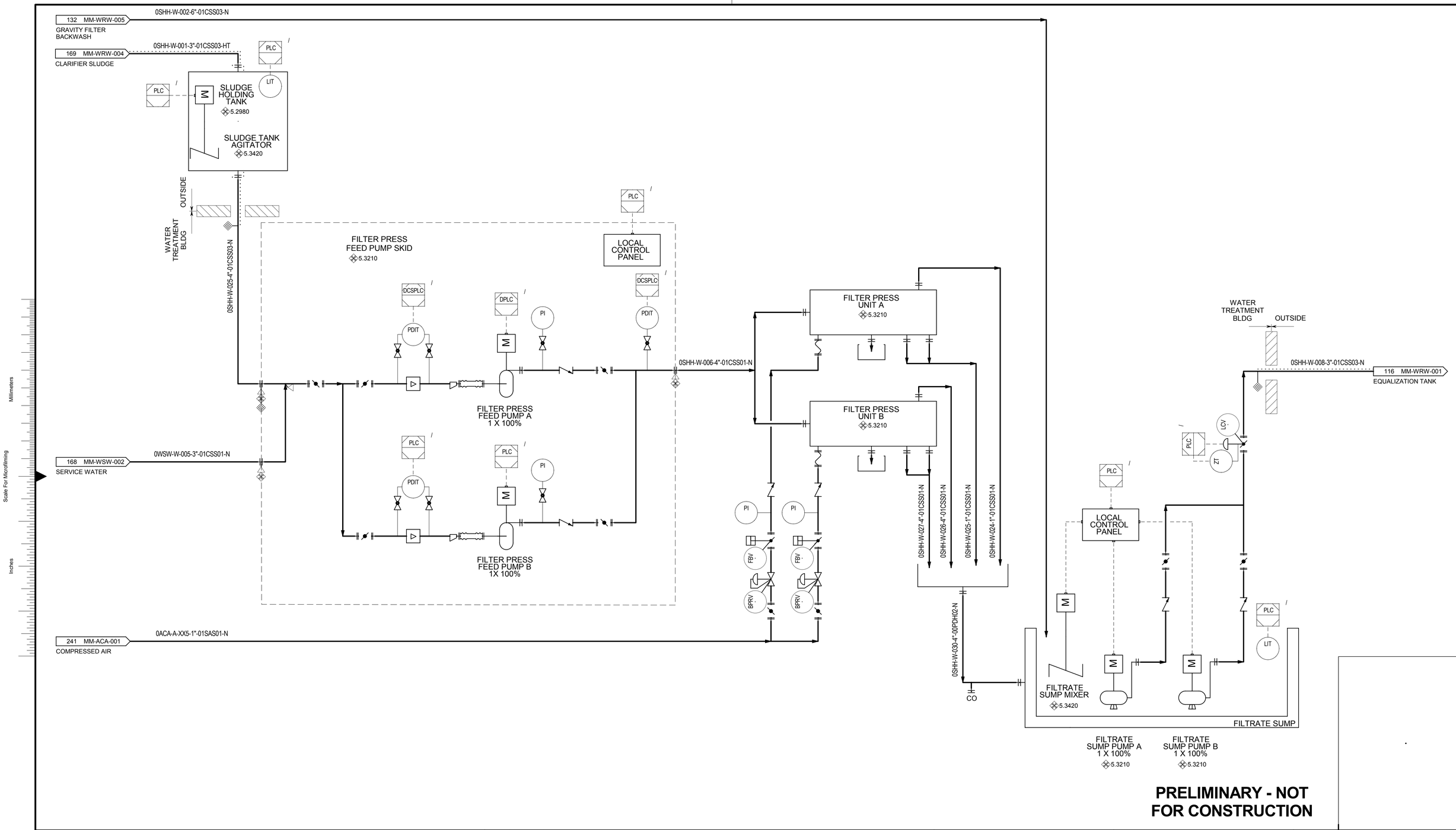
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Piping & Instrumentation Diagram
SLUDGE HANDLING

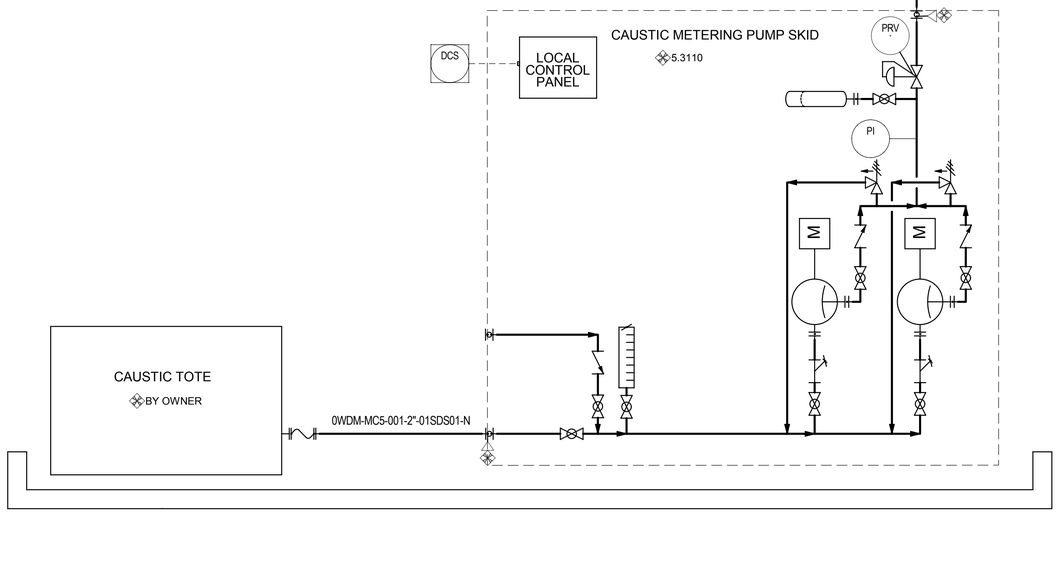
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124020	

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0WDM-M-002-1/2"-01SDS01-N

142 MM-WDM-002

UF BACKWASH

Millimeters

Inches

Scale For Microfilming

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Piping & Instrumentation Diagram
DEMINERALIZED WATER

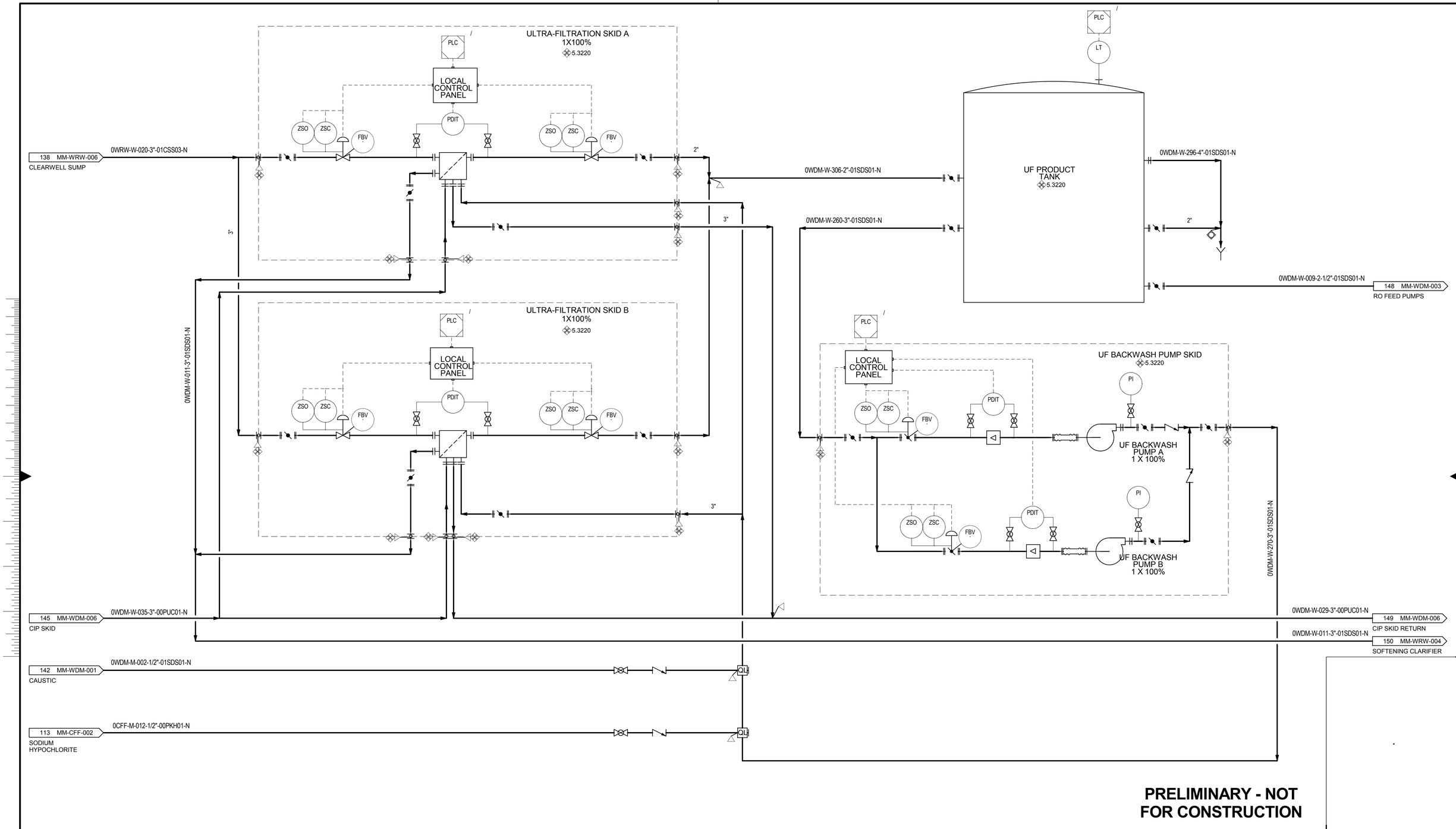
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Oliver County, ND

Piping & Instrumentation Diagram
DEMINERALIZED WATER

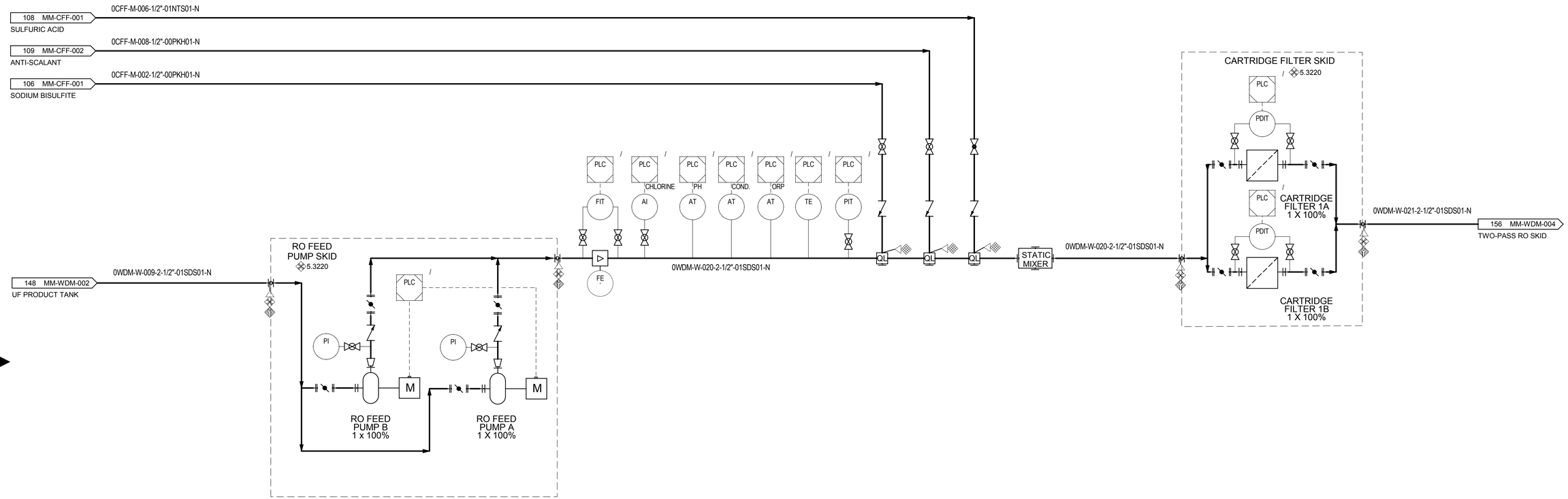
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Scale For Microfilming
Millimeters
Inches

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Piping & Instrumentation Diagram
DEMINERALIZED WATER

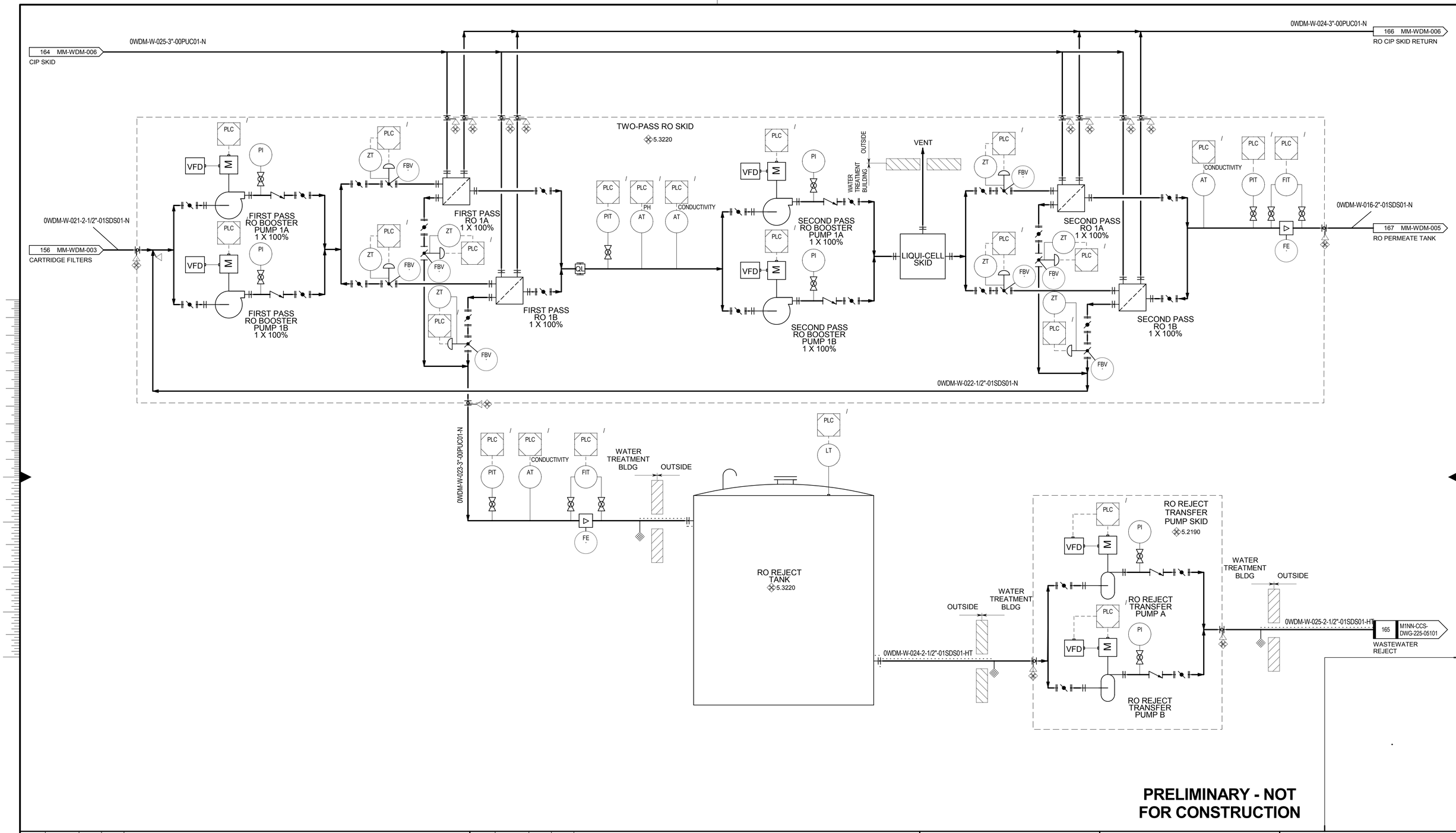
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Inches

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DEMINERALIZED WATER

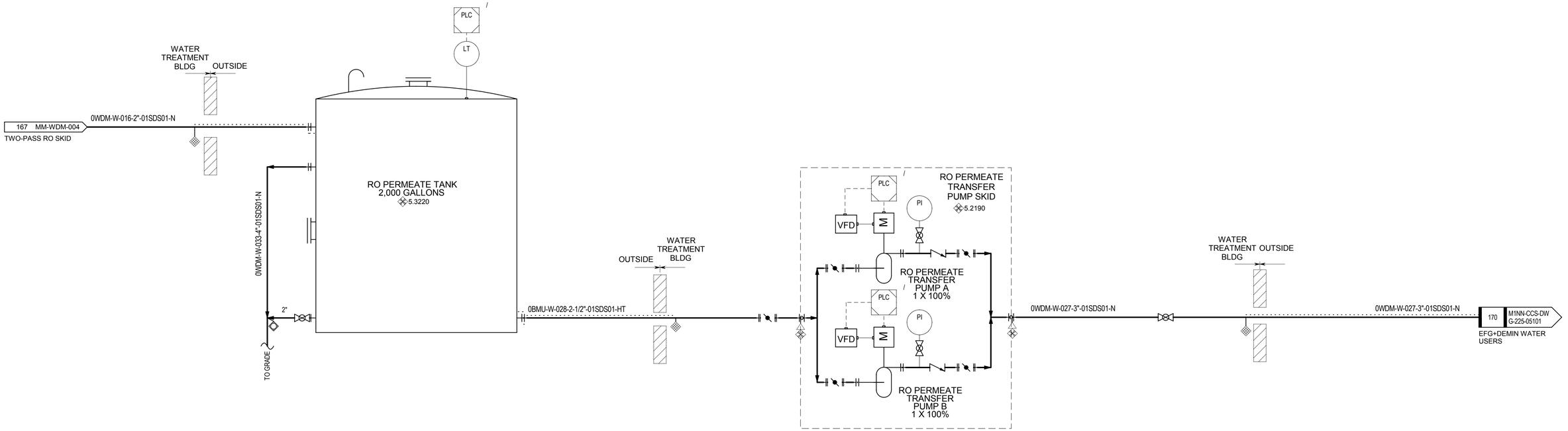
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Millimeters

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Inches

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Oliver County, ND

Piping & Instrumentation Diagram
DEMINERALIZED WATER

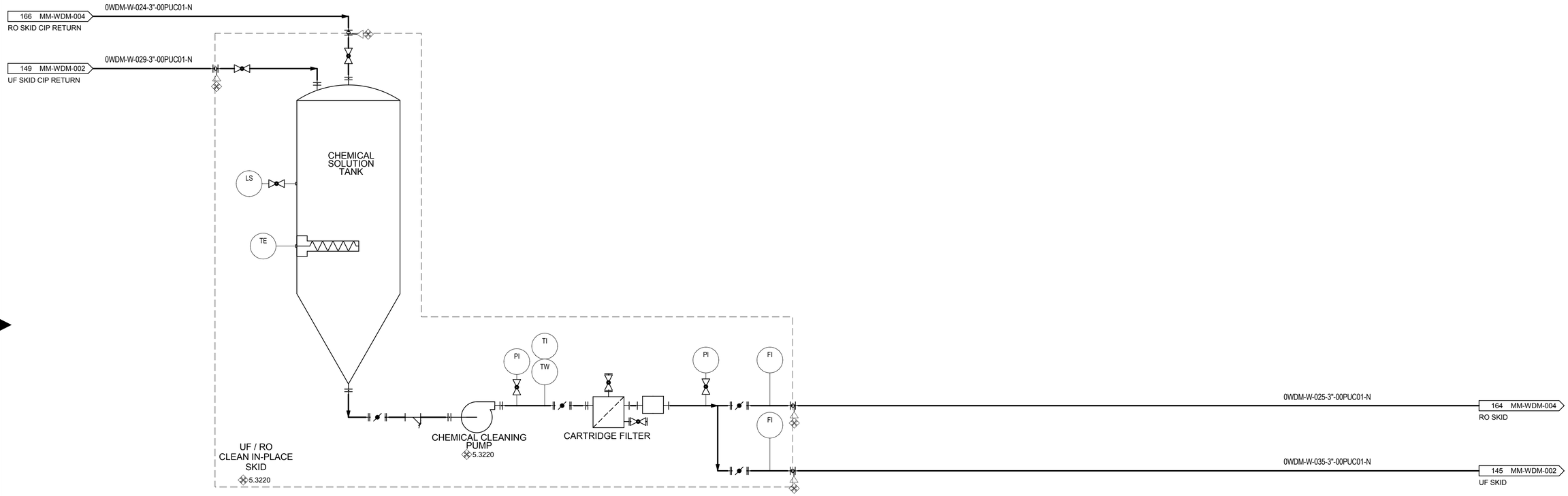
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Millimeters
Inches
Scale For Microfilming

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Oliver County, ND

Piping & Instrumentation Diagram
DEMINERALIZED WATER

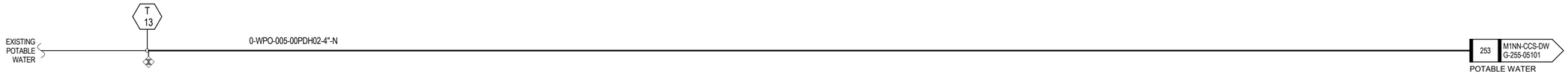
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Millimeters

Scale For Microfilming

Inches

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Oliver County, ND

Piping & Instrumentation Diagram
POTABLE WATER

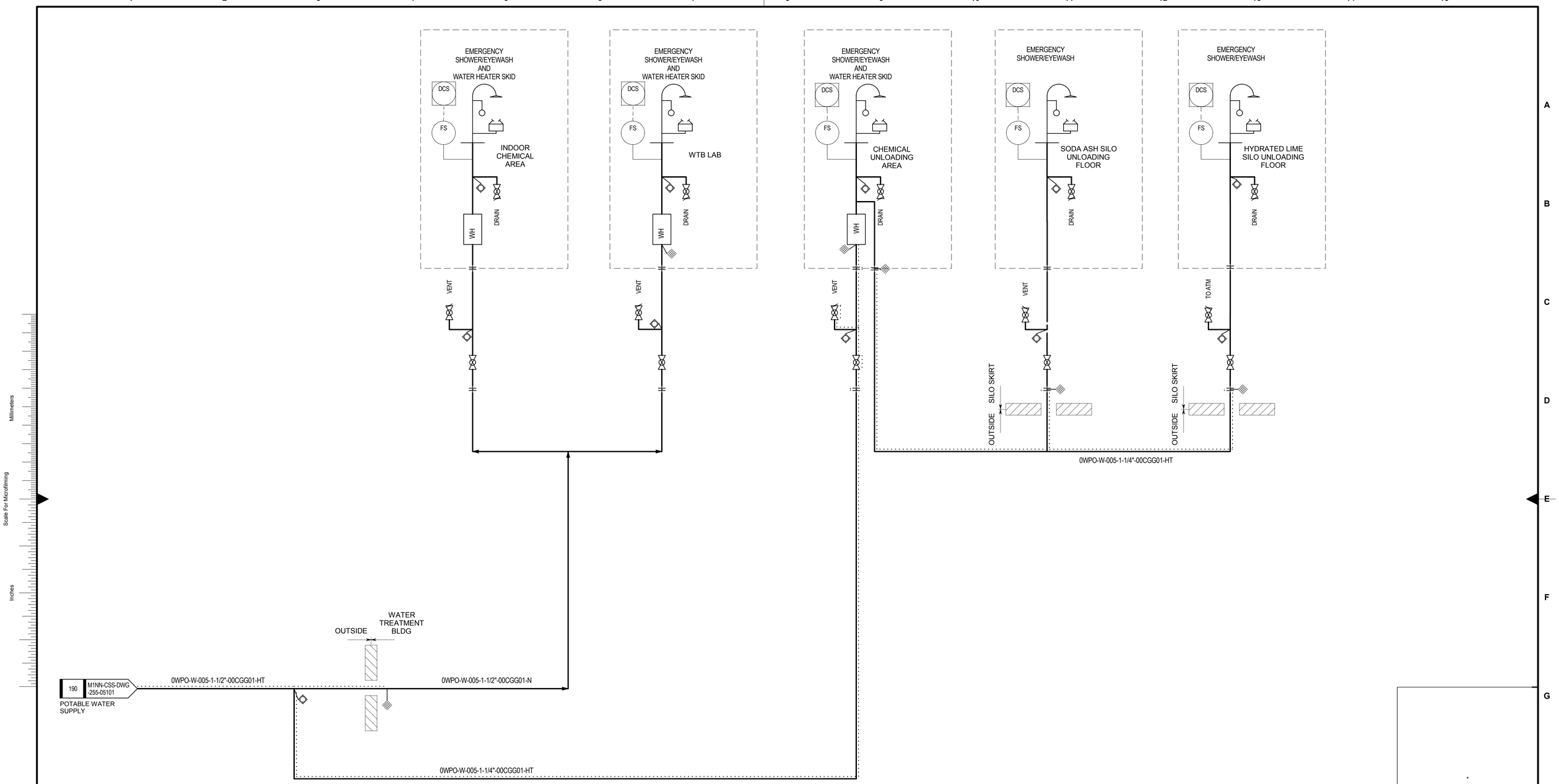
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FEED STUDY

Oliver County, ND

Piping & Instrumentation Diagram
POTABLE WATER

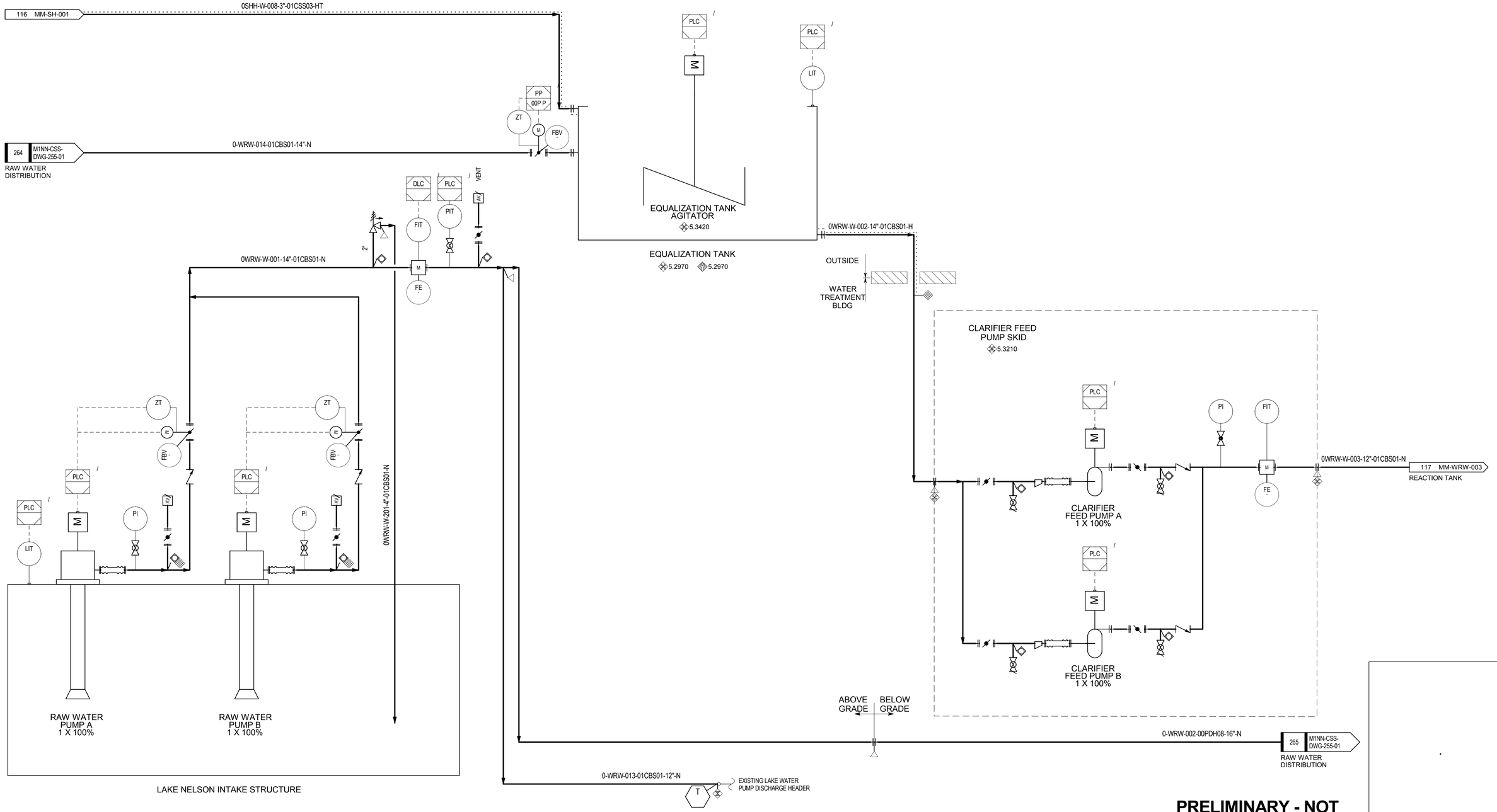
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FEED STUDY

Oliver County, ND

Piping & Instrumentation Diagram
Raw Water Softening Treatment System

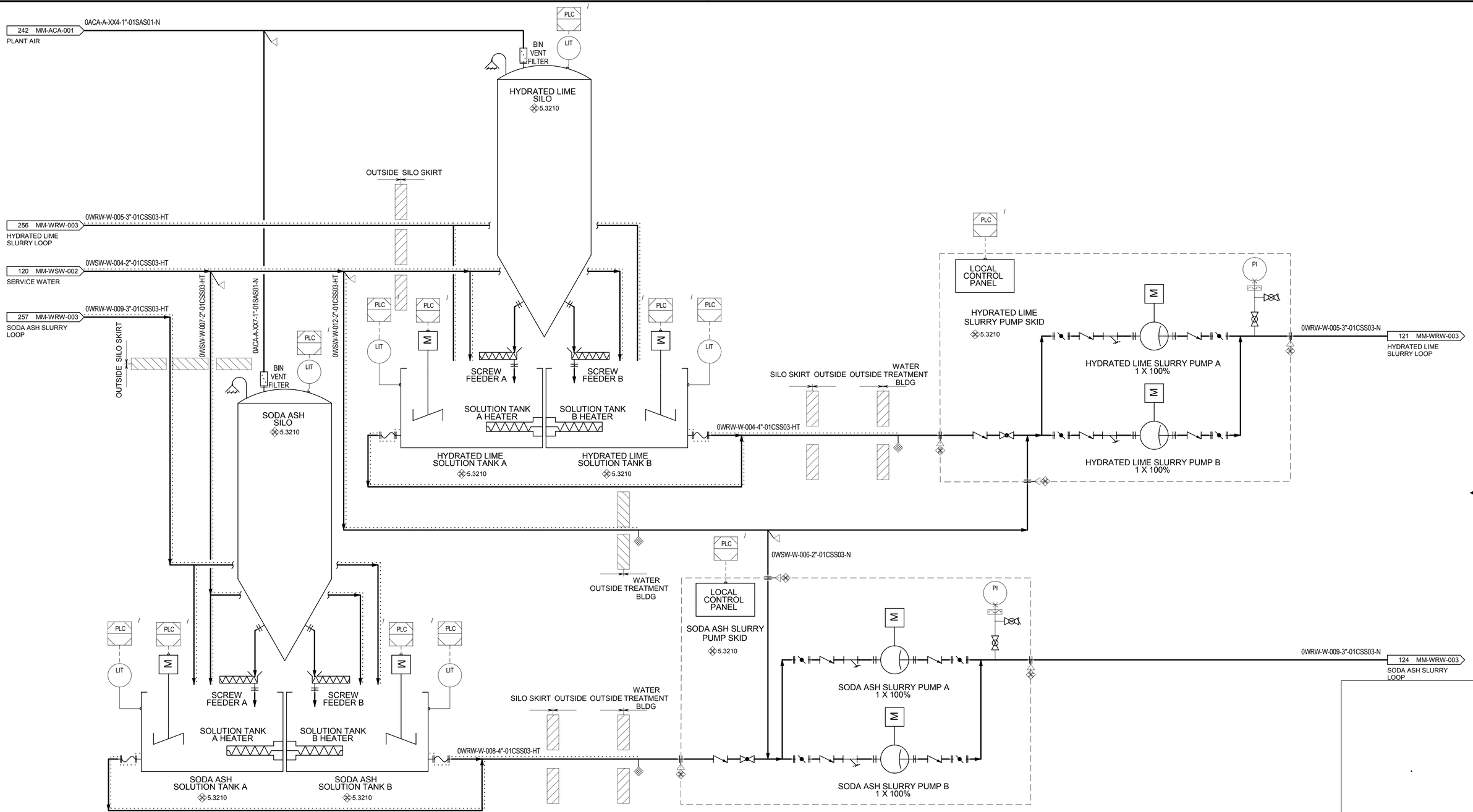
project 124020 | contract

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FEED STUDY

Oliver County, ND

Piping & Instrumentation Diagram
Raw Water Softening Treatment System

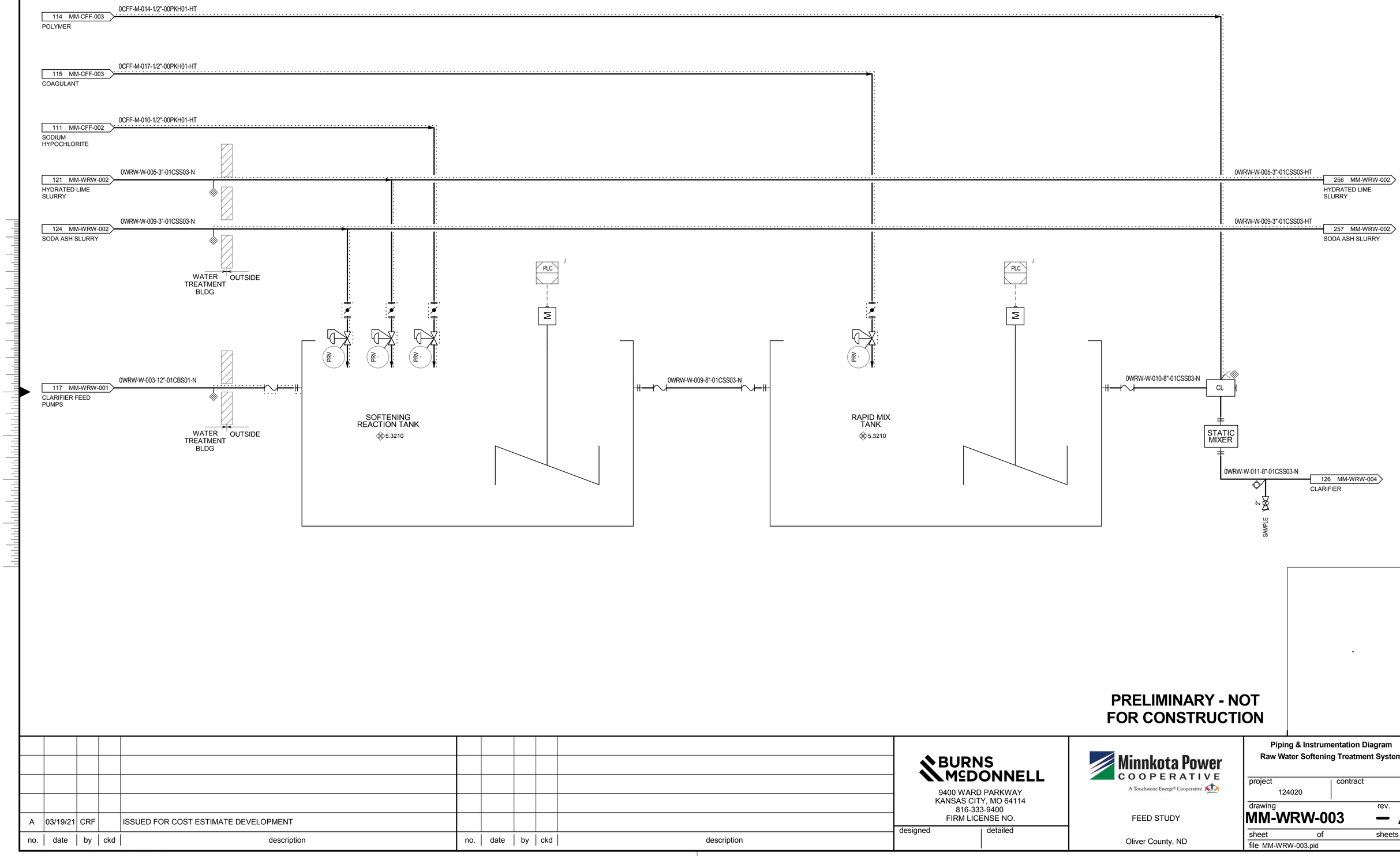
project	contract
124020	

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sheet of sheets

file MM-WRW-002.pid

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Millimeters
Inches
Scale For Microfilming

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FEED STUDY

Oliver County, ND

Piping & Instrumentation Diagram
Raw Water Softening Treatment System

project 124020 | contract

drawing **MM-WRW-003** | rev. **– A**

sheet | of | sheets

file MM-WRW-003.pid

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252 MM-CFF-001
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0CFF-M-005-1/2"-01NTS01-HT

150 MM-WDM-002
UF REJECT

0WDM-W-011-3"-01SDS01-N

126 MM-WRW-003
RAPID MIX TANK

0WRW-W-011-8"-01CSS03-N

PLC

M

CLARIFIER RAKE

HIGH RATE
CLARIFIER
5.3210

0WRW-W-014-10"-01CSS03-N

CL

STATIC
MIXER

0WRW-W-015-10"-01CSS03-N

130 MM-WRW-005
GRAVITY FILTERS

2"

SAMPLE

WATER
TREATMENT
BLDG

OUTSIDE

0WRW-W-211-2"-01CSS03-N

0WRW-W-209-2"-01CSS03-N

0WRW-W-210-2"-01CSS03-N

CLARIFIER SLUDGE
RECIRCULATING PUMP SKID
5.3210

FIT

FE

PI

CLARIFIER SLUDGE
RECIRCULATION PUMP A
1 X 100%

CLARIFIER SLUDGE
RECIRCULATION PUMP B
1 X 100%

CLARIFIER SLUDGE
RECIRCULATING PUMP SKID
5.3210

CLARIFIER SLUDGE
BLOWDOWN PUMP A
1 X 100%

CLARIFIER SLUDGE
BLOWDOWN PUMP B
1 X 100%

WATER
TREATMENT
BLDG

OUTSIDE

0SHH-W-001-3"-01CSS03-N

169 MM-SH-001
SLUDGE HOLDING
TANK

128 MM-WSW-002
SERVICE WATER

0WSW-W-001-2"-01CSS03-N

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FEED STUDY

Oliver County, ND

Piping & Instrumentation Diagram
Raw Water Softening Treatment System

project 124020 | contract

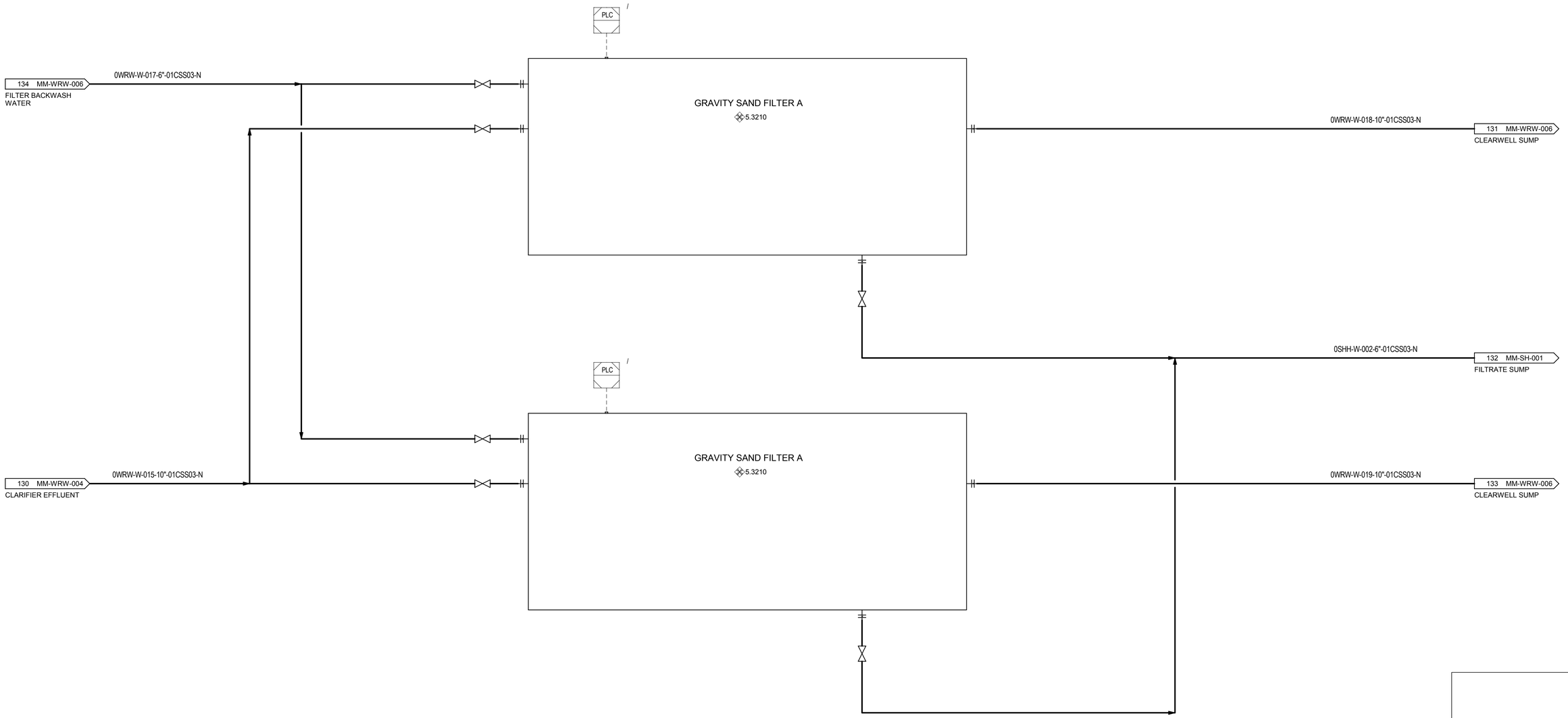
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Scale For Microfilming
Millimeters
Inches



Millimeters

Scale For Microfilming

Inches

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FEED STUDY

Oliver County, ND

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Raw Water Softening Treatment System

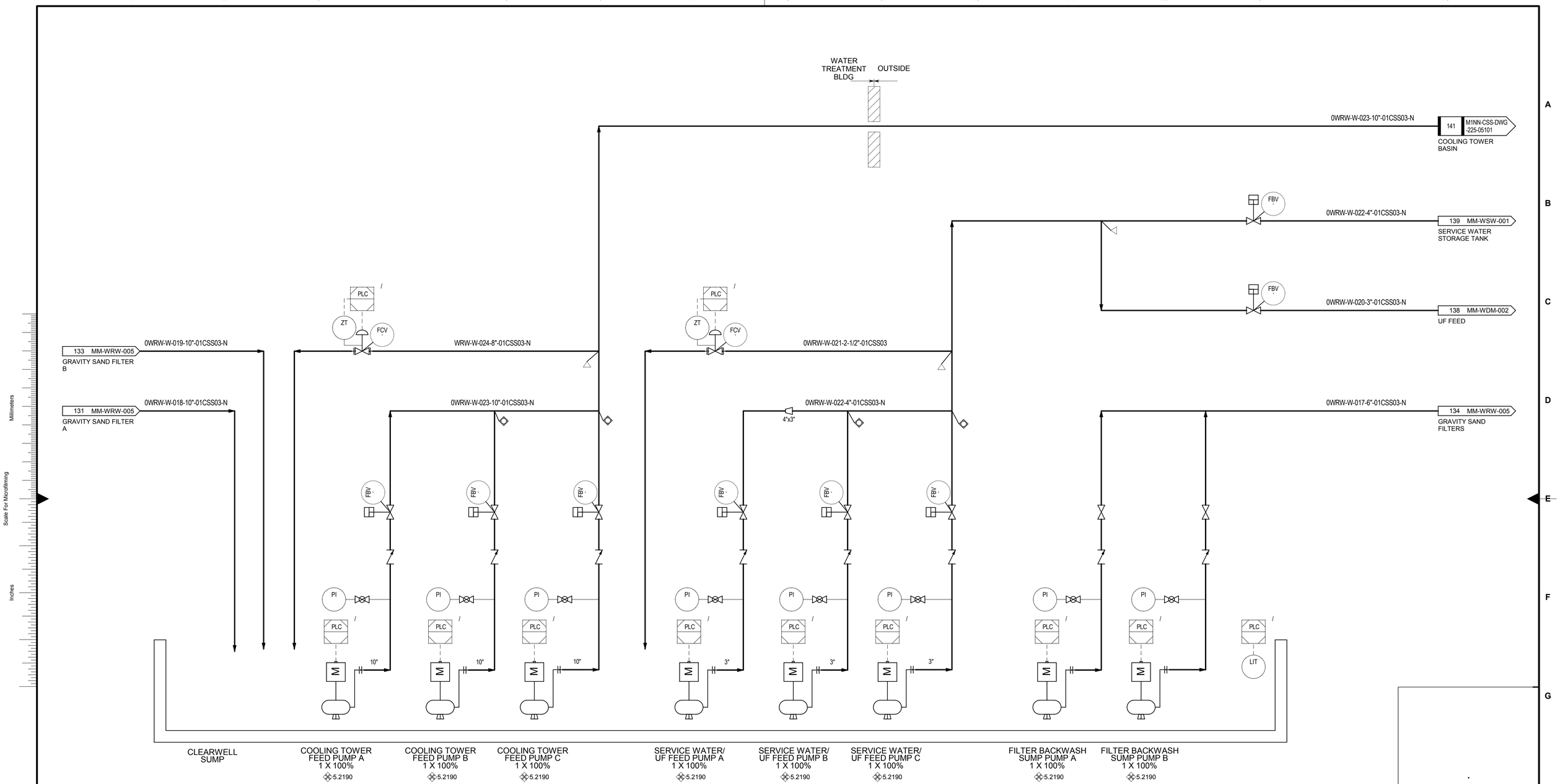
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Oliver County, ND

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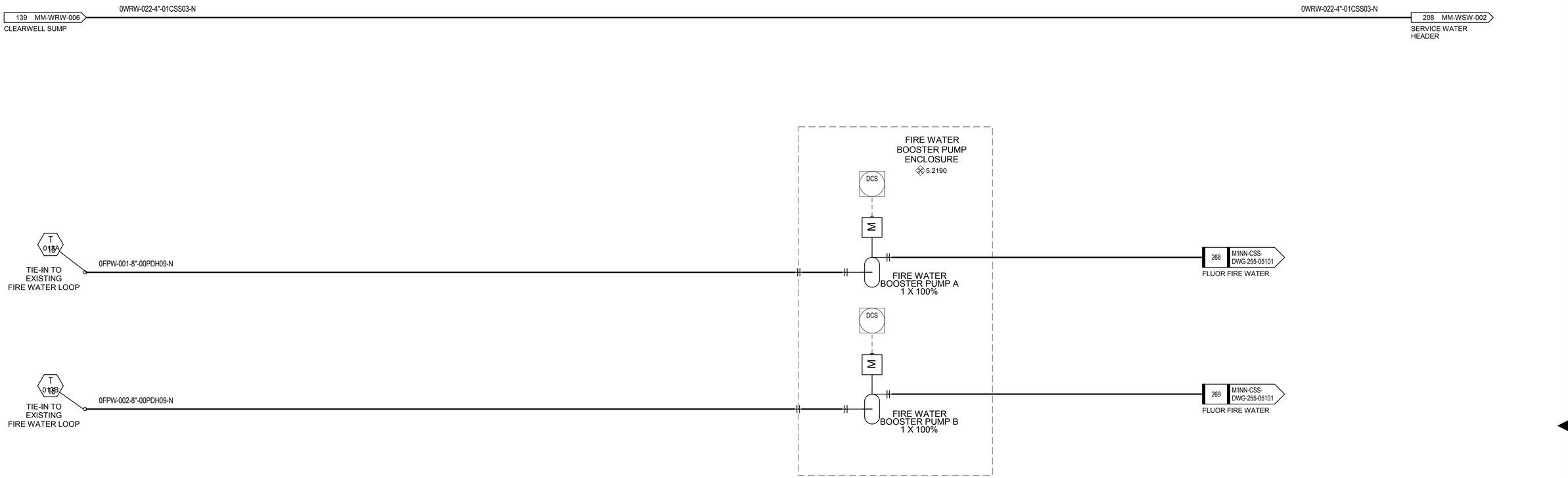
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Millimeters

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FEED STUDY

Oliver County, ND

Piping & Instrumentation Diagram
SERVICE WATER

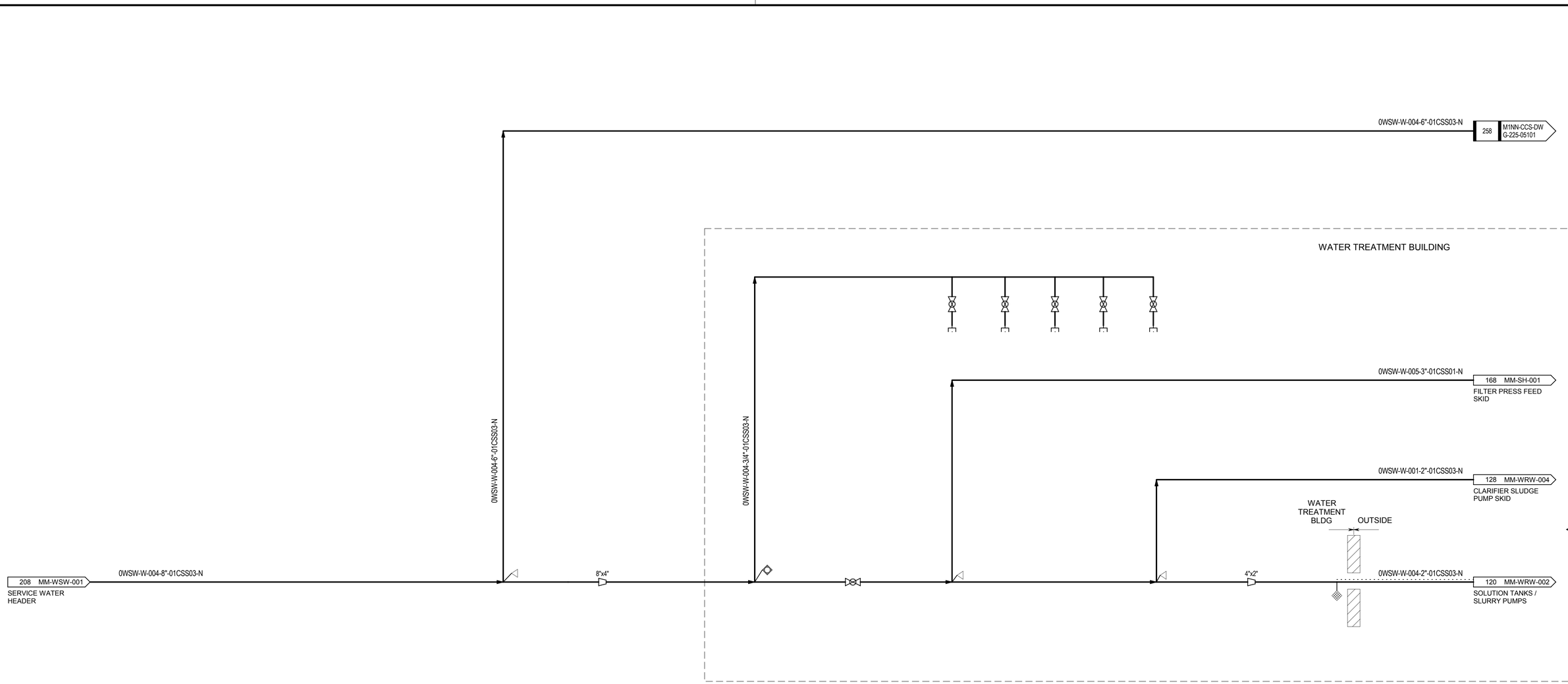
project	contract
124020	

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SERVICE WATER

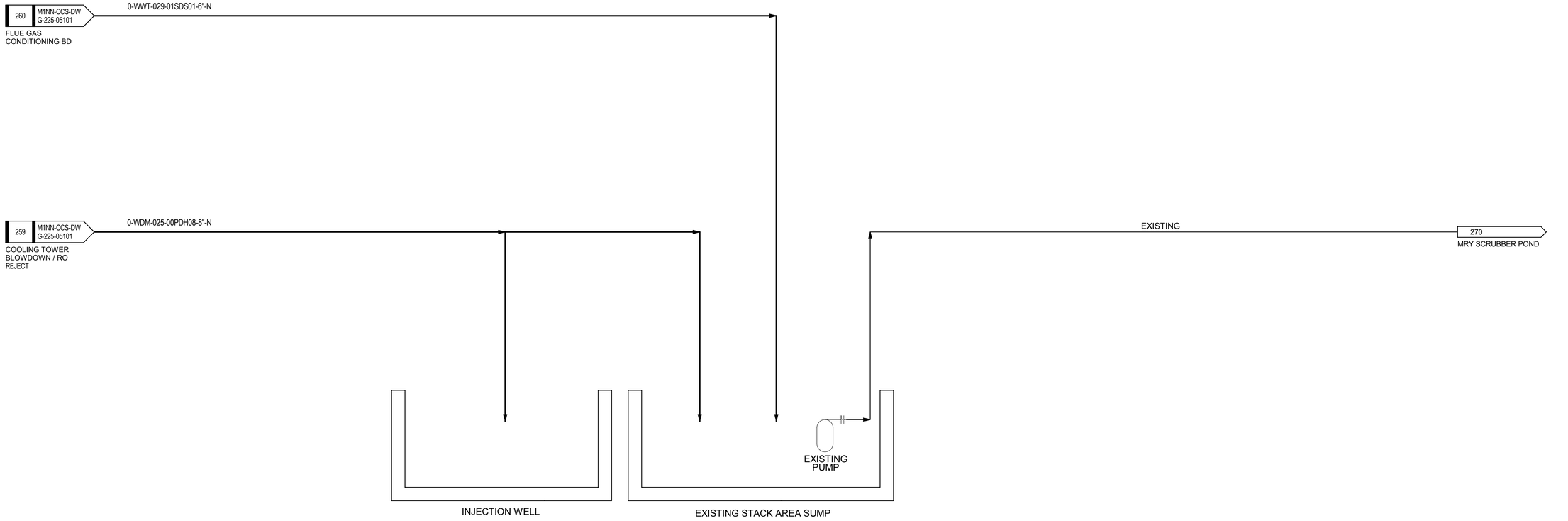
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Oliver County, ND

Piping & Instrumentation Diagram
WASTEWATER TREATMENT

project 124020 | contract

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sheet | of | sheets

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ATTACHMENT 22 – MAJOR EQUIPMENT LIST

Equipment List

Minnkota Power Co-Operative

Project Tundra

Project Number: 124020

Rev: C

PRELIMINARY - NOT FOR CONSTRUCTION

Supply Contract	Tag Number	Equipment Name/Description	Skid Number (Package Area)	Motor Rating / Rated Load	Rating Units	Driver	Rated Voltage	Full Load Current (note 1)	Insulation (Y/N)	Insulation Thickness (in)	Installation Contract	Wiring Contract (note 1)	P&ID Drawing (note 1)	General Arrangement (note 1)	Notes
5.2970		EQUALIZATION TANK									5.2970	N/A			200,000 gallons
5.3210		CLARIFIER FEED PUMP SKID									5.8320	N/A			
5.3210		CLARIFIER FEED PUMP A		100	HP	MOTOR	480				5.3210	5.8410			
5.3210		CLARIFIER FEED PUMP B		100	HP	MOTOR	480				5.3210	5.8410			
5.3210		HIGH RATE SOFTENER/CLARIFIER									5.2970	N/A			
5.3210		CLARIFIER RAKE		.75	HP	MOTOR	480				5.8320	5.8410			
5.3210		RAPID MIX TANK AGITATOR		1	HP	VFD	480				5.8320	5.8410			
5.3210		REACTION TANK									5.8320	N/A			
5.3210		REACTION TANK AGITATOR		5	HP	VFD	480				5.8320	5.8410			
5.3210		SLUDGE RECIRCULATION PUMP SKID									5.8320	N/A			
5.3210		SLUDGE RECIRCULATION PUMP A		5	HP	MOTOR	480				5.3210	5.8410			
5.3210		SLUDGE RECIRCULATION PUMP B		5	HP	MOTOR	480				5.3210	5.8410			
5.3210		SLUDGE BLOWDOWN PUMP SKID									5.8320	N/A			
5.3210		SLUDGE BLOWDOWN PUMP A		10	HP	MOTOR	480				5.3210	5.8410			
5.3210		SLUDGE BLOWDOWN PUMP A		10	HP	MOTOR	480				5.3210	5.8410			
5.3210		SODA ASH SILO									5.8320	N/A			
5.3210		PNEUMATIC CONVEYING UNLOADING STATION									5.3210	5.8410			
5.3210		BIN VENT FILTER with FAN		3	HP	MOTOR	480				5.3210	5.8410			
5.3210		BIN ACTIVATOR		1	HP	MOTOR	480				5.3210	5.8410			
5.3210		VOLUMETRIC SCREW FEEDER A		1	HP	MOTOR	480				5.3210	5.8410			
5.3210		VOLUMETRIC SCREW FEEDER B		1	HP	MOTOR	480				5.3210	5.8410			
5.3210		SOLUTION TANK W/ MIXER A		0.5	HP	MOTOR	120				5.3210	5.8410			
5.3210		SOLUTION TANK W/ MIXER B		0.5	HP	MOTOR	120				5.3210	5.8410			
5.3210		SOLUTION TANK A HEATER		12	KW	ELECTRIC	480				5.3210	5.8410			
5.3210		SOLUTION TANK B HEATER		12	KW	ELECTRIC	480				5.3210	5.8410			
5.3210		UNLOADING FLOOR EXHAUST FAN		.25	KW	ELECTRIC	120				5.3210	5.8410			
5.3210		UNLOADING FLOOR SPACE HEATER		10	KW	ELECTRIC	480				5.3210	5.8410			
5.3210		SODA ASH SLURRY PUMP SKID									5.8320	N/A			
5.3210		SODA ASH SLURRY PUMP A		10	HP	MOTOR	480				5.3210	5.8410			
5.3210		SODA ASH SLURRY PUMP B		10	HP	MOTOR	480				5.3210	5.8410			
5.3210		HYDRATED LIME SILO									5.8320	N/A			
5.3210		PNEUMATIC CONVEYING UNLOADING STATION									5.3210	5.8410			
5.3210		BIN VENT FILTER with FAN		3	HP	MOTOR	480				5.3210	5.8410			
5.3210		BIN ACTIVATOR		1	HP	MOTOR	480				5.3210	5.8410			
5.3210		VOLUMETRIC SCREW FEEDER A		1	HP	MOTOR	480				5.3210	5.8410			
5.3210		VOLUMETRIC SCREW FEEDER B		1	HP	MOTOR	480				5.3210	5.8410			
5.3210		SOLUTION TANK W/ MIXER A		0.5	HP	MOTOR	120				5.3210	5.8410			
5.3210		SOLUTION TANK W/ MIXER B		0.5	HP	MOTOR	120				5.3210	5.8410			
5.3210		SOLUTION TANK A HEATER		12	KW	ELECTRIC	480				5.3210	5.8410			
5.3210		SOLUTION TANK B HEATER		12	KW	ELECTRIC	480				5.3210	5.8410			
5.3210		UNLOADING FLOOR EXHAUST FAN		.25	KW	ELECTRIC	120				5.3210	5.8410			
5.3210		UNLOADING FLOOR SPACE HEATER		10	KW	ELECTRIC	480				5.3210	5.8410			
5.3210		HYDRATED LIME SLURRY PUMP SKID									5.8320	N/A			
5.3210		HYDRATED LIME SLURRY PUMP A		10	HP	MOTOR	480				5.3210	5.8410			
5.3210		HYDRATED LIME SLURRY PUMP B		10	HP	MOTOR	480				5.3210	5.8410			
5.3210		GRAVITY SAND FILTER A									5.8320	N/A			
5.3210		GRAVITY SAND FILTER B									5.8320	N/A			
5.3210		FILTER PRESS FEED PUMP SKID									5.8320	N/A			
5.3210		FILTER PRESS FEED PUMP A		50	HP	MOTOR	480				5.3210	5.8410			
5.3210		FILTER PRESS FEED PUMP B		50	HP	MOTOR	480				5.3210	5.8410			
5.3210		RECESSED CHAMBER PLATE AND FRAME FILTER PRESS A									5.8320	N/A			
5.3210		FILTER PRESS A HYDRAULIC PUMP		7.5	HP	MOTOR	480				5.3210	5.8410			
5.3210		RECESSED CHAMBER PLATE AND FRAME FILTER PRESS B									5.8320	N/A			
5.3210		FILTER PRESS B HYDRAULIC PUMP		7.5	HP	MOTOR	480				5.3210	5.8410			
5.3220		UF SKID A									5.8320	N/A			
5.3220		UF SKID B									5.8320	N/A			
5.3220		UF SYSTEM PRODUCT TANK									5.8320	N/A			
5.3220		UF BACKWASH SKID									5.8320	N/A			
5.3220		UF BACKWASH PUMP A		5	HP	MOTOR	480				5.3220	5.8410			
5.3220		UF BACKWASH PUMP B		5	HP	MOTOR	480				5.3220	5.8410			
5.3220		REVERSE OSMOSIS (RO) FEED PUMP SKID									5.8320	N/A			
5.3220		REVERSE OSMOSIS (RO) FEED PUMP A		7.5	HP	MOTOR	480				5.3220	5.8410			
5.3220		REVERSE OSMOSIS (RO) FEED PUMP B		7.5	HP	MOTOR	480				5.3220	5.8410			
5.3220		2-PASS RO SKID A									5.8320	N/A			
5.3220		FIRST PASS RO BOOSTER PUMP A		25	HP	VFD	480				5.3220	5.8410			
5.3220		LIQUID-CELL UNIT A									5.3220	N/A			
5.3220		SECOND PASS RO BOOSTER PUMP A		20	HP	VFD	480				5.3220	5.8410			
5.3220		2-PASS RO SKID B									5.8320	N/A			
5.3220		FIRST PASS RO BOOSTER PUMP B		25	HP	VFD	480				5.3220	5.8410			
5.3220		LIQUID-CELL UNIT B									5.3220	N/A			
5.3220		SECOND PASS RO BOOSTER PUMP B		20	HP	VFD	480				5.3220	5.8410			
5.3220		CARTRIDGE FILTER SKID									5.8320	N/A			
5.3220		CLEAN-IN-PLACE SKID									5.8320	N/A			
5.3220		CIP PUMP		7.5	HP	MOTOR	480				5.3220	5.8410			
5.3220		CIP HEATER		20	KW	ELECTRIC	480				5.3220	5.8410			
5.3220		RO REJECT TANK									5.8320	N/A			1x100%, 8,000 gallons
5.3220		RO SYSTEM PERMEATE TANK									5.8320	N/A			1x100% 8,000 gallons
5.3220		RO SULFURIC ACID PUMP SKID									5.8320	N/A			2x100%
5.3220		RO SULFURIC ACID FEED PUMP A		0.5	HP	MOTOR	120				5.3220	5.8410			
5.3220		RO SULFURIC ACID FEED PUMP B		0.5	HP	MOTOR	120				5.3220	5.8410			
5.3210		SULFURIC ACID PUMP SKID									5.8320	N/A			2x100%
5.3210		SULFURIC ACID FEED PUMP A		0.5	HP	MOTOR	120				5.3210	5.8410			
5.3210		SULFURIC ACID FEED PUMP B		0.5	HP	MOTOR	120				5.3210	5.8410			

Equipment List

Minnkota Power Co-Operative

Project Tundra

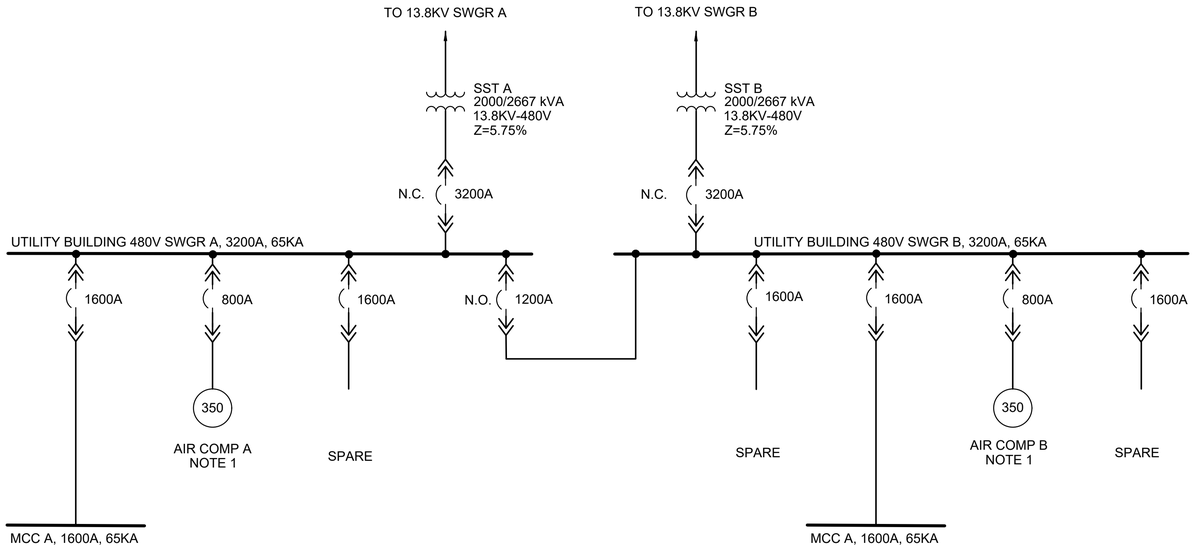
Project Number: 124020

Rev: C

PRELIMINARY - NOT FOR CONSTRUCTION

Supply Contract	Tag Number	Equipment Name/Description	Skid Number (Package Area)	Motor Rating / Rated Load	Rating Units	Driver	Rated Voltage	Full Load Current (note 1)	Insulation (Y/N)	Insulation Thickness (in)	Installation Contract	Wiring Contract (note 1)	P&ID Drawing (note 1)	General Arrangement (note 1)	Notes
5.3210		SODIUM HYPOCHLORITE FEED SKID									5.8320	N/A			
5.3210		SODIUM HYPOCHLORITE FEED PUMP A		0.5	HP	MOTOR	120				5.3210	5.8410			
5.3210		SODIUM HYPOCHLORITE FEED PUMP B		0.5	HP	MOTOR	120				5.3210	5.8410			
5.3220		CEB SODIUM HYPOCHLORITE FEED SKID									5.8320	N/A			
5.3220		CEB SODIUM HYPOCHLORITE FEED PUMP A		0.5	HP	MOTOR	120				5.3220	5.8410			
5.3220		CEB SODIUM HYPOCHLORITE FEED PUMP B		0.5	HP	MOTOR	120				5.3220	5.8410			
5.3210		COAGULANT METERING PUMP SKID									5.8320	N/A			
5.3210		COAGULANT METERING PUMP A		0.5	HP	MOTOR	120				5.3210	5.8410			
5.3210		COAGULANT METERING PUMP B		0.5	HP	MOTOR	120				5.3210	5.8410			
5.3210		POLYMER METERING PUMP SKID									5.8320	N/A			
5.3210		POLYMER METERING PUMP A		0.5	HP	MOTOR	120				5.3210	5.8410			
5.3210		POLYMER METERING PUMP B		0.5	HP	MOTOR	120				5.3210	5.8410			
5.3220		SODIUM BI-SULFITE METERING PUMP SKID									5.8320	N/A			
5.3220		SODIUM BI-SULFITE METERING PUMP A		0.5	HP	MOTOR	120				5.3220	5.8410			
5.3220		SODIUM BI-SULFITE METERING PUMP B		0.5	HP	MOTOR	120				5.3220	5.8410			
5.3220		ANTISCALANT METERING PUMP SKID									5.8320	N/A			
5.3220		ANTISCALANT METERING PUMP A		0.5	HP	MOTOR	120				5.3220	5.8410			
5.3220		ANTISCALANT METERING PUMP B		0.5	HP	MOTOR	120				5.3220	5.8410			
5.3220		CAUSTIC METERING PUMP SKID									5.8320	N/A			
5.3220		CAUSTIC METERING PUMP A		0.5	HP	MOTOR	120				5.3220	5.8410			
5.3220		CAUSTIC METERING PUMP B		0.5	HP	MOTOR	120				5.3220	5.8410			
5.8110		CLEARWELL SUMP									5.8110	N/A			47,000 gallons
5.8110		FILTRATE SUMP									5.8110	N/A			10,000 gallons
5.2190		SERVICE WATER TRANSFER PUMP / UF FEED PUMP A		20	HP	MOTOR	480				5.8320	5.8410			3x50% pumps, 300 gpm, Submersibles
5.2190		SERVICE WATER TRANSFER PUMP / UF FEED PUMP B		20	HP	MOTOR	480				5.8320	5.8410			3x50% pumps, 300 gpm, Submersibles
5.2190		SERVICE WATER TRANSFER PUMP / UF FEED PUMP C		20	HP	MOTOR	480				5.8320	5.8410			3x50% pumps, 300 gpm, Submersibles
5.2190		COOLING TOWER FEED PUMP A		100	HP	MOTOR	480				5.8320	5.8410			3x50% pumps, 2,500gpm, Submersibles
5.2190		COOLING TOWER FEED PUMP B		100	HP	MOTOR	480				5.8320	5.8410			3x50% pumps, 2,500gpm, Submersibles
5.2190		COOLING TOWER FEED PUMP C		100	HP	MOTOR	480				5.8320	5.8410			3x50% pumps, 2,500gpm, Submersibles
5.2190		FILTER BACKWASH PUMP A (1X100%)		30	HP	MOTOR	480				5.8320	5.8410			2x100% pumps, 1,700 gpm, Submersibles
5.2190		FILTER BACKWASH PUMP B (1X100%)		30	HP	MOTOR	480				5.8320	5.8410			2x100% pumps, 1,700 gpm, Submersibles
5.2190		FILTRATE SUMP PUMP A		25	HP	MOTOR	480				5.8320	5.8410			2x100% pumps, 1,000 gpm, Submersibles
5.2190		FILTRATE SUMP PUMP B		25	HP	MOTOR	480				5.8320	5.8410			2x100% pumps, 1,000 gpm, Submersibles
5.2190		RO REJECT TRANSFER PUMP SKID									5.8320	N/A			2x100%, 25 gpm
5.2190		RO REJECT TRANSFER PUMP A		15	HP	MOTOR	480				5.2190	5.8410			
5.2190		RO REJECT TRANSFER PUMP B		15	HP	MOTOR	480				5.2190	5.8410			
5.2190		RO PERMEATE TRANSFER PUMP SKID									5.8320	N/A			2x100%, 125 gpm
5.2190		RO PERMEATE TRANSFER PUMP A		25	HP	MOTOR	480				5.2190	5.8410			
5.2190		RO PERMEATE TRANSFER PUMP B		25	HP	MOTOR	480				5.2190	5.8410			
5.2150		FIRE WATER BOOSTER PUMP A		200	HP	MOTOR	480				5.8320	5.8410			Shop installed in a pre-fab enclosure
5.2150		FIRE WATER BOOSTER PUMP B		200	HP	MOTOR	480				5.8320	5.8410			Shop installed in a pre-fab enclosure
5.2190		LAKE NELSON INTAKE PUMP A		500	HP	MOTOR	4,160				5.8320	5.8410			
5.2190		LAKE NELSON INTAKE PUMP B		500	HP	MOTOR	4,160				5.8320	5.8410			
5.2980		SULFURIC ACID STORAGE TANK									5.8320	N/A			8,000 gallons
5.2980		SODIUM HYPOCHLORITE STORAGE TANK									5.8320	N/A			15,000 gallons
5.8320		SODIUM HYPOCHLORITE TANK IMMERSION HEATER		4	KW	ELECTRIC	480				5.8320	5.8410			
5.2980		COAGULANT STORAGE TANK									5.8320	N/A			8,000 gallons
5.8320		COAGULANT TANK IMMERSION HEATER		4	KW	ELECTRIC	480				5.8320	5.8410			
5.2980		SLUDGE STORAGE TANK									5.8320	N/A			12,000 gallons
5.2980		DRY AIR RECIEVER									5.8320	N/A			
5.3420		SLUDGE STORAGE TANK AGITATOR		10	HP	MOTOR	480				5.8320	5.8410			
5.3420		FILTRATE SUMP AGITATOR		5	HP	MOTOR	480				5.8320	5.8410			
5.8320		COAGULANT TANK TRUCK UNLOADING PANEL		.3	KVA	ELECTRIC	120				5.8320	5.8410			
5.8320		SODIUM HYPOCHLORITE TANK TRUCK UNLOADING PANEL		.3	KVA	ELECTRIC	120				5.8320	5.8410			
5.8320		SULFURIC ACID TANK TRUCK UNLOADING PANEL		.3	KVA	ELECTRIC	120				5.8320	5.8410			
5.8320		SODA ASH SILO TRUCK UNLOADING PANEL		.3	KVA	ELECTRIC	120				5.8320	5.8410			
5.8320		HYDRATED LIME SILO TRUCK UNLOADING PANEL		.3	KVA	ELECTRIC	120				5.8320	5.8410			
5.8320		INDOOR EMERGENCY EYE WASH / SHOWER STATIONS SKID WITH WATER HEATER		6	kW	ELECTRIC	480				5.8320	5.8410			HAWS MODEL 8760
5.8320		INDOOR EMERGENCY EYE WASH / SHOWER STATIONS SKID WITH WATER HEATER		6	kW	ELECTRIC	480				5.8320	5.8410			HAWS MODEL 8760
5.8320		INDOOR EMERGENCY EYE WASH / SHOWER STATION									5.8320	5.8410			HAWS MODEL 8320
5.8320		INDOOR EMERGENCY EYE WASH / SHOWER STATION									5.8320	5.8410			HAWS MODEL 8320
5.8320		OUTDOOR EMERGENCY EYE WASH / SHOWER STATIONS SKID WITH WATER HEATER		8	kW	ELECTRIC	480				5.8320	5.8410			HAWS MODEL 8710
OWNER		POLYMER CHEMICAL TOTE													1x100%, 400 gallons
OWNER		SODIUM BI-SULFITE CHEMICAL TOTE													
OWNER		CAUSTIC CHEMICAL TOTE													
OWNER		ANTI-SCALANT CHEMICAL TOTE													
5.5310		SERVICE STATION TRANSFORMER A													
5.5310		SERVICE STATION TRANSFORMER B													
5.4560		UNIT 1 FLUE GAS TIE-IN ISOLATION DAMPER		5	HP	MOTOR	480				5.8320	5.8410			Power feed to come from existing power station.
5.4560		UNIT 1 ISOLATION DAMPER SEAL AIR FAN		40	HP	MOTOR	480				5.8320	5.8410			Power feed to come from existing power station.
5.4560		UNIT 2 FLUE GAS TIE-IN ISOLATION DAMPER		5	HP	MOTOR	480				5.8320	5.8410			Power feed to come from existing power station.
5.4560		UNIT 2 ISOLATION DAMPER SEAL AIR FAN		40	HP	MOTOR	480				5.8320	5.8410			Power feed to come from existing power station.
5.4220		FILTER PRESS PLATE REMOVAL BRIDGE CRANE		20	HP	MOTOR	480				5.8320	5.8410			
5.3210		SAND FILTER AIR SCOUR BLOWER SKID									5.8320	5.8410			
5.3210		SAND FILTER AIR SCOUR BLOWER A		20	HP	MOTOR	480				5.3210	5.8410			
5.3210		SAND FILTER AIR SCOUR BLOWER B		20	HP	MOTOR	480				5.3210	5.8410			

ATTACHMENT 23 – ELECTRICAL ONE LINE DIAGRAMS



NOTES:

1. AIR COMPRESSORS ARE PROVIDED BY OTHERS, MOTOR HORSEPOWERS ARE SUBJECT TO CHANGE AND WILL BE CONFIRMED AT A LATER DATE.

PRELIMINARY - NOT FOR CONSTRUCTION

no.	date	by	ckd	description
A	8/25/20	TPH	TPH	ISSUED FOR OWNER REVIEW

BURNS McDONNELL
9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.

designed T. HALLING | detailed T. HALLING

Minnkota Power COOPERATIVE
A Touchstone Energy® Cooperative

OLIVER COUNTY, ND

PROJECT TUNDRA PDR
UTILITY BUILDING
OVERALL ONE-LINE DIAGRAM

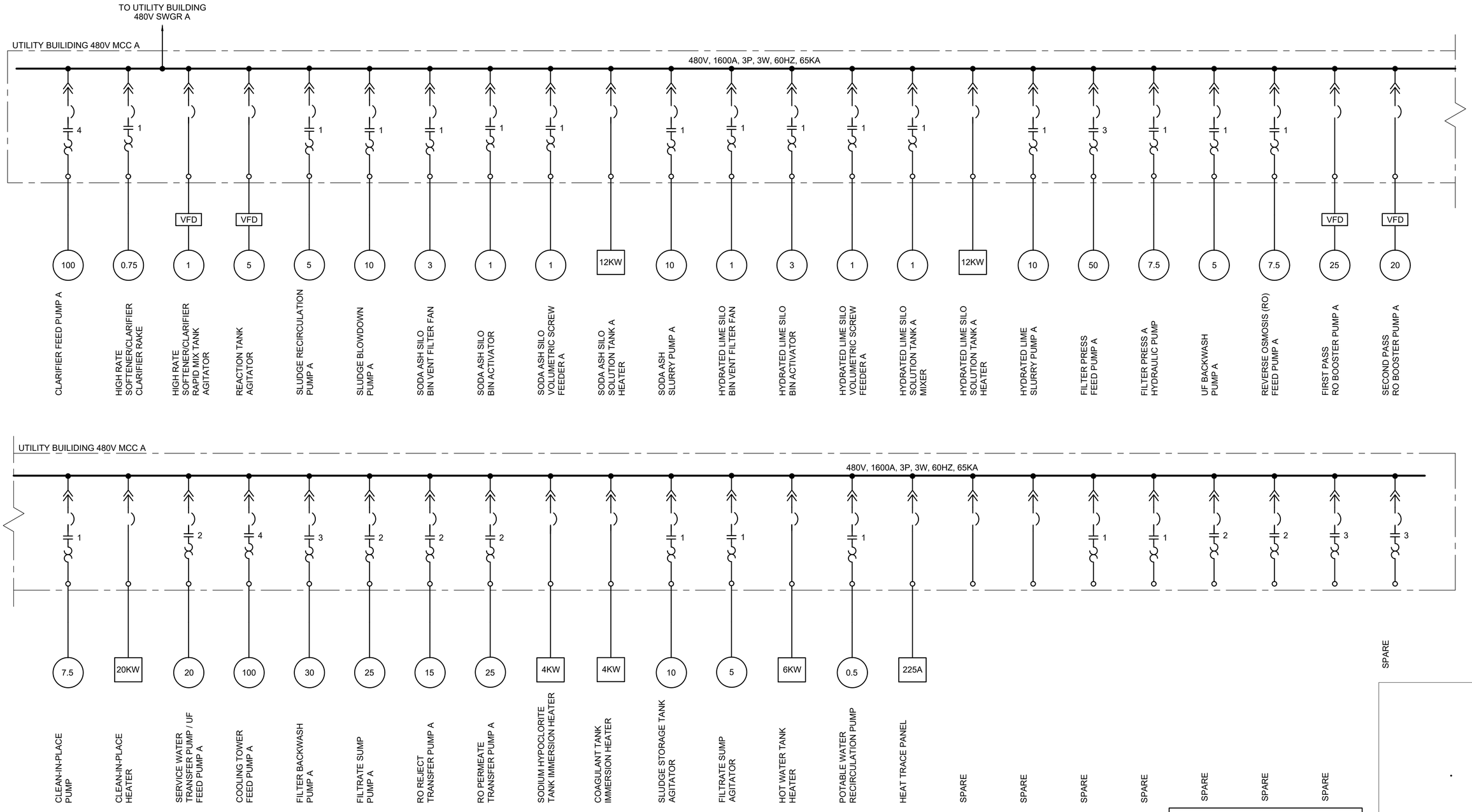
project 124020 | contract -

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sheet 1 of 1 sheets

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no.	date	by	ckd	description

BURNS McDONNELL
9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.

designed T. HALLING | detailed T. HALLING

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OLIVER COUNTY, ND

PROJECT TUNDRA PDR
UTILITY BUILDING
480V MCC A ONE-LINE

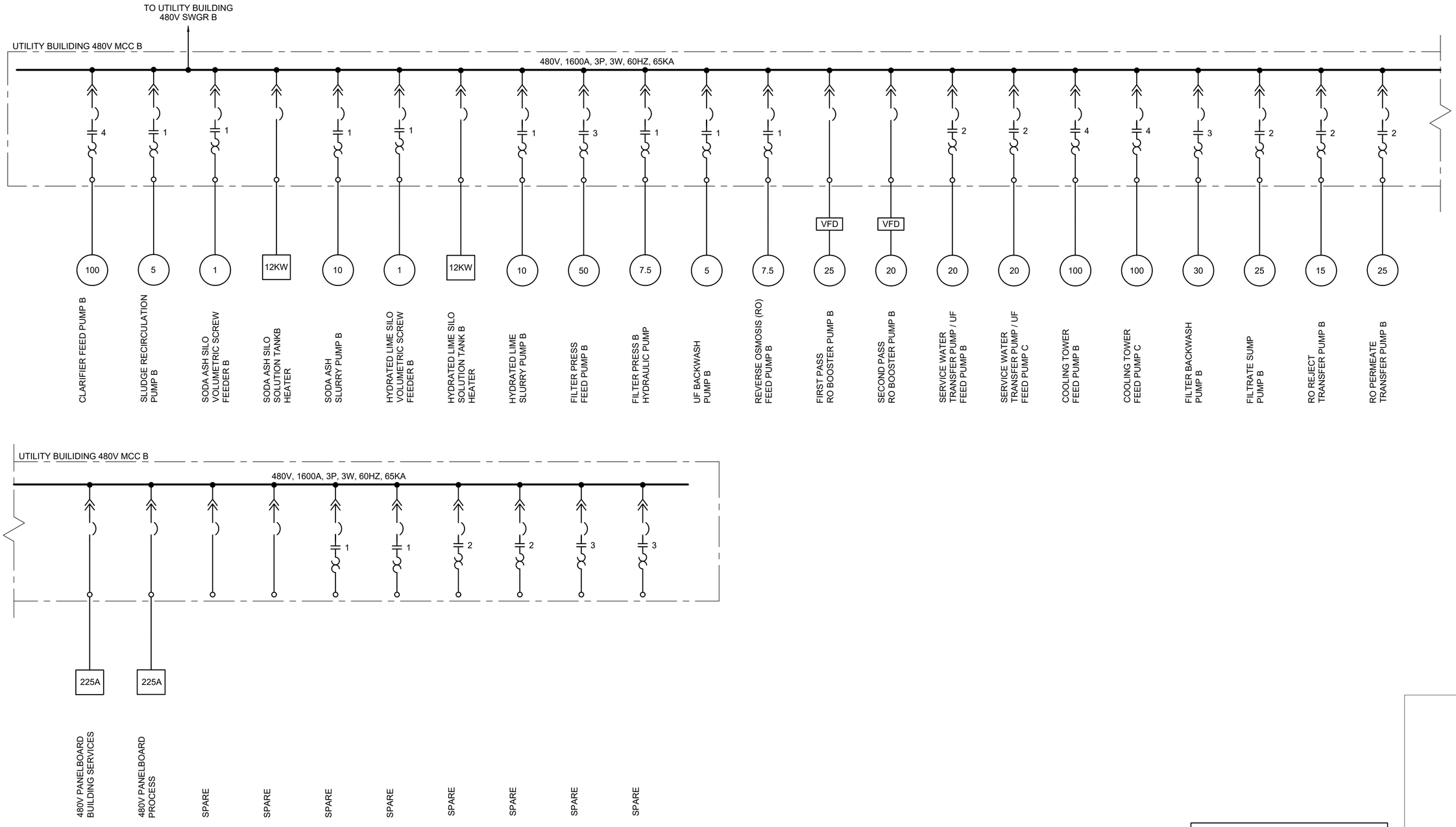
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drawing SKE-0002 | rev. A

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Scale For Microfilming
Millimeters
Inches

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no.	date	by	ckd	description
A	8/25/20	TPH	TPH	ISSUED FOR OWNER REVIEW

no.	date	by	ckd	description

BURNS McDONNELL
9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
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designed T. HALLING | detailed T. HALLING

Minnkota Power COOPERATIVE
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OLIVER COUNTY, ND

PROJECT TUNDRA PDR
UTILITY BUILDING
480V MCC B ONE-LINE

project 124020 | contract -

drawing **SKE-0003** | rev. **A**

sheet 1 of 1 sheets

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ATTACHMENT 24 – CLASS I INJECTION WELL & INFRASTRUCTURE

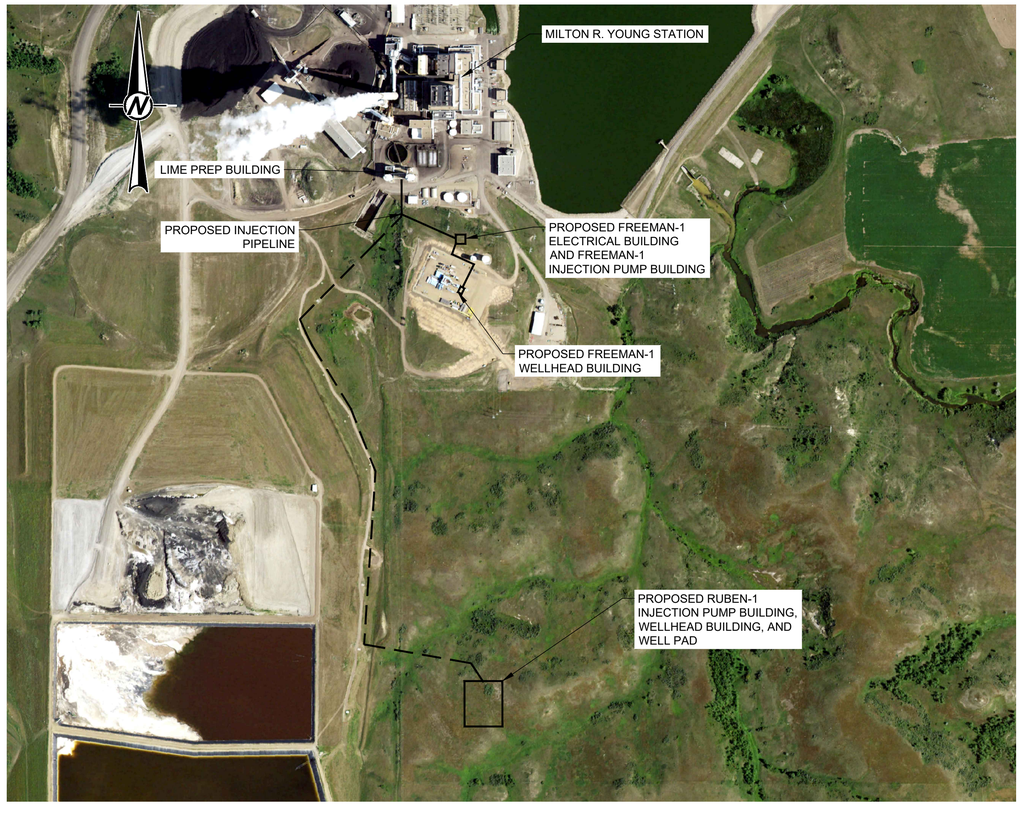
MINNKOTA POWER COOPERATIVE INC.
SURFACE INFRASTRUCTURE DESIGN
CLASS I INJECTION WELL

PREPARED FOR:

MINNKOTA POWER COOPERATIVE INC.
MILTON R. YOUNG STATION
CENTER, NORTH DAKOTA

PREPARED BY:

GOLDER ASSOCIATES USA INC.
7245 WEST ALASKA DRIVE, SUITE 200
LAKEWOOD, COLORADO USA 80226



NOT FOR CONSTRUCTION

ISSUED FOR 60% DESIGN

SHEET LIST TABLE

DRAWING NUMBER	SHEET TITLE	REVISION
	GENERAL DRAWINGS	
G-001	TITLE SHEET	C
G-002	GENERAL NOTES	B
G-003	SITE OVERVIEW	C
	CIVIL DRAWINGS	
C-001	YARD PIPING - LIME PREP BUILDING TO FREEMAN-1 INJECTION PUMP BUILDING	C
C-002	YARD PIPING - FREEMAN-1 INJECTION PUMP BUILDING TO FREEMAN-1 WELLHEAD BUILDING	B
C-003	FREEMAN-1 INJECTION PUMP BUILDING GRADING PLAN	B
C-004	CIVIL DETAILS	C
C-005	YARD PIPING - DRAINS VAULT TO RUBEN-1 WELLHEAD BUILDING	B
C-006	YARD PIPING - RUBEN 1 WELL PAD LAYOUT	B
	MECHANICAL DRAWINGS	
M-001	LIME PREP BUILDING PLAN VIEW	C
M-002	LIME PREP BUILDING SECTON VIEWS (1 OF 2)	C
M-003	LIME PREP BUILDING SECTION VIEWS (2 OF 2)	C
M-004	LIME PREP BUILDING SECTION PHOTOS	C
M-005	INJECTION PUMP BUILDING PIPING	C
M-006	WELLHEAD BUILDING PIPING	C
M-007	PIPING AND INSTRUMENTATION DIAGRAM SYMBOLS AND ABBREVIATIONS	B
M-008	PIPING AND INSTRUMENTATION DIAGRAM - FREEMAN-1 SYSTEM	C
M-009	PIPING AND INSTRUMENTATION DIAGRAM - RUBEN-1 SYSTEM	C
	STRUCTURAL DRAWINGS	
S-010	INJECTION PUMP BUILDING CONCRETE FOUNDATION AND SLAB SLOPE PLAN	B
S-011	INJECTION PUMP BUILDING CONCRETE SECTION (1 OF 2)	B
S-012	INJECTION PUMP BUILDING CONCRETE SECTION (2 OF 2)	B
S-013	WELLHEAD BUILDING CONCRETE FOUNDATION AND SLAB SLOPE PLAN	B
S-014	WELLHEAD BUILDING CONCRETE SECTIONS	B
S-015	ELECTRICAL BUILDING CONCRETE FOUNDATION PLAN	B
S-016	ELECTRICAL BUILDING CONCRETE SECTION	B
S-017	TRANSFORMER PAD CONCRETE TRANSFORMER PAD DETAILS	B
S-020	INJECTION PUMP BUILDING ROOF PLAN	B
S-021	INJECTION PUMP BUILDING ELEVATIONS	B
S-022	WELLHEAD BUILDING ROOF PLAN	B
S-023	WELLHEAD BUILDING ELEVATIONS	B
S-024	ELECTRICAL BUILDING ROOF PLAN	B
S-025	ELECTRICAL BUILDING ELEVATIONS	B
	ELECTRICAL DRAWINGS	
E-001	FREEMAN-1 INJECTION WELL ELECTRICAL SINGLE LINE	B
E-002	INJECTION PUMP BUILDING DISTRIBUTION PANEL DP-001 PANEL SCHEDULE	B
E-003	LIME PREP BUILDING DISTRIBUTION PANEL PANEL SCHEDULE	B
E-004	ELECTRICAL BUILDING EQUIPMENT LAYOUT	B
E-005	FREEMAN-1 WELLHEAD SUBPANEL DP-003 PANEL SCHEDULE	B
E-006	FREEMAN-1 INJECTION PUMP BUILDING ELECTRICAL CABLE ROUTING	B

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
C	2022-07-08	ISSUED FOR 60% DESIGN	BJP	BJP	AMS	TJS
B	2022-06-16	REVISED ISSUED FOR CLIENT REVIEW	BJP	BCB	AMS	TJS
A	2022-02-07	ISSUED FOR CLIENT REVIEW	BJP	BJP	AMS	TJS

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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
TITLE SHEET

PROJECT NO. 19122669 | REV. C | DRAWING G-001

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

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ABBREVIATION/ACRONYMS

ACI	AMERICAN CONCRETE INSTITUTE
AWG	AMERICAN WIRE GAUGE
DR	DIMENSION RATIO
ft	FEET
GPM	GALLONS PER MINUTE
HDPE	HIGH DENSITY POLYETHYLENE
HP	HORSE POWER
in	INCH
IPS	IRON PIPE SIZING
KCMIL	THOUSAND CIRCULAR MIL
KVA	THOUSAND VOLT AMPS
LOTO	LOCK-OUT / TAG-OUT
MPC	MINNKOTA POWER COOPERATIVE INC.
NPT	NATIONAL PIPE THREAD
OSHA	OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
PSI	POUNDS PER SQUARE INCH
PVC	POLYVINYL CHLORIDE
SCH.	SCHEDULE
TDH	TOTAL DYNAMIC HEAD
TOC	TOP OF CONCRETE
V	VOLT
VFD	VARIABLE FREQUENCY DRIVE

GENERAL NOTE(S)

1. ALL MPC AND APPLICABLE OSHA HEALTH AND SAFETY REQUIREMENTS SHALL BE FOLLOWED DURING EXECUTION OF THE WORK. MPC PROCEDURES SHALL BE USED FOR ALL EXCAVATIONS, HOT WORK, CONFINED SPACE ENTRY, LOTO, AND WORKING CLEARANCE. ALL CONTRACTOR AND SUBCONTRACTOR EMPLOYEES ASSIGNED TO THE WORK SHALL ATTEND THE OWNER'S CONTRACTOR SAFETY ORIENTATION.
2. FOR THIS WORK, MPC IS THE OWNER.
3. UNLESS SPECIFICALLY NOTED OTHERWISE, THE CONTRACTOR IS RESPONSIBLE FOR FURNISHING ALL LABOR, MATERIALS, QUALITY CONTROL, EQUIPMENT, AND INCIDENTALS REQUIRED TO COMPLETE THE WORK AS SHOWN.
4. CONTRACTOR IS RESPONSIBLE FOR LOCATING AND PROTECTING ALL EXISTING UNDERGROUND, ABOVE-GRADE, AND OVERHEAD UTILITIES. ALL EXISTING UNDERGROUND UTILITIES SHOULD BE FIELD VERIFIED AND LOCATED BY POTHOLING PER MPC REQUIREMENTS.
5. THE SITE IS AN ACTIVE FACILITY. WORKERS SHALL BE AWARE OF ACTIVE EQUIPMENT IN THE VICINITY OF THE WORK AREA AND SHALL TAKE PRECAUTIONS NOT TO DISTURB OPERATING EQUIPMENT.
6. CONTRACTOR SHALL VERIFY ALL DIMENSIONS, ELEVATIONS, AND SITE CONDITIONS PRIOR TO STARTING WORK, AND SHALL NOTIFY THE OWNER'S REPRESENTATIVE IF CONFLICTS EXIST ON OR BETWEEN THE DRAWINGS.
7. LOCATIONS AND DIMENSIONS OF EXISTING UTILITIES AND STRUCTURES ARE BASED ON DRAWINGS PROVIDED BY THE OWNER AND FIELD MEASUREMENTS, AND SHOULD BE FIELD-VERIFIED.
8. CONTRACTOR SHALL PERFORM HOUSEKEEPING DUTIES ON A DAILY BASIS TO KEEP WORK AREAS CLEAN. SITE RESTORATION SHALL BE PERFORMED AT THE COMPLETION OF THE WORK TO THE SATISFACTION OF THE OWNER.
9. THE CONTRACTOR SHALL PROVIDE ALL NECESSARY SAFETY EQUIPMENT AND PROVIDE ACCESS FOR THE OWNER AND THE OWNER'S REPRESENTATIVE TO INSPECT THE WORK. INSPECTION ACCESS IS REQUIRED THROUGHOUT THE DURATION OF THE PROJECT.
10. CONTRACTOR SHALL PARK VEHICLES AND STAGE EQUIPMENT AND MATERIALS ONLY IN AREAS APPROVED BY THE OWNER.
11. CONTRACTOR IS RESPONSIBLE FOR SURVEY CONTROL, CONSTRUCTION STAKING, AND AS-BUILT SURVEYING.
12. CONTROL OF FUGITIVE DUST GENERATED IN THE WORK AREA IS THE RESPONSIBILITY OF THE CONTRACTOR.
13. SPECIAL TOOLS AND OTHER REQUIRED INSTALLATION EQUIPMENT SUCH AS SLINGS, LEVER TOOLS, RATCHET JACKS, PULLING CABLES, ETC., FOR MAKEUP OF JOINTS SHALL BE FURNISHED BY THE CONTRACTOR.
14. TEST PLUGS, HYDROTEST PUMPS, GAUGES, RELIEF VALVES, AND ALL TESTING EQUIPMENT SHALL BE FURNISHED BY THE CONTRACTOR.
15. WHERE VERTICAL OR HORIZONTAL ALIGNMENT REQUIRES DEFLECTION FROM STRAIGHT LINE OR GRADE, SUCH DEFLECTION SHALL NOT EXCEED MAXIMUM DEFLECTION RECOMMEND BY THE PIPE MANUFACTURER. IF ALIGNMENT REQUIRES DEFLECTION EXCEEDING RECOMMENDED LIMITS, FURNISH SPECIAL BENDS TO PROVIDE ANGULAR DEFLECTIONS WITHIN THE ALLOWABLE LIMITS.
16. PIPE SHALL BE CUT NEATLY AND WITHOUT DAMAGE TO THE PIPE. UNLESS OTHERWISE RECOMMENDED BY THE PIPE MANUFACTURER, CUT PIPE WITH MECHANICAL CUTTER ONLY. CUT PLASTIC PIPE SQUARE, USING HAND SAW, AND REMOVE ALL BURRS.
17. APPROPRIATE PROVISIONS SHALL BE MADE TO PREVENT PIPE FLOTATION AND PREVENT FOREIGN MATERIAL FROM ENTERING PIPE OPENINGS. TEMPORARY BLINDS SHALL BE PLACED ON ALL PIPE ENDS AND STUB-UPS DURING INSTALLATION. BLINDS ARE NOT TO BE REMOVED UNTIL PERMANENT CONNECTIONS ARE MADE.
18. CONFIGURATIONS AND DIMENSIONS SHOWN ARE BASED ON TYPICAL DIMENSIONS FOR FITTINGS AND VALVES. ACTUAL DIMENSIONS MAY VARY BY MANUFACTURER AND WILL REQUIRE FIELD ADJUSTMENTS.
19. THE CONTRACTOR SHALL BE AWARE OF ACTIVITIES ASSOCIATED WITH OPERATION OF THE SITE AND ADDITIONAL CONSTRUCTION PROJECTS IN THE VICINITY OF THE WORK AREA. THE CONTRACTOR SHALL COORDINATE WITH THE OWNER FOR ALL WORK ACTIVITIES HAVING THE POTENTIAL TO AFFECT OR BE AFFECTED BY OPERATION OF THE SITE AND/OR ADDITIONAL CONSTRUCTION PROJECTS.
20. COORDINATION OF MATERIAL DELIVERY, STORAGE, AND STOCKPILING IS ANTICIPATED AND EXPECTED BETWEEN THE CONTRACTOR AND THE OWNER TO ENSURE THAT CONCURRENT WORK ACTIVITIES CAN BE COMPLETED WITHOUT SAFETY INCIDENT, PROJECT DELAYS, OR COST IMPLICATIONS.

UNDERGROUND PIPE INSTALLATION

1. CONTRACTOR SHALL SUBMIT A TRENCHING SAFETY PLAN FOR REVIEW AND APPROVAL BY THE OWNER BEFORE ANY TRENCHING ACTIVITIES CAN BEGIN. THE PLAN SHALL INDICATE THE SYSTEMS, METHODS, AND TECHNIQUES TO BE USED TO ENSURE THAT ALL TRENCH SIDEWALLS WILL BE STABLE AND/OR GUARDED FOR THE PROTECTION OF PERSONNEL AND FACILITIES IN THE VICINITY OF THE WORK.
2. AS REQUIRED, CONTRACTOR SHALL PREPARE AND IMPLEMENT AN OWNER APPROVED PLAN TO CONTROL GROUNDWATER IN ALL DEVELOPED EXCAVATIONS (INCLUDING GROUNDWATER AND SURFACE WATER).
3. UNDERGROUND PIPE SHALL BE LOWERED INTO TRENCH BY MEANS OF DERRICK, ROPES, BELT SLINGS, OR OTHER EQUIPMENT RECOMMENDED BY THE PIPE SUPPLIER. TAKE SPECIAL CARE IN HANDLING PREFABRICATED SECTIONS OF HDPE PIPE - THE FUSED FITTINGS MAY NOT BE CAPABLE OF CARRYING THE WEIGHT OF ADJACENT PIPING. DO NOT DUMP OR DROP ANY MATERIALS INTO THE TRENCH.
4. FOR UNDERGROUND PIPE, REST THE FULL LENGTH OF EACH SECTION OF THE PIPE SOLIDLY ON THE PIPE BED. DO NOT LAY PIPE IN WATER, OR WHEN FOUNDATION CONDITIONS ARE UNSUITABLE FOR THE WORK.
5. UNDERGROUND PIPING SHALL BE BEDDED ON FOUR (4) INCHES OF GRANULAR PIPE BEDDING MATERIAL APPROVED BY THE OWNER'S REPRESENTATIVE AND EMBEDDED IN THE SAME MATERIAL TO TWELVE (12) INCHES ABOVE THE TOP OF THE PIPING. THE MATERIAL DIRECTLY ABOVE THE PIPE IN THE EMBEDMENT ZONE SHALL BE ONLY LIGHTLY COMPACTED TO AVOID DISTORTING THE PIPE.
6. GENERAL FILL (MORE THAN 12 INCHES ABOVE THE PIPE) SHALL CONSIST OF SOILS EXCAVATED AS PART OF THE WORK AS APPROVED BY THE OWNER'S REPRESENTATIVE. IF EXCAVATED SOILS ARE DEEMED UNSUITABLE, GENERAL FILL SHALL CONSIST OF IMPORTED EARTHEN MATERIALS APPROVED BY THE OWNER'S REPRESENTATIVE. GENERAL FILL SHALL BE PLACED IN HORIZONTAL LOOSE LIFTS NOT EXCEEDING TEN (10) INCHES IN THICKNESS AND MOISTURE CONDITIONED TO 1 PERCENT BELOW TO 3 PERCENT ABOVE STANDARD PROCTOR (ASTM D698) OPTIMUM MOISTURE CONTENT. GENERAL FILL SHALL BE COMPACTED TO A MINIMUM OF 90 PERCENT OF THE STANDARD PROCTOR MAXIMUM DRY DENSITY.
7. TRACER WIRE SHALL BE INSTALLED ABOVE ALL NEW CONSTRUCTED UNDERGROUND PIPING. CAUTION TAPE SHALL BE INSTALLED APPROXIMATELY TWO TO THREE FEET ABOVE ALL NEW CONSTRUCTED UNDERGROUND PIPING.
8. PIPING SHALL BE CONSTRUCTED PER THE MANUFACTURER'S RECOMMENDATIONS AND SHALL HAVE A LINE TOLERANCE OF ±0.2 FEET AND A GRADE TOLERANCE OF ±0.1 FEET. PIPING SHALL INCLUDE APPROPRIATE CAMBER TO LIMIT SAGS OR HUMPS FROM DEVELOPING IN THE PIPING AFTER PLACEMENT OF FILL MATERIALS.
9. AN AS-BUILT SURVEY SHALL BE PERFORMED ON PIPING AS CONSTRUCTED. COORDINATES AND ELEVATIONS SHALL BE SURVEYED AT ALL PIPE BENDS AND AT MINIMUM 100-FOOT INTERVALS ALONG STRAIGHT PORTIONS OF PIPE. COORDINATES SHALL BE REPORTED IN NORTH DAKOTA STATE PLANE SOUTH ZONE NAD 27 COORDINATE SYSTEM. HORIZONTAL ACCURACY SHALL BE ±0.2 FEET. VERTICAL ACCURACY SHALL BE ±0.1 FEET. THE CONTRACTOR SHALL PROVIDE AN EXCEL SPREADSHEET CONTAINING SURVEY POINT NUMBER, NORTHING, EASTING, TOP OF PIPE ELEVATION, AND GROUND ELEVATION AFTER PIPE IS BURIED (IF APPLICABLE). SURVEY METHOD AND EQUIPMENT USED SHALL BE INDICATED WITH THE DELIVERABLE.
10. ALL PARTS SHALL BE ACCURATELY ASSEMBLED AND ERECTED AS SHOWN ON THE DRAWINGS OR APPROVED SHOP DRAWINGS, OR AS OTHERWISE APPROVED BY THE OWNER'S REPRESENTATIVE, AND ALL MATCHMARKS OF THE FABRICATOR SHALL BE CAREFULLY FOLLOWED. MEMBERS SHALL NOT BE OVERSTRESSED DURING THE PROCESS OF ASSEMBLY, AND HAMMERING THAT WILL INJURE OR DISTORT THE MEMBERS WILL NOT BE PERMITTED. BEARING SURFACES AND SURFACES TO BE IN PERMANENT CONTACT SHALL BE CLEANED BEFORE THE MEMBERS ARE ASSEMBLED OR ERECTED.
11. THE CONTRACTOR SHALL PROVIDE REDLINE DRAWINGS IDENTIFYING KEY ELEMENTS OF THE PIPE ASSEMBLY THAT MAY DIFFER FROM THE DRAWINGS OR APPROVED SHOP DRAWINGS.

HDPE PIPE INSTALLATION

1. ALL UNDERGROUND PIPING UPSTREAM OF THE INJECTION PUMP SHALL BE HDPE IPS DR11 PIPE UNLESS OTHERWISE NOTED.
2. FUSION MACHINE FOR BUTT FUSION OF HDPE PIPING SHALL BE FURNISHED BY THE CONTRACTOR.
3. SECTIONS OF POLYETHYLENE PIPE SHOULD BE JOINED INTO CONTINUOUS LENGTHS ON THE JOBSITE ABOVE GROUND. THE JOINING METHOD SHALL BE THE BUTT FUSION METHOD AND SHALL BE PERFORMED IN STRICT ACCORDANCE WITH THE PIPE MANUFACTURER'S RECOMMENDATIONS BY CRAFT WORKERS CERTIFIED FOR THE FUSION MACHINE AND PIPING MATERIALS BEING UTILIZED. THE BUTT FUSION JOINING WILL PRODUCE A JOINT WITH WELD STRENGTH EQUAL TO OR GREATER THAN THE TENSILE STRENGTH OF THE PIPE ITSELF. ALL FIELD WELDS SHALL BE MADE WITH FUSION EQUIPMENT EQUIPPED WITH A DATA LOGGER. TEMPERATURE, FUSION PRESSURE, AND A GRAPHIC REPRESENTATION OF THE FUSION CYCLE SHALL BE PART OF THE QUALITY CONTROL RECORDS.
4. MECHANICAL JOINING OF HDPE PIPE TO OTHER MATERIALS SHALL BE ACCOMPLISHED USING AN HDPE FLANGE ADAPTER WITH A DUCTILE IRON BACK-UP RING.
5. SOCKET FUSION, HOT GAS FUSION, THREADING, SOLVENTS, AND EPOXIES WILL NOT BE USED TO JOIN HDPE PIPE.
6. PRESSURE PIPING SYSTEMS CONSTRUCTED FROM HDPE MATERIAL SHALL BE LEAKAGE TESTED USING THE METHODOLOGY OUTLINED IN ASTM F2164, AND PER THE MANUFACTURER'S RECOMMENDATIONS.

STAINLESS STEEL PIPE INSTALLATION

1. COATING/PAINTING SHALL BE APPLIED AND TOUCHED UP AS DIRECTED BY THE OWNER.
2. ALL NEW PIPING WITHIN THE EXISTING LIME PREP BUILDING SHALL BE SUPPORTED WITH MEMBERS CONSISTENT WITH THE EXISTING PIPE SUPPORTS IN THE STRUCTURE.
3. ALL WELDING SHALL BE COMPLETED BY QUALIFIED WELDERS.
4. ALL VALVES AND STAINLESS STEEL PIPING SHALL BE INSTALLED IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS.
5. PRESSURE PIPING SYSTEMS CONSTRUCTED FROM STAINLESS STEEL MATERIAL SHALL BE LEAKAGE TESTED PER THE MANUFACTURER'S RECOMMENDATIONS.

MATERIALS AND EQUIPMENT

1. CONTRACTOR IS RESPONSIBLE FOR PROCURING ADDITIONAL NEEDED QUANTITIES TO MAKE UP FOR SHORTAGES DUE TO LOSS, FIELD REVISIONS, WASTE, ETC.
2. CONTRACTOR TO FURNISH TRACER WIRE AND CAUTION MARKING TAPE FOR NON-METALLIC UNDERGROUND PIPING.
3. ALL NEW SOLID WALL HDPE PIPING AND FITTINGS SHALL BE COMPOSED OF PE4710 RESIN CONSTRUCTED TO ASTM F714, OR ALTERNATE AS APPROVED BY THE OWNER'S REPRESENTATIVE.
4. ALL HDPE PIPING, FITTINGS, AND FLANGES SHALL HAVE IRON PIPE SIZING (IPS) AND SHALL HAVE A DIMENSION RATIO (DR) OF 11.
5. ALL NEW STAINLESS STEEL PIPING AND FITTINGS SHALL BE ASTM A312 STAINLESS STEEL (316) PIPE CONFORMING TO ASME 31.1 POWER PIPING. STAINLESS STEEL PIPING UPSTREAM OF THE INJECTION PUMP SHALL BE SCHEDULE 40. STAINLESS STEEL PIPING DOWNSTREAM OF THE INJECTION PUMP SHALL BE SCHEDULE 80.
6. ALL FLANGES UPSTREAM OF THE INJECTION PUMP SHALL CONFORM TO ASME B16.5 CLASS 150. ALL FLANGES DOWNSTREAM OF THE INJECTION PUMP SHALL CONFORM TO ASME B16.5 CLASS 600.
7. ALL THREADED FITTINGS SHALL HAVE NATIONAL PIPE THREAD (NPT) THREADS.
8. CONCRETE SHALL CONFORM TO ACI 318 AND ACI 301 AS APPLICABLE. THE CONCRETE MIX DESIGN APPROVED BY THE OWNER'S REPRESENTATIVE SHALL HAVE A MINIMUM 28-DAY COMPRESSIVE STRENGTH OF 4,500 PSI.
9. PIPE BEDDING AND EMBEDMENT SHALL CONSIST OF ON-SITE OR IMPORTED EARTHEN MATERIAL CLASSIFYING UNDER ASTM D2487 AS WELL-GRADED SAND (SW OR SW-SM) OR WELL-GRADED GRAVEL (GW OR GW-GM) OR AS OTHERWISE APPROVED IN WRITING BY THE OWNER'S REPRESENTATIVE. PIPE BEDDING SHALL CONTAIN NO PARTICLES LARGER THAN 0.5 INCHES, AND FREE FROM ROOTS, DEBRIS, OR ANY OTHER SUBSTANCE THAT WOULD HARM THE PIPE OR MIGHT IMPAIR THE PERFORMANCE OF THE MATERIALS AS BEDDING OR EMBEDMENT FOR THE PIPE. FINAL MATERIAL SELECTION SHALL BE APPROVED BY THE OWNER'S REPRESENTATIVE.
10. CRUSHED STONE FOR ROADWAY SURFACING SHALL BE APPROVED BY OWNER'S REPRESENTATIVE.
11. TRANSFER PUMP TO BE 150 HORSEPOWER VERTICAL DISCHARGE CENTRIFUGAL PUMP (950 GPM AT 120 FEET TDH), OR APPROVED EQUIVALENT.
12. INJECTION PUMP TO BE 900 HORSEPOWER HORIZONTAL DISCHARGE CENTRIFUGAL PUMP (950 GPM AT 1,000 PSI TDH), OR APPROVED EQUIVALENT.
13. AUTOMATIC SCREEN FILTER TO BE SELF-CLEANING (AUTOMATIC BACKFLUSHING) SCREEN FILTER RATED FOR A MAXIMUM FLOW RATE OF 1,000 GPM, A MAXIMUM PRESSURE OF 150 PSI, AND A FILTER OPENING OF 100 MICRONS, OR APPROVED EQUIVALENT.
14. EXPANSION DEVICES TO BE TOWNLEY SERIES 8000 CONNECTOR WITH BUNA ELASTOMER, OR APPROVED EQUIVALENT.

EROSION AND SEDIMENT CONTROL NOTES

1. THE CONTRACTOR IS RESPONSIBLE FOR INSTALLING AND MAINTAINING EROSION CONTROL DEVICES DURING CONSTRUCTION. THE CONTRACTOR SHALL TAKE ALL NECESSARY MEASURES TO MANAGE SEDIMENT AND PREVENT SEDIMENT FROM LEAVING THE SITE. THE CONTRACTOR SHALL PREPARE A SITE-SPECIFIC EROSION AND SEDIMENT CONTROL PLAN FOR THE OWNER'S APPROVAL PRIOR TO MOBILIZATION. EROSION CONTROL MEASURES SHOWN ON THE DRAWINGS ARE INTENDED AS MINIMUM REQUIREMENTS TO BE SUPPLEMENTED BY THE THE CONTRACTOR'S EROSION AND SEDIMENT CONTROL PLAN.
2. ALL PERMANENT AND TEMPORARY EROSION CONTROL MEASURES ARE SUBJECT TO REVIEW FOR EFFECTIVENESS. NECESSARY ADJUSTMENTS SHALL BE MADE BY THE CONTRACTOR AS DIRECTED BY THE OWNER'S REPRESENTATIVE.
3. THE CONTRACTOR SHALL BE REQUIRED TO FILE ALL APPLICABLE LOCAL, STATE, AND FEDERAL PERMITS AND PREPARE A PROJECT-SPECIFIC STORMWATER MANAGEMENT PLAN.
4. THE CONTRACTOR SHALL SEED AND MULCH AREAS DISTURBED BY CONSTRUCTION OPERATIONS.
5. TEMPORARY EROSION CONTROL DEVICES SHALL BE REMOVED WHEN THEY HAVE SERVED THEIR USEFUL PURPOSE AS DETERMINED BY THE OWNER.

REFERENCES

1. EXISTING GRADES PROVIDED BY MPC ON APRIL 4, 2021 (2021-04-06 Minnkota flight_elev1.0ft_res100cm_size20_DSM.dwg). EXISTING GRADES WERE OBTAINED USING AERIAL LIDAR. EXISTING BUILDING AND STRUCTURES WERE SCANNED AND HAVE NOT BEEN REMOVED FROM THE DATA SET.
2. THE COORDINATE SYSTEM: NORTH DAKOTA STATE PLANE SOUTH ZONE NAD 27. VERTICAL DATUM IS NVGD 1929.
3. DIMENSIONS ARE IN UNITS OF FEET UNLESS OTHERWISE NOTED.

NOT FOR CONSTRUCTION

ISSUED FOR 60% DESIGN

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B	2022-07-08	ISSUED FOR 60% DESIGN	BJP	BJP	AMS	TJS
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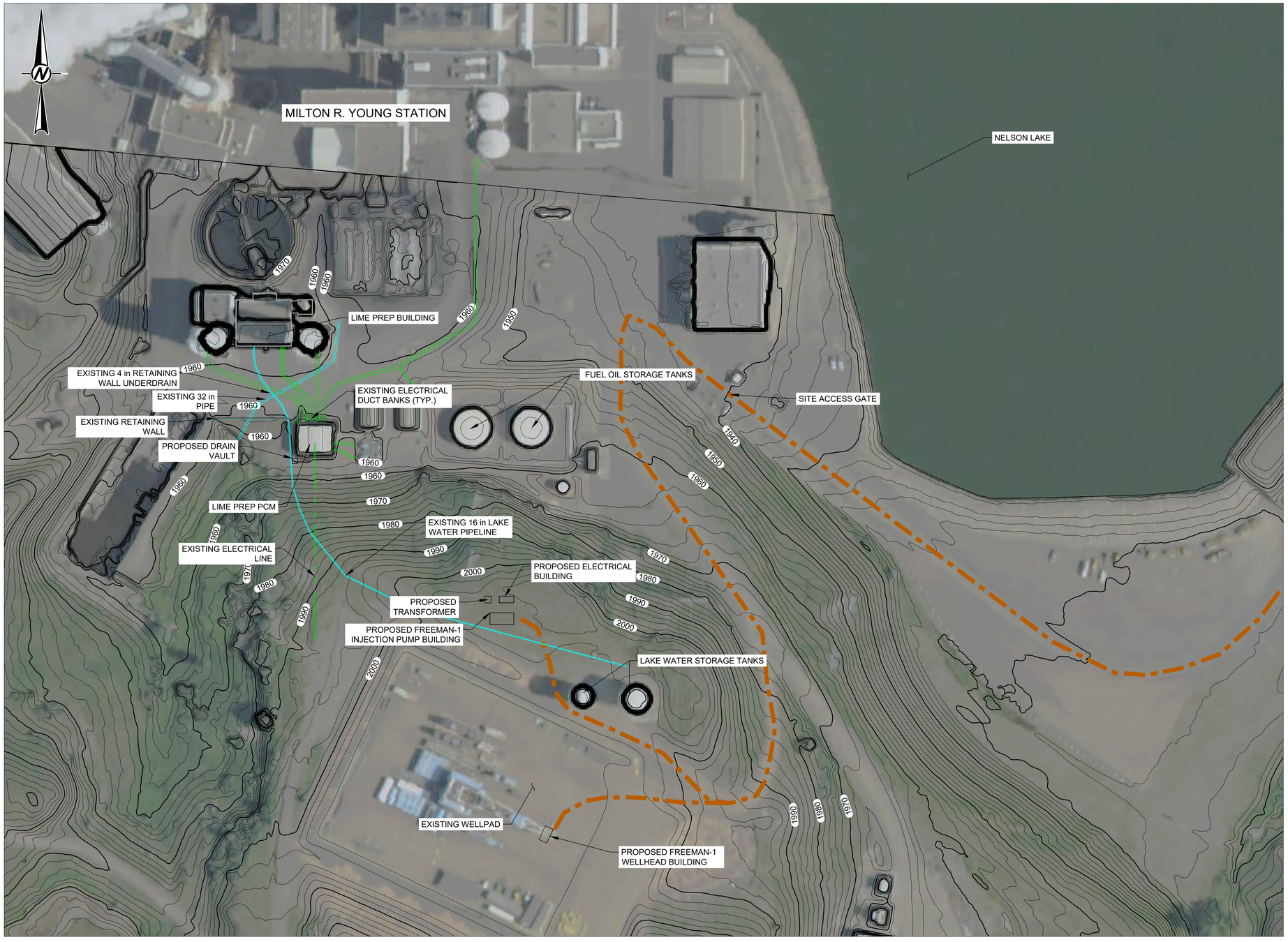
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PROJECT NO. 19122669 | REV. B | DRAWING G-002

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LEGEND

- 2000 — EXISTING GRADES (REFERENCES 1 AND 2)
- ACCESS ROUTE
- EXISTING PIPE (REFERENCE 5)
- EXISTING ELECTRICAL DUCT BANKS (REFERENCE 5)
- EXISTING ELECTRICAL LINE (REFERENCE 5)
- EXISTING RETAINING WALL

REFERENCE(S)

1. EXISTING UTILITY LOCATIONS ARE APPROXIMATE AND ARE NOT INCLUSIVE OF ALL UTILITIES IN THE AREA. ALL UTILITIES IN THE CONSTRUCTION AREA SHALL BE FIELD LOCATED PRIOR TO CONSTRUCTION.

REFERENCE(S)

1. EXISTING GRADES PROVIDED BY MPC ON APRIL 4, 2021 (2021-04-06 Minnkota flight_elev1.0ft_res100cm_size20_DSM.dwg). EXISTING GRADES WERE OBTAINED USING AERIAL LIDAR. EXISTING BUILDING AND STRUCTURES WERE SCANNED AND HAVE NOT BEEN REMOVED FROM THE DATA SET.
2. EXISTING GRADES CONTOUR INTERVAL IS TWO FEET.
3. COORDINATE SYSTEM: NORTH DAKOTA STATE PLANE SOUTH ZONE NAD 27. VERTICAL DATUM IS NVGD 1929.
4. AERIAL IMAGERY: NATIONAL AGRICULTURE IMAGERY PROGRAM (NAIP), USDA. IMAGE FLOWN AUGUST 10, 2020.
5. EXISTING YARD PIPING AND DUCT BANKS WERE PROVIDED BY MPC ON MAY 3, 2021 (UU-0-000.dwg). THE YARD PIPING AND DUCT BANKS HAVE BEEN TRANSLATED TO NORTH DAKOTA STATE PLANE SOUTH ZONE NAD27 COORDINATES TO MATCH THE SURVEYED GRADES AND THE LOCATIONS SHOULD BE CONSIDERED APPROXIMATE.

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1" = 50' FEET

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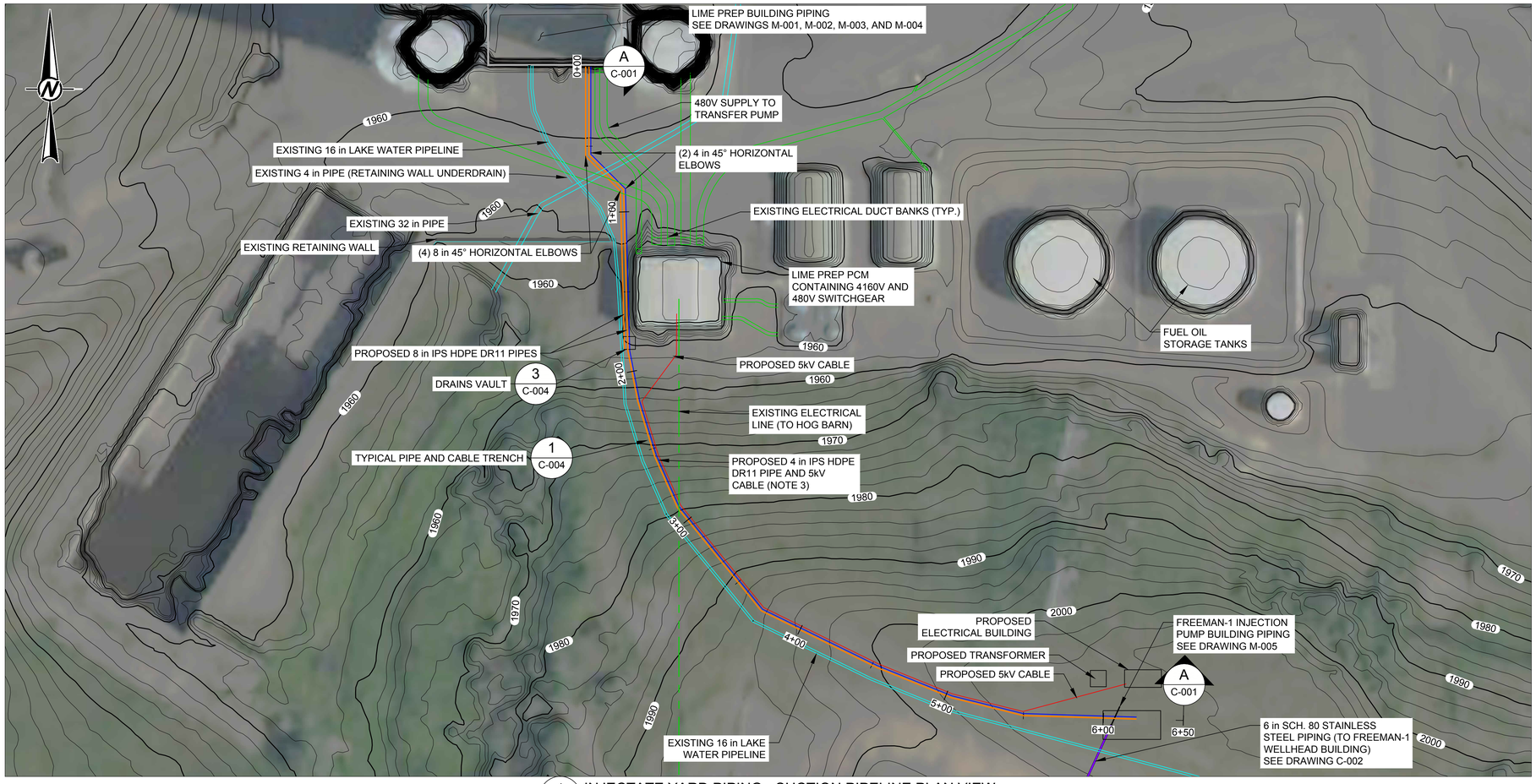
PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
SITE OVERVIEW

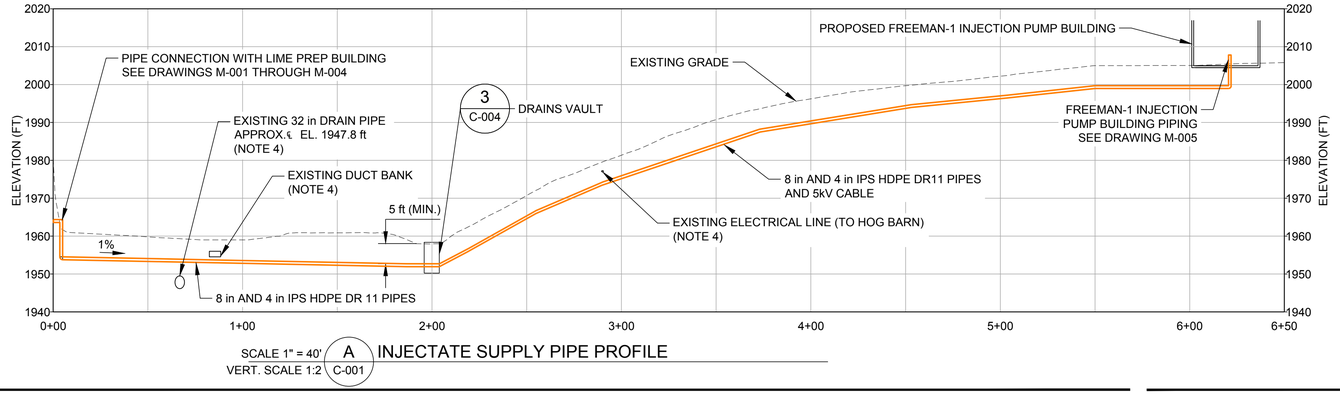
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SCALE 1" = 40' — 1 / C-001 — INJECTATE YARD PIPING - SUCTION PIPELINE PLAN VIEW



SCALE 1" = 40' — A / C-001 — VERT. SCALE 1:2 — INJECTATE SUPPLY PIPE PROFILE

LEGEND

- EXISTING GRADES (PLAN VIEW) (REFERENCE 1)
- EXISTING GRADES (PROFILE VIEW) (REFERENCE 1)
- EXISTING PIPE (REFERENCE 5)
- EXISTING ELECTRICAL DUCT BANKS (REFERENCE 5)
- EXISTING ELECTRICAL LINE (REFERENCE 5)
- EXISTING RETAINING WALL
- PROPOSED HDPE INJECTATE SUPPLY PIPING (NOTES 1 AND 2)
- PROPOSED HDPE SUMP DRAIN PIPING (NOTES 1, 2, AND 3)
- PROPOSED 4160V (5 KV) CABLE (NOTE 3)

NOTE(S)

1. UNDERGROUND PIPING SHALL BE HDPE IPS DR 11 PIPE UNLESS OTHERWISE STATED.
2. UNDERGROUND PIPING SHALL HAVE A MINIMUM OF 5 FEET OF COVER FOR FROST PROTECTION.
3. THE 4-INCH SUMP DISCHARGE PIPING AND 4160V (5kV) CABLE SHALL GENERALLY FOLLOW THE SAME PROFILE AS THE 8-INCH INJECTATE SUPPLY PIPING
4. LOCATIONS AND ELEVATIONS OF EXISTING BELOW GRADE PIPING AND ELECTRICAL UTILITIES TO BE CONFIRMED PRIOR TO CONSTRUCTION.
5. THE 8-INCH HDPE IPS DR 11 PIPELINE TO THE RUBEN-1 INJECTION WELL ONLY EXTENDS FROM THE LIME PREP BUILDING TO THE DRAINS VAULT NEAR THE LIME PREP PCM.

REFERENCE(S)

1. EXISTING GRADES PROVIDED BY MPC ON APRIL 4,2021 (2021-04-06 Minnkota flight_elev1.0ft_res100cm_size20_DSM.dwg). EXISTING GRADES WERE OBTAINED USING AERIAL LIDAR. EXISTING BUILDING AND STRUCTURES WERE SCANNED AND HAVE NOT BEEN REMOVED FROM THE DATA SET.
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3. AERIAL IMAGERY: NATIONAL AGRICULTURE IMAGERY PROGRAM (NAIP), USDA. IMAGE FLOWN AUGUST 10, 2020.
4. EXISTING GRADES CONTOUR INTERVAL IS TWO FEET.
5. EXISTING YARD PIPING AND DUCT BANKS WERE PROVIDED BY MPC ON MAY 3, 2021 (UU-0-000.dwg). THE YARD PIPING AND DUCT BANKS HAVE BEEN TRANSLATED TO NORTH DAKOTA STATE PLANE SOUTH ZONE NAD27 COORDINATES TO MATCH THE SURVEYED GRADES AND THE LOCATIONS SHOULD BE CONSIDERED APPROXIMATE.

NOT FOR CONSTRUCTION

ISSUED FOR 60% DESIGN

0 40 80
1" = 40' FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
C	2022-07-08	ISSUED FOR 60% DESIGN	BJP	BJP	AMS	TJS
B	2022-06-16	REVISED ISSUED FOR CLIENT REVIEW	BJP	BCB	AMS	TJS
A	2022-02-07	ISSUED FOR CLIENT REVIEW	BJP	BJP	AMS	TJS

CLIENT
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CENTER, NORTH DAKOTA

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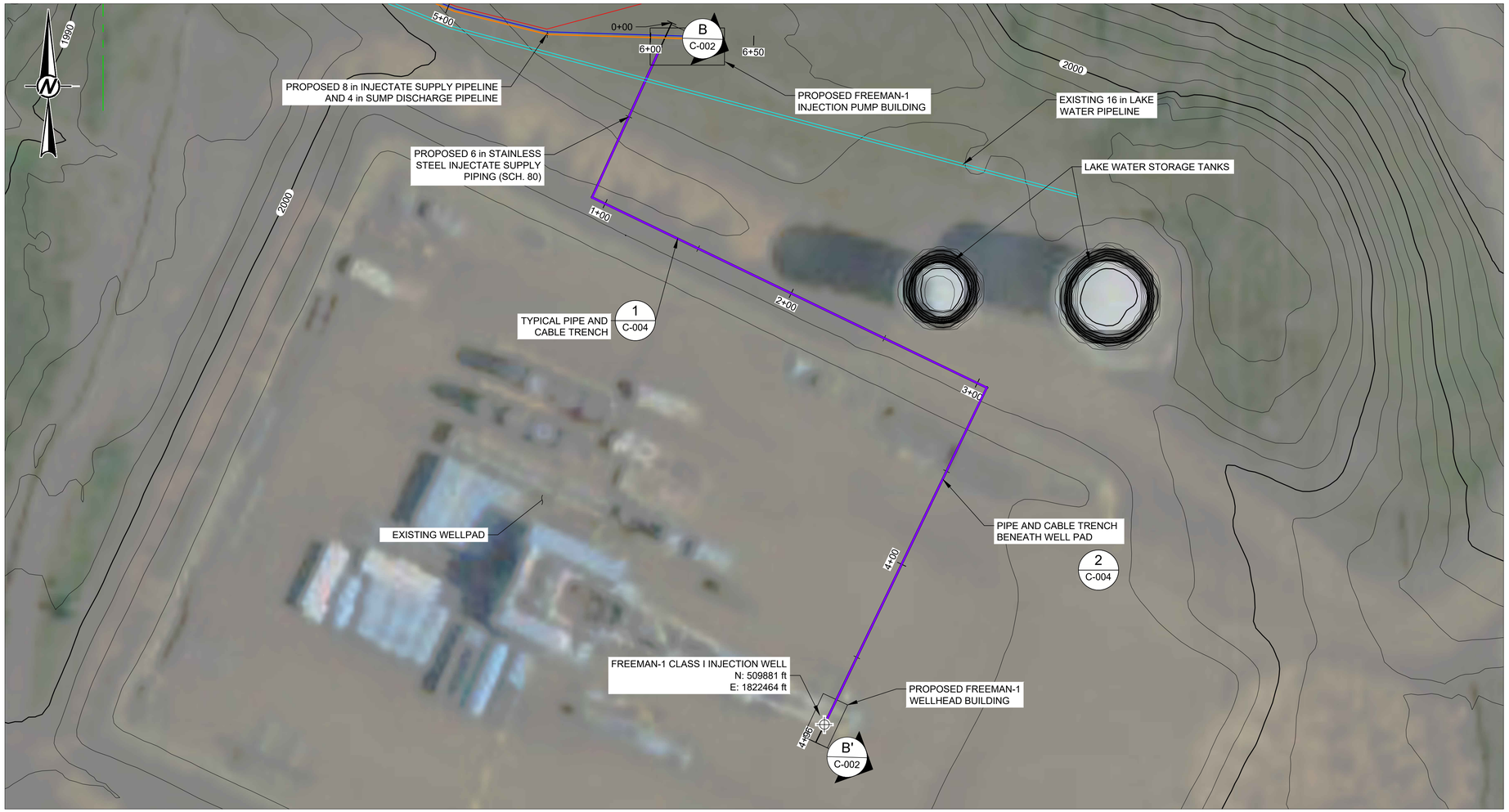
PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

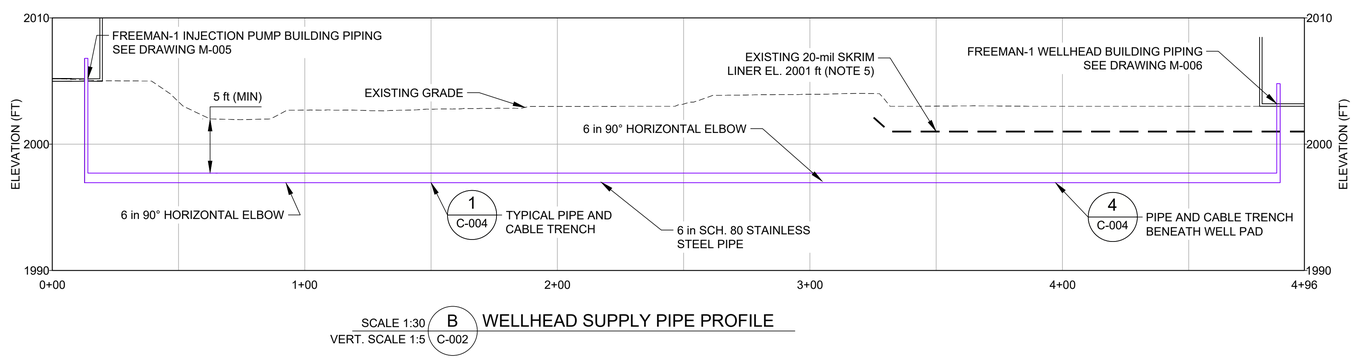
TITLE
YARD PIPING - LIME PREP BUILDING TO FREEMAN-1 INJECTION PUMP BUILDING

PROJECT NO. 19122669 | REV. C | DRAWING C-001

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
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Path: \\golder.gds\complexdata\office\denver\acad\Minnkota Power Cooperative\99_PROJECTS\19122669\B - Infrastructure\02_PRODUCT\DWG\ | File Name: 19122669A006.dwg | Last Edited By: adarr Date: 2022-07-07 Time:4:29:14 PM | Printed By: ADarr Date: 2022-07-07 Time:4:30:28 PM





SCALE 1:30 / VERT. SCALE 1:5 — B / C-002 — WELLHEAD SUPPLY PIPE PROFILE

LEGEND

- EXISTING GRADES (PLAN VIEW) (REFERENCE 1)
- EXISTING GRADES (PROFILE VIEW) (REFERENCE 1)
- EXISTING PIPE (REFERENCE 5)
- EXISTING SKRIM LINER (NOTE 5)
- PROPOSED HDPE INJECTATE SUPPLY PIPING (NOTE 1)
- PROPOSED STEEL INJECTATE SUPPLY PIPING (NOTES 1 AND 3)
- PROPOSED HDPE SUMP DRAIN PIPING (NOTE 1)
- PROPOSED 4160V (5 KV) CABLE
- CLASS I INJECTION WELL (CONSTRUCTED BY OTHERS)

NOTE(S)

1. UNDERGROUND PIPING SHALL HAVE A MINIMUM OF 5 FEET OF COVER FOR FROST PROTECTION.
2. LOCATIONS AND ELEVATIONS OF EXISTING BELOW GRADE PIPING AND ELECTRICAL UTILITIES TO BE CONFIRMED PRIOR TO CONSTRUCTION.
3. PIPING ON THE DISCHARGE SIDE OF THE INJECTION PUMP SHALL BE SCHEDULE 80 STAINLESS STEEL PIPE. FLANGES ON THE DISCHARGE SIDE OF THE INJECTION PUMP SHALL BE CLASS 600.
4. THE BURIED STAINLESS STEEL PIPING WILL BE COATED WITH AN APPROPRIATE MATERIAL APPROVED BY THE OWNER'S REPRESENTATIVE.
5. WELL PAD IS UNDERLAIN BY A 20-mil SKRIM LINER AT EL. 2001. PIPE SHALL BE TRENCHED BENEATH THE SKRIM LINER TO THE ELEVATIONS SHOWN AND THE SKRIM LINER SHALL BE REPAIRED IN ACCORDANCE WITH THESE DRAWINGS FOLLOWING PIPING INSTALLATION.

REFERENCE(S)

1. EXISTING GRADES PROVIDED BY MPC ON APRIL 4,2021 (2021-04-06 Minnkota flight_elev1.0ft_res100cm_size20_DSM.dwg). EXISTING GRADES WERE OBTAINED USING AERIAL LIDAR. EXISTING BUILDING AND STRUCTURES WERE SCANNED AND HAVE NOT BEEN REMOVED FROM THE DATA SET.
2. EXISTING GRADES CONTOUR INTERVAL IS TWO FEET.
3. COORDINATE SYSTEM: NORTH DAKOTA STATE PLANE SOUTH ZONE NAD 27. VERTICAL DATUM IS NVGD 1929.
4. AERIAL IMAGERY: NATIONAL AGRICULTURE IMAGERY PROGRAM (NAIP), USDA. IMAGE FLOWN AUGUST 10, 2020.
5. EXISTING YARD PIPING AND DUCT BANKS WERE PROVIDED BY MPC ON MAY 3, 2021 (UU-0-000.dwg). THE YARD PIPING AND DUCT BANKS HAVE BEEN TRANSLATED TO NORTH DAKOTA STATE PLANE SOUTH ZONE NAD27 COORDINATES TO MATCH THE SURVEYED GRADES AND THE LOCATIONS SHOULD BE CONSIDERED APPROXIMATE.

NOT FOR CONSTRUCTION

ISSUED FOR 60% DESIGN

0 30 60
1" = 30' FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2022-07-08	ISSUED FOR 60% DESIGN	BJP	BJP	AMS	TJS
A	2022-06-16	ISSUED FOR CLIENT REVIEW	BJP	BCB	AMS	TJS

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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
YARD PIPING - FREEMAN-1 INJECTION PUMP BUILDING TO FREEMAN-1 WELLHEAD BUILDING

PROJECT NO. 19122669 | REV. B | DRAWING C-002

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LEGEND

- EXISTING GRADES (REFERENCES 1 AND 2)
- PROPOSED GRADES
- PROPOSED CONCRETE FOUNDATION EXTENTS
- PROPOSED BUILDING EXTENTS
- AREA TO BE REVEGETATED
- GRAVEL SURFACING

REFERENCE(S)

1. EXISTING GRADES PROVIDED BY MPC ON APRIL 4, 2021 (2021-04-06 Minnkota flight_elev1.0ft_res100cm_size20_DSM.dwg). EXISTING GRADES WERE OBTAINED USING AERIAL LIDAR. EXISTING BUILDING AND STRUCTURES WERE SCANNED AND HAVE NOT BEEN REMOVED FROM THE DATA SET.
2. EXISTING GRADES CONTOUR INTERVAL IS ONE FOOT.
3. COORDINATE SYSTEM: NORTH DAKOTA STATE PLANE SOUTH ZONE NAD 27. VERTICAL DATUM IS NVGD 1929.

NOT FOR CONSTRUCTION

ISSUED FOR 60% DESIGN

0 8 16
1" = 8' FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2022-07-08	ISSUED FOR 60% DESIGN	BJP	BJP	AMS	TJS
A	2022-06-16	ISSUED FOR CLIENT REVIEW	BJP	BJP	AMS	TJS

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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

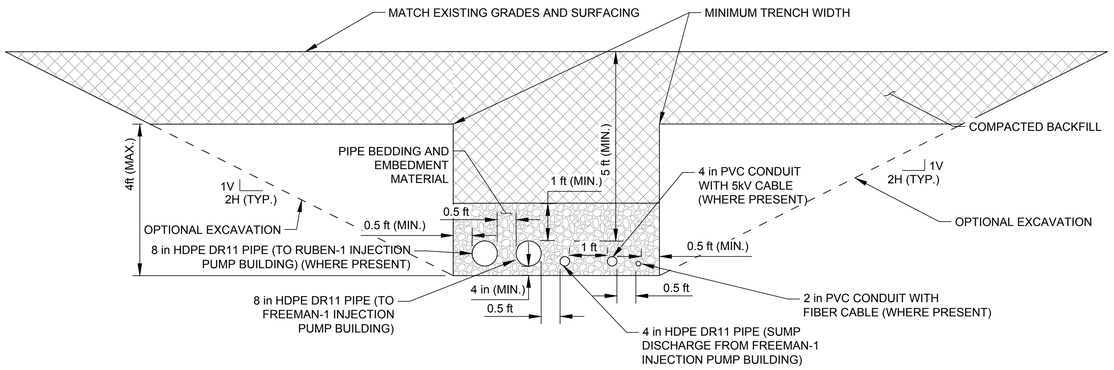
TITLE
FREEMAN-1 INJECTION PUMP BUILDING GRADING PLAN

PROJECT NO. 19122669 | REV. B | DRAWING C-003

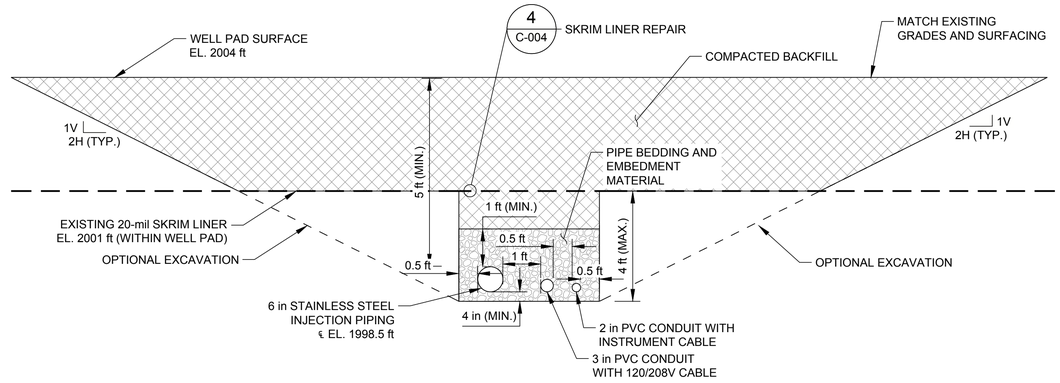
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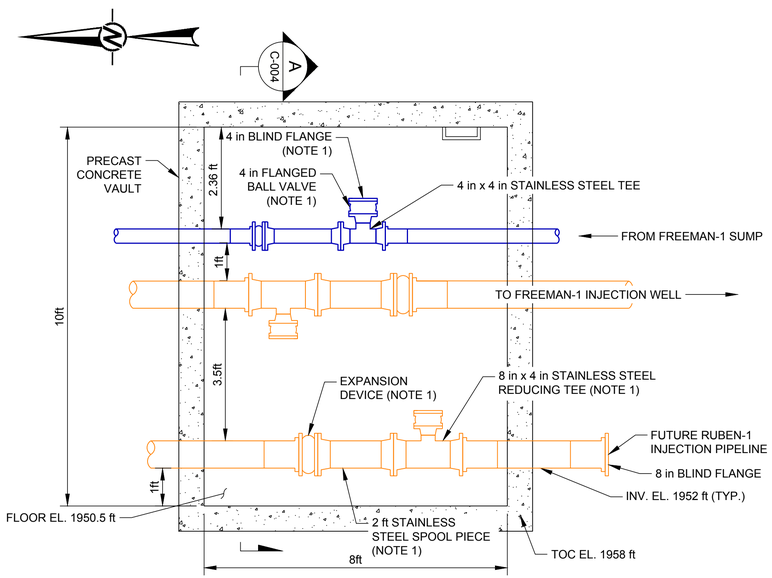
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SCALE N.T.S. 1 C-004 TYPICAL PIPE AND CABLE TRENCH DETAIL



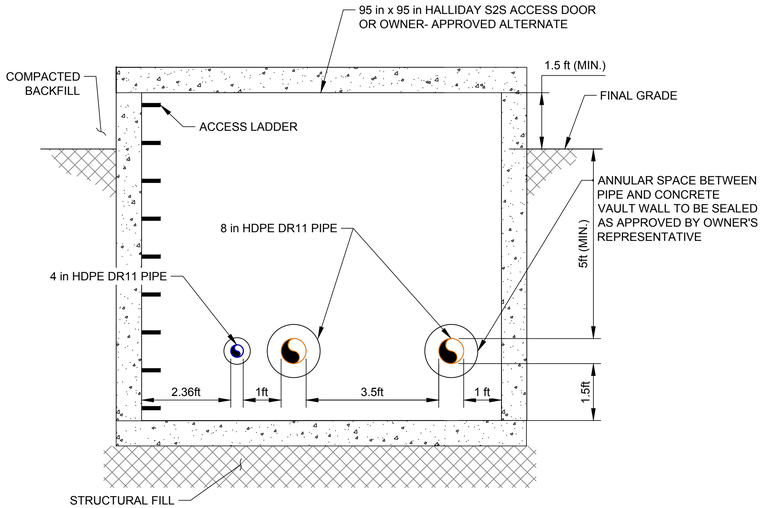
SCALE N.T.S. 2 C-004 PIPE AND CABLE TRENCH DETAIL ON WELL PAD



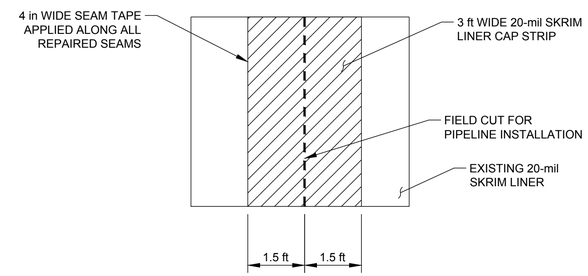
SCALE N.T.S. 3 C-004 DRAINS VAULT PLAN

NOTE(S)

1. EACH PIPELINE WILL HAVE AN EXPANSION DEVICE, FLANGES, 2-FOOT SPOOL PIECE, TEE, AND BALL VALVE AS SHOWN.



SCALE N.T.S. A C-004 DRAINS VAULT SECTION



SCALE N.T.S. 4 C-004 SKRIM LINER REPAIR DETAIL

NOT FOR CONSTRUCTION

ISSUED FOR 60% DESIGN

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C	2022-07-08	ISSUED FOR 60% DESIGN	BJP	BJP	AMS	TJS
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A	2022-02-07	ISSUED FOR CLIENT REVIEW	BJP	BJP	AMS	TJS

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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

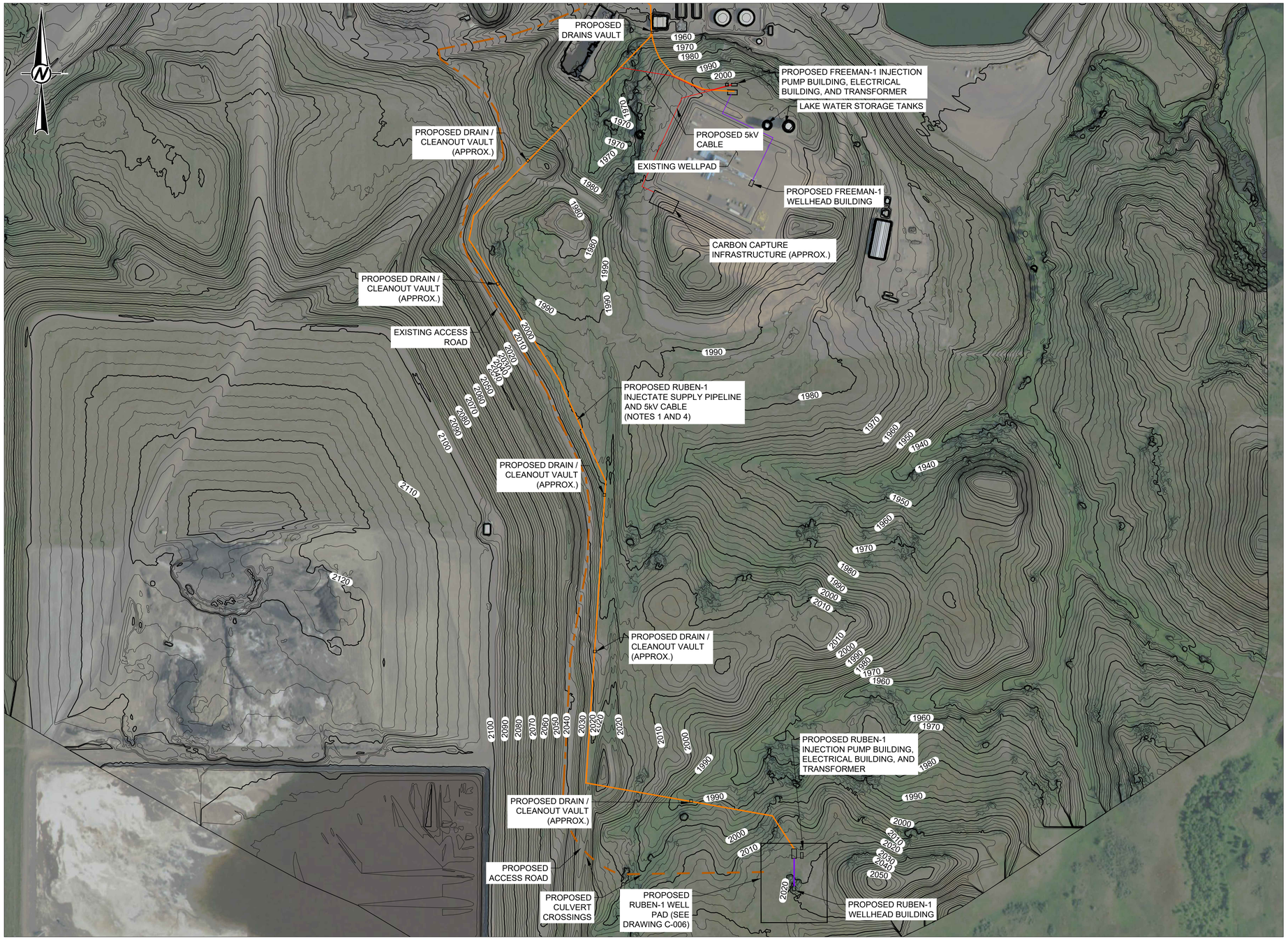
TITLE
CIVIL DETAILS

PROJECT NO.	REV.	DRAWING
19122669	C	C-004

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LEGEND

- 2000 — EXISTING GRADES (REFERENCES 1 AND 2)
- EXISTING ACCESS ROUTE
- PROPOSED ACCESS ROAD
- PROPOSED HDPE INJECTATE SUPPLY PIPING (NOTES 1 AND 4)
- PROPOSED STAINLESS STEEL INJECTATE SUPPLY PIPING (NOTES 1 AND 5)
- PROPOSED 4160 V (5 KV) BURIED ELECTRICAL CABLE

NOTE(S)

1. INJECTATE SUPPLY PIPELINE TO RUBEN-1 IS CONCEPTUAL AND WILL BE UPDATED DURING DETAILED DESIGN.
2. UNDERGROUND PIPING SHALL HAVE A MINIMUM OF 5 FEET OF COVER FOR FROST PROTECTION.
3. LOCATIONS AND ELEVATIONS OF EXISTING BELOW GRADE PIPING AND ELECTRICAL UTILITIES TO BE CONFIRMED PRIOR TO CONSTRUCTION.
4. UNDERGROUND PIPING BETWEEN THE DRAINS VAULT AND THE RUBEN-1 INJECTION PUMP BUILDING SHALL BE 12 in HDPE IPS DR 11 PIPE. THE CONCEPTUAL PIPELINE LENGTH IS APPROXIMATELY 4,200 ft.
5. PIPING ON THE DISCHARGE SIDE OF THE RUBEN-1 INJECTION PUMP SHALL BE 6 in SCHEDULE 80 STAINLESS STEEL PIPE. FLANGES ON THE DISCHARGE SIDE OF THE INJECTION PUMP SHALL BE CLASS 600.
6. CLEANOUTS ARE SPACED APPROXIMATELY 1,000-FEET APART BASED ON ANTICIPATED CONTRACTOR CAPABILITIES TO CLEANOUT UP TO 500-FEET IN EACH DIRECTION FROM EACH CLEANOUT. EACH CLEANOUT WILL CONSIST OF THE PIPING PASSING THROUGH A PRECAST MANHOLE AND A 2-FOOT FLANGED SPOOL PIECE AND EXPANSION DEVICE TO ALLOW FOR REMOVAL AND ACCESS WITH CLEANOUT EQUIPMENT.

REFERENCE(S)

1. EXISTING GRADES PROVIDED BY MPC ON APRIL 4,2021 (2021-04-06 Minnkota flight_elev1.0ft_res100cm_size20_DSM.dwg). EXISTING GRADES WERE OBTAINED USING AERIAL LIDAR. EXISTING BUILDING AND STRUCTURES WERE SCANNED AND HAVE NOT BEEN REMOVED FROM THE DATA SET.
2. EXISTING GRADES CONTOUR INTERVAL IS TWO FEET.
3. COORDINATE SYSTEM: NORTH DAKOTA STATE PLANE SOUTH ZONE NAD 27. VERTICAL DATUM IS NVGD 1929.
4. AERIAL IMAGERY: NATIONAL AGRICULTURE IMAGERY PROGRAM (NAIP), USDA. IMAGE FLOWN AUGUST 10, 2020.
5. EXISTING YARD PIPING AND DUCT BANKS WERE PROVIDED BY MPC ON MAY 3, 2021 (UU-0-000.dwg). THE YARD PIPING AND DUCT BANKS HAVE BEEN TRANSLATED TO NORTH DAKOTA STATE PLANE SOUTH ZONE NAD27 COORDINATES TO MATCH THE SURVEYED GRADES AND THE LOCATIONS SHOULD BE CONSIDERED APPROXIMATE.

NOT FOR CONSTRUCTION

CONCEPTUAL

0 200 400

1" = 200' FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2022-07-08	ISSUED FOR 60% DESIGN	BJP	BJP	AMS	TJS
A	2022-06-16	ISSUED FOR CLIENT REVIEW	BJP	BCB	AMS	TJS

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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

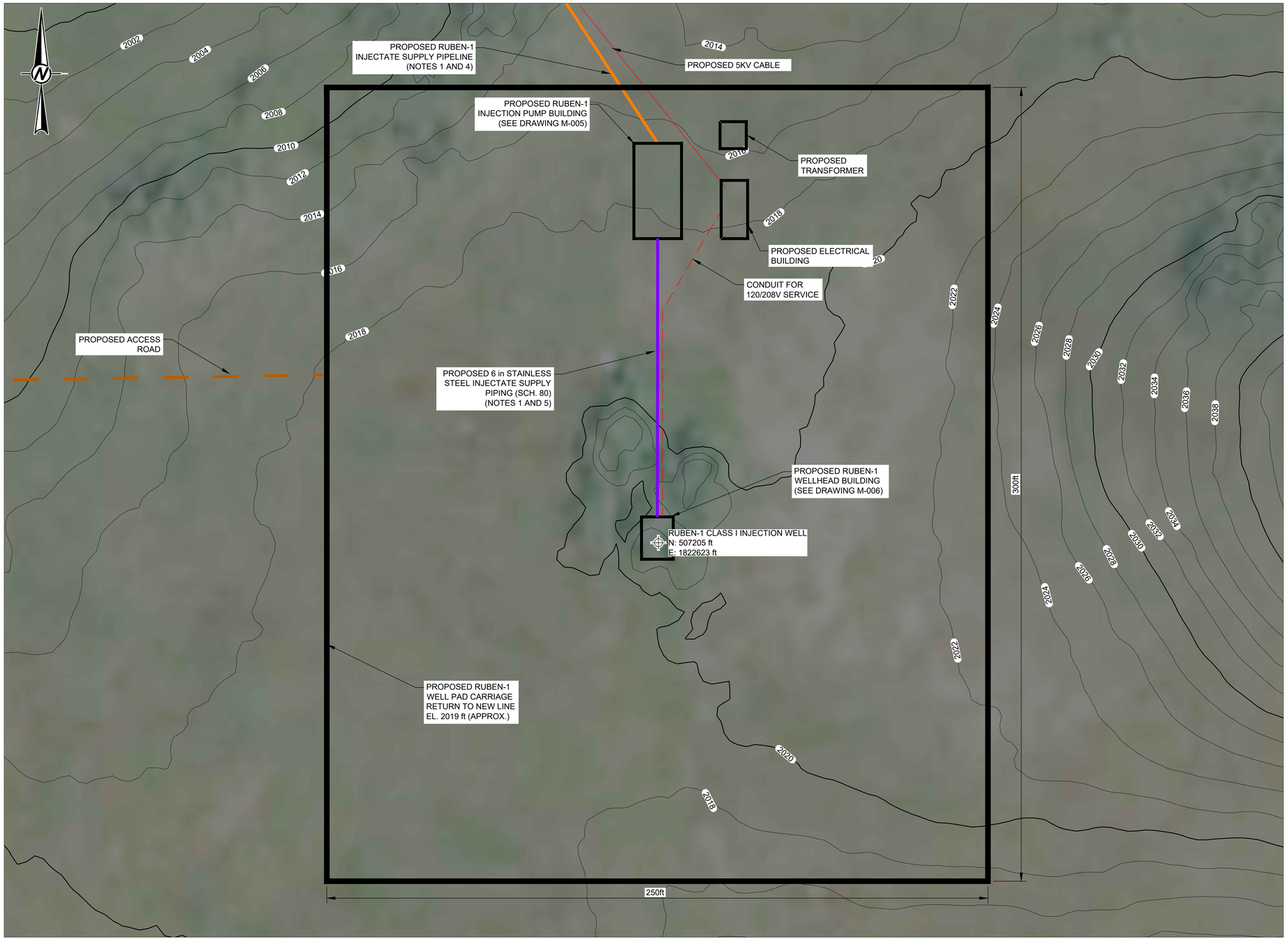
TITLE
YARD PIPING - DRAINS VAULT TO RUBEN-1 WELLHEAD BUILDING

PROJECT NO. 19122669 | REV. B | DRAWING C-005

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

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LEGEND

- 2000 — EXISTING GRADES (REFERENCES 1 AND 2)
- PROPOSED ACCESS ROAD
- PROPOSED HDPE INJECTATE SUPPLY PIPING (NOTES 1 AND 4)
- PROPOSED STAINLESS STEEL INJECTATE SUPPLY PIPING (NOTES 1 AND 5)
- PROPOSED 4160 V (5KV) CABLE
- PROPOSED CONDUIT
- CLASS I INJECTION WELL (CONSTRUCTED BY OTHERS)

NOTE(S)

1. INJECTATE SUPPLY PIPELINE TO RUBEN-1 IS CONCEPTUAL AND WILL BE UPDATED DURING DETAILED DESIGN.
2. UNDERGROUND PIPING SHALL HAVE A MINIMUM OF 5 FEET OF COVER FOR FROST PROTECTION.
3. LOCATIONS AND ELEVATIONS OF EXISTING BELOW GRADE PIPING AND ELECTRICAL UTILITIES TO BE CONFIRMED PRIOR TO CONSTRUCTION.
4. UNDERGROUND PIPING BETWEEN THE DRAINS VAULT AND THE RUBEN-1 INJECTION PUMP SHALL BE 12 in HDPE IPS DR 11 PIPE.
5. UNDERGROUND PIPING ON THE DISCHARGE SIDE OF THE RUBEN-1 INJECTION PUMP SHALL BE 6 in SCHEDULE 80 STAINLESS STEEL PIPE. FLANGES ON THE DISCHARGE SIDE OF THE INJECTION PUMP SHALL BE CLASS 600.
6. RUBEN-1 INJECTION PUMP BUILDING AND WELLHEAD BUILDING WILL GENERALLY MATCH THE FREEMAN-1 BUILDINGS. BUILDING ORIENTATIONS AND PIPING ALIGNMENTS WITHIN BUILDINGS WILL DIFFER.

REFERENCE(S)

1. EXISTING GRADES PROVIDED BY MPC ON APRIL 4,2021 (2021-04-06 Minnkota flight_elev1.0ft_res100cm_size20_DSM.dwg). EXISTING GRADES WERE OBTAINED USING AERIAL LIDAR. EXISTING BUILDING AND STRUCTURES WERE SCANNED AND HAVE NOT BEEN REMOVED FROM THE DATA SET.
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3. COORDINATE SYSTEM: NORTH DAKOTA STATE PLANE SOUTH ZONE NAD 27. VERTICAL DATUM IS NVGD 1929.
4. AERIAL IMAGERY: NATIONAL AGRICULTURE IMAGERY PROGRAM (NAIP), USDA. IMAGE FLOWN AUGUST 10, 2020.

NOT FOR CONSTRUCTION

CONCEPTUAL

0 20 40
1" = 20' FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2022-07-08	ISSUED FOR 60% DESIGN	BJP	BJP	AMS	TJS
A	2022-06-16	ISSUED FOR CLIENT REVIEW	BJP	BCB	AMS	TJS

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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

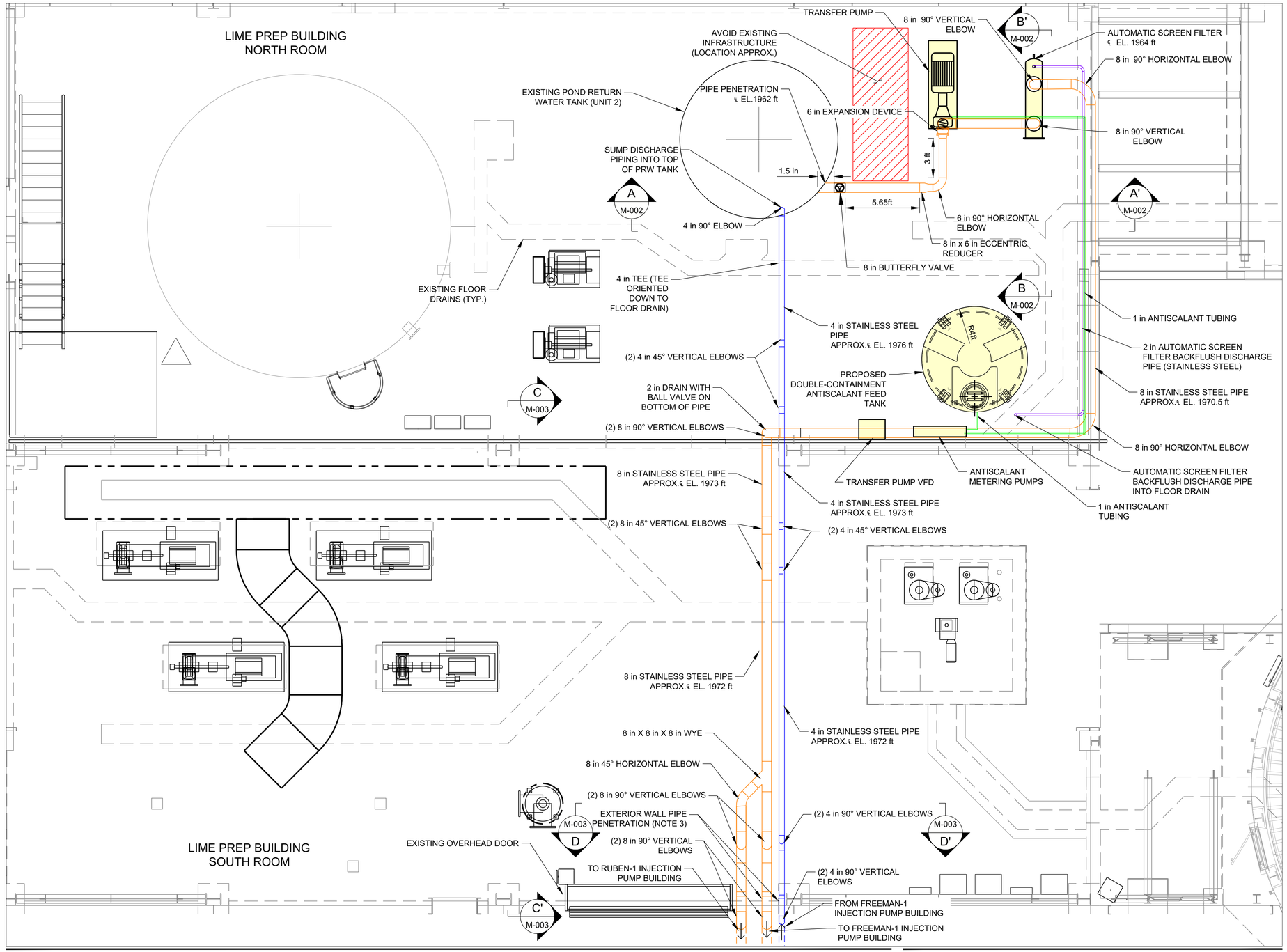
TITLE
YARD PIPING - RUBEN 1 WELL PAD LAYOUT

PROJECT NO. 19122669 | REV. B | DRAWING C-006

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

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LEGEND

- EXISTING LIME PREP BUILDING INFRASTRUCTURE (NOTE 2)
- EXISTING LIME PREP BUILDING FLOOR DRAINS
- PROPOSED EQUIPMENT
- PROPOSED INJECTATE SUPPLY PIPING (STAINLESS STEEL) (NOTES 1 AND 3)
- PROPOSED SUMP DISCHARGE PIPING (STAINLESS STEEL) (NOTES 1 AND 3)
- PROPOSED INJECTATE SUPPLY PIPING (HDPE)
- PROPOSED SUMP DISCHARGE PIPING (HDPE)
- PROPOSED ANTISCALANT TUBING
- PROPOSED AUTOMATIC SCREEN FILTER BACKFLUSH DISCHARGE PIPING (STAINLESS STEEL)

NOTE(S)

1. THE PROPOSED PIPING ALIGNMENT AIMS TO AVOID EXISTING INFRASTRUCTURE WITHIN THE LIME PREP BUILDING AS IDENTIFIED DURING SITE VISITS CONDUCTED BY GOLDER ON JUNE 21, 2021 AND OCTOBER 14, 2021, AND AS SHOWN IN THE THREE-DIMENSIONAL MODEL PROVIDED BY MPC (REFERENCE 2). DEVIATIONS FROM THE PROPOSED PIPE ALIGNMENT MAY BE NECESSARY TO AVOID CONFLICTS WITH EXISTING INFRASTRUCTURE. ALL PROPOSED DEVIATIONS FROM THE PROPOSED ALIGNMENT SHALL BE APPROVED BY THE OWNER'S REPRESENTATIVE DURING CONSTRUCTION.
2. EXISTING INFRASTRUCTURE SHOWN ON THESE DRAWINGS IS FOR INFORMATION PURPOSES ONLY AND MAY NOT BE INCLUSIVE OF ALL EXISTING PIPING AND INFRASTRUCTURE.
3. ALL PROPOSED PIPING WITHIN THE LIME PREP BUILDING SHALL BE SCHEDULE 40 STAINLESS STEEL PIPE, UNLESS OTHERWISE NOTED. PIPE SHALL TRANSITION TO HDPE IPS DR11 PIPE UPON EXITING THE BUILDING.

REFERENCE(S)

1. EXISTING LIME PREP BUILDING, EQUIPMENT, AND OTHER COMPONENTS EXTRACTED FROM THE LIME PREPARATION BUILDING DRAWING (GA-331.dwg) PROVIDED BY MPC.
2. EXISTING PIPE ELEVATIONS AND APPROXIMATE LOCATIONS EXTRACTED FROM THE THREE-DIMENSIONAL MODEL PROVIDED BY MPC ON AUGUST 10, 2021 (MINNKOTA MASTER 1-26-21.NWD).

NOT FOR CONSTRUCTION

ISSUED FOR 60% DESIGN

0 4 8

1" = 4' FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

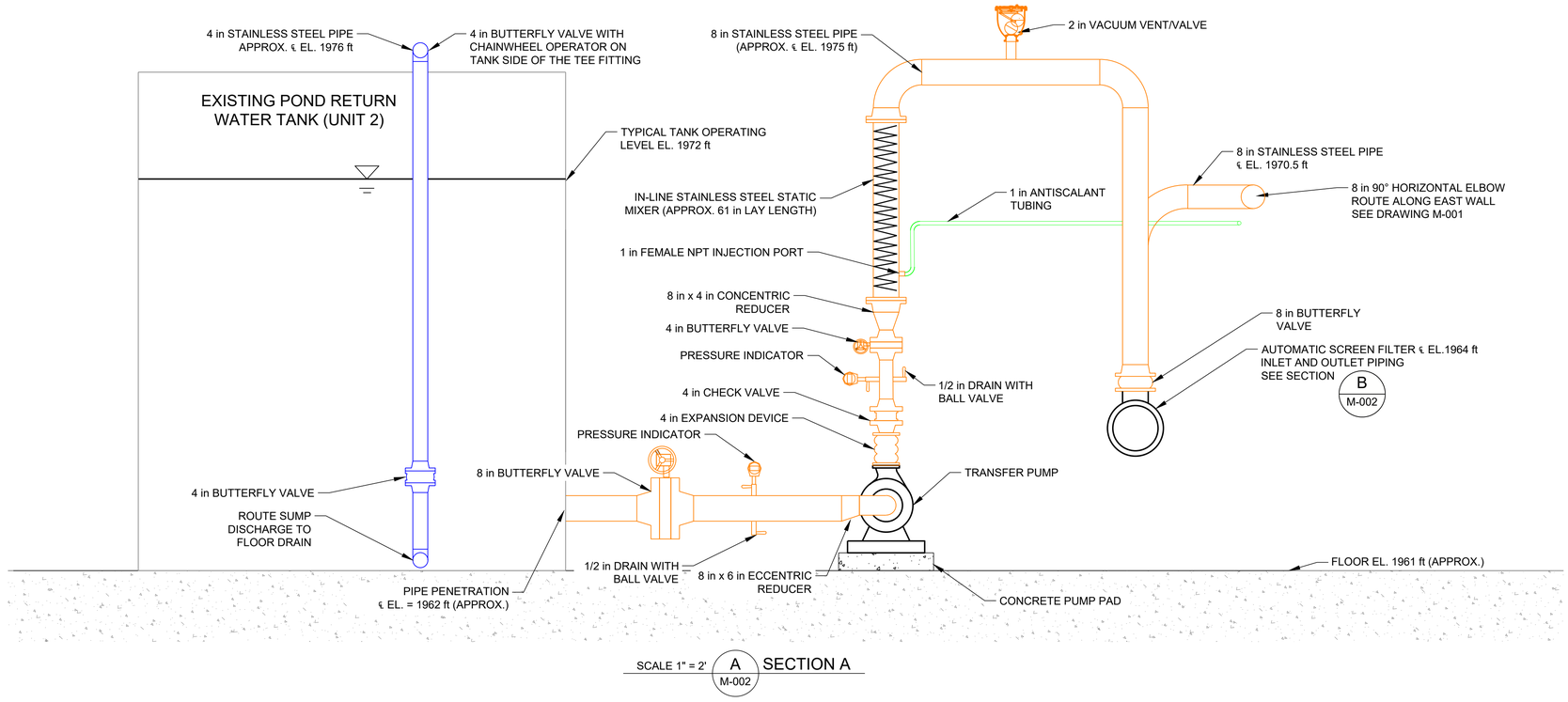
TITLE
LIME PREP BUILDING PLAN VIEW

PROJECT NO. 19122669 | REV. C | DRAWING M-001

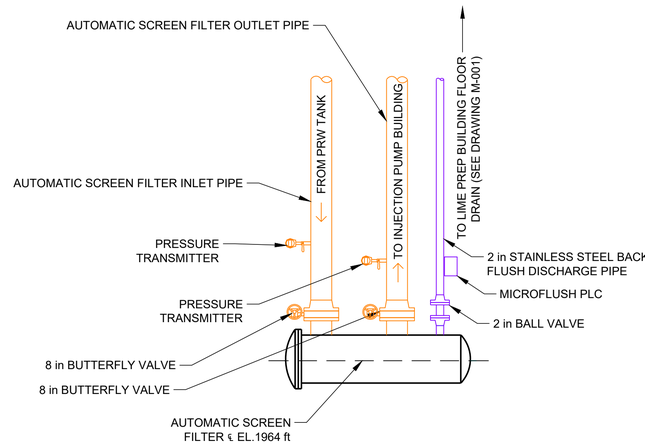
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

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Path: \\golder.gds\complexdata\office\Denver\acad\Minnkota Power Cooperative\09_PROJECTS\19122669\B - Infrastructure\02_PRODUCTION\DWG\ | File Name: 19122669A003.dwg | Last Edited By: adarr Date: 2022-07-08 Time:9:20:22 AM | Printed By: ADarr Date: 2022-07-08 Time:9:20:54 AM



SCALE 1" = 2' A M-002 SECTION A



SCALE 1" = 2' B M-002 AUTOMATIC SCREEN FILTER SECTION

LEGEND

- EXISTING LIME PREP BUILDING INFRASTRUCTURE (NOTE 2)
- EXISTING CONCRETE FLOOR
- PROPOSED EQUIPMENT
- PROPOSED INJECTATE SUPPLY PIPING (STAINLESS STEEL) (NOTES 1 AND 3)
- PROPOSED ANTISCALANT TUBING
- PROPOSED SUMP DISCHARGE PIPING (STAINLESS STEEL) (NOTE 3)
- PROPOSED AUTOMATIC SCREEN FILTER BACKFLUSH DISCHARGE PIPING (STAINLESS STEEL)

NOTE(S)

1. THE PROPOSED PIPING ALIGNMENT AIMS TO AVOID EXISTING INFRASTRUCTURE WITHIN THE LIME PREP BUILDING AS IDENTIFIED DURING SITE VISITS CONDUCTED BY GOLDER ON JUNE 21, 2021 AND OCTOBER 14, 2021, AND AS SHOWN IN THE THREE-DIMENSIONAL MODEL PROVIDED BY MPC (REFERENCE 2). DEVIATIONS FROM THE PROPOSED PIPE ALIGNMENT MAY BE NECESSARY TO AVOID CONFLICTS WITH EXISTING INFRASTRUCTURE. ALL PROPOSED DEVIATIONS FROM THE PROPOSED ALIGNMENT SHALL BE APPROVED BY THE OWNER'S REPRESENTATIVE DURING CONSTRUCTION.
2. EXISTING INFRASTRUCTURE SHOWN ON THESE DRAWINGS IS FOR INFORMATION PURPOSES ONLY AND MAY NOT BE INCLUSIVE OF ALL EXISTING PIPING AND INFRASTRUCTURE.
3. ALL PROPOSED PIPING WITHIN THE LIME PREP BUILDING SHALL BE SCHEDULE 40 STAINLESS STEEL PIPE, UNLESS OTHERWISE NOTED. PIPE SHALL TRANSITION TO HDPE IPS DR11 PIPE UPON EXITING THE BUILDING.

REFERENCE(S)

1. EXISTING LIME PREP BUILDING, EQUIPMENT, AND OTHER COMPONENTS EXTRACTED FROM THE LIME PREPARATION BUILDING DRAWING (GA-331.dwg) PROVIDED BY MPC.
2. EXISTING PIPE ELEVATIONS AND APPROXIMATE LOCATIONS EXTRACTED FROM THE THREE-DIMENSIONAL MODEL PROVIDED BY MPC ON AUGUST 10, 2021 (MINNKOTA MASTER 1-26-21.NWD)

NOT FOR CONSTRUCTION

ISSUED FOR 60% DESIGN

0 2 4
1" = 2' FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
C	2022-07-08	ISSUED FOR 60% DESIGN	BJP	BJP	AMS	TJS
B	2022-06-16	REVISED ISSUED FOR CLIENT REVIEW	BJP	BCB	AMS	TJS
A	2022-02-07	ISSUED FOR CLIENT REVIEW	BJP	BJP	AMS	TJS

CLIENT
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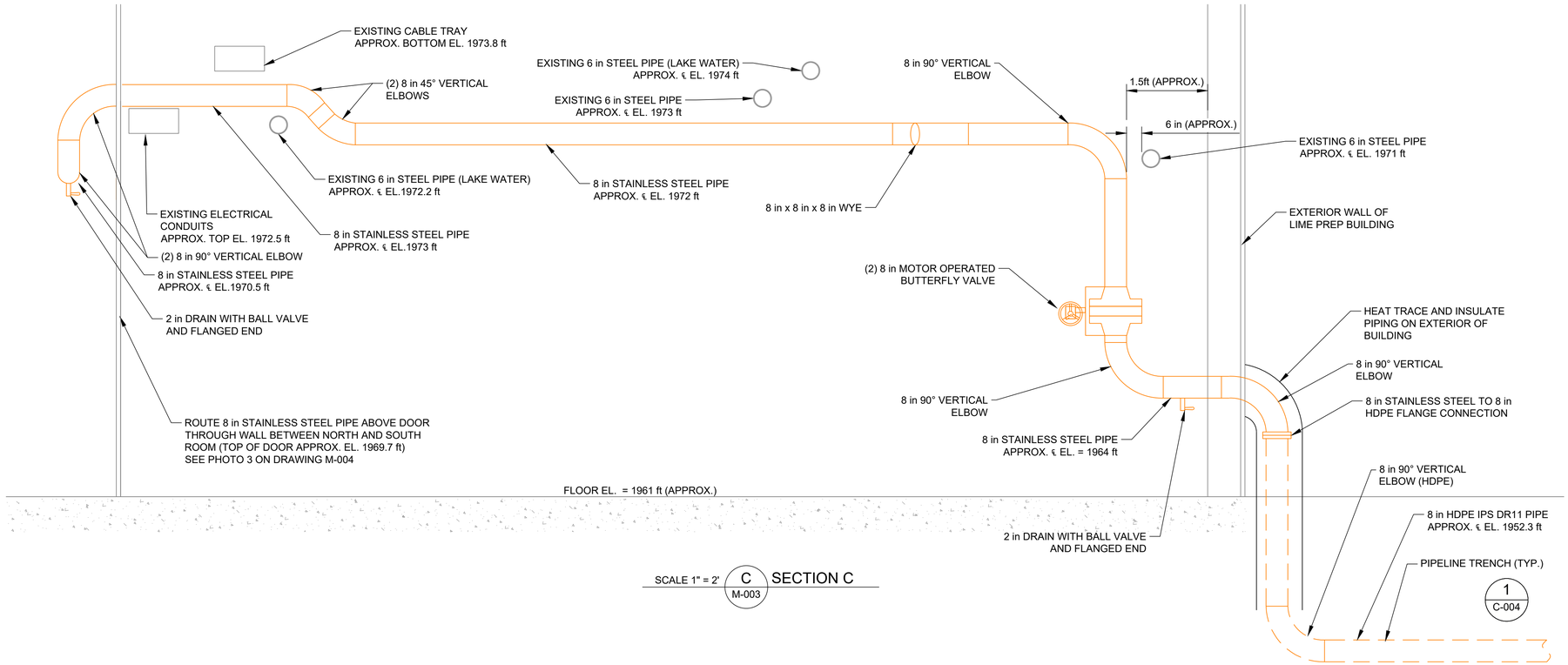
PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
LIME PREP BUILDING SECTION VIEWS (1 OF 2)

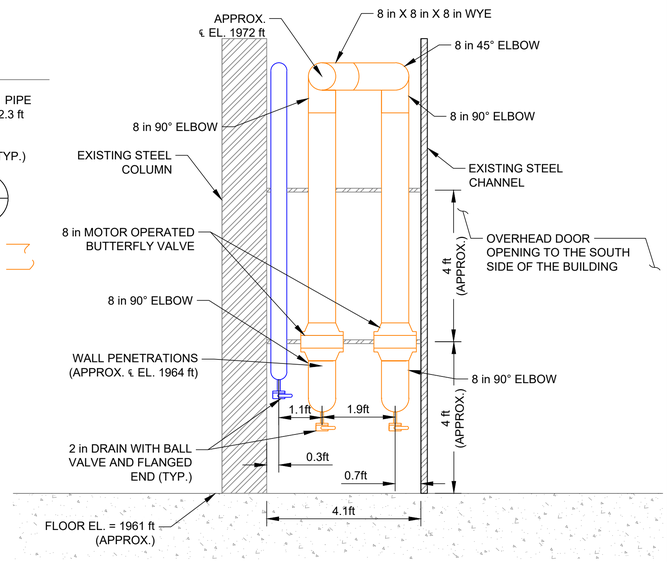
PROJECT NO. 19122669 | REV. C | DRAWING M-002

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SCALE 1" = 2' C M-003 SECTION C



SCALE 1" = 2' D M-003 SECTION D

NOT FOR CONSTRUCTION

ISSUED FOR 60% DESIGN

0 2 4
1" = 2' FEET

LEGEND

- EXISTING LIME PREP BUILDING INFRASTRUCTURE (NOTE 2)
- EXISTING CONCRETE FLOOR
- PROPOSED SUMP DISCHARGE PIPING (STAINLESS STEEL) (NOTE 3)
- PROPOSED INJECTATE SUPPLY PIPING (STAINLESS STEEL) (NOTE 3)
- PROPOSED INJECTATE SUPPLY PIPING (HDPE)

NOTE(S)

1. THE PROPOSED PIPING ALIGNMENT AIMS TO AVOID EXISTING INFRASTRUCTURE WITHIN THE LIME PREP BUILDING AS IDENTIFIED DURING SITE VISITS CONDUCTED BY GOLDER ON JUNE 21, 2021 AND OCTOBER 14, 2021, AND AS SHOWN IN THE THREE-DIMENSIONAL MODEL PROVIDED BY MPC (REFERENCE 2). DEVIATIONS FROM THE PROPOSED PIPE ALIGNMENT MAY BE NECESSARY TO AVOID CONFLICTS WITH EXISTING INFRASTRUCTURE. ALL PROPOSED DEVIATIONS FROM THE PROPOSED ALIGNMENT SHALL BE APPROVED BY THE OWNER'S REPRESENTATIVE DURING CONSTRUCTION.
2. EXISTING INFRASTRUCTURE SHOWN ON THESE DRAWINGS IS FOR INFORMATION PURPOSES ONLY AND MAY NOT BE INCLUSIVE OF ALL EXISTING PIPING AND INFRASTRUCTURE.
3. ALL PROPOSED PIPING WITHIN THE LIME PREP BUILDING SHALL BE SCHEDULE 40 STAINLESS STEEL PIPE, UNLESS OTHERWISE NOTED. PIPE SHALL TRANSITION TO HDPE IPS DR11 PIPE UPON EXITING THE BUILDING.
4. THE 4 in SUMP DISCHARGE PIPING SHALL GENERALLY FOLLOW THE SAME PROFILE AS THE 8 in INJECTATE SUPPLY PIPING. THE 4 in SUMP DISCHARGE PIPING SHALL TERMINATE IN THE LOCATION SHOWN ON DRAWING M-001 AND THIS DRAWING.

REFERENCE(S)

1. EXISTING LIME PREP BUILDING, EQUIPMENT, AND OTHER COMPONENTS EXTRACTED FROM THE LIME PREPARATION BUILDING DRAWING (GA-331.dwg) PROVIDED BY MPC.
2. EXISTING PIPE ELEVATIONS AND APPROXIMATE LOCATIONS EXTRACTED FROM THE THREE-DIMENSIONAL MODEL PROVIDED BY MPC ON AUGUST 10, 2021 (MINNKOTA MASTER 1-26-21.NWD)

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
C	2022-07-08	ISSUED FOR 60% DESIGN	BJP	BJP	AMS	TJS
B	2022-06-16	REVISED ISSUED FOR CLIENT REVIEW	BJP	BCB	AMS	TJS
A	2022-02-07	ISSUED FOR CLIENT REVIEW	BJP	BJP	AMS	TJS

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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
LIME PREP BUILDING SECTION VIEWS (2 OF 2)

PROJECT NO. 19122669 | REV. C | DRAWING M-003

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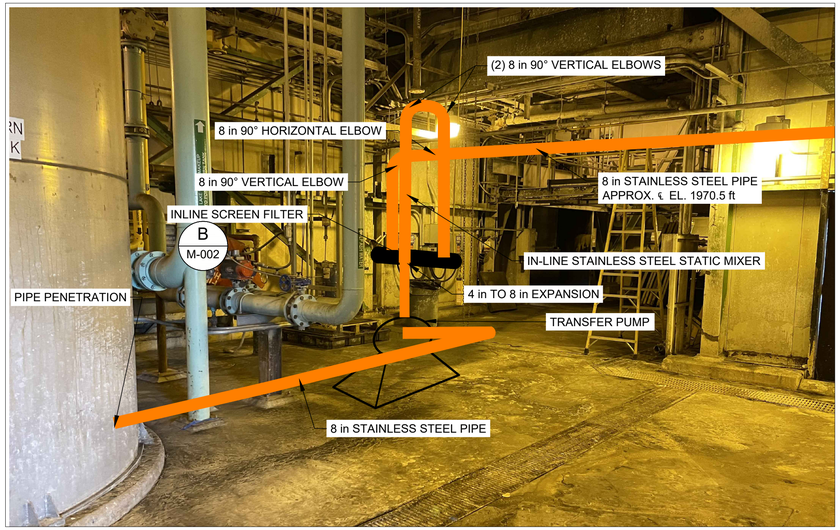


PHOTO 1. NORTH ROOM, LOOKING NORTHEAST

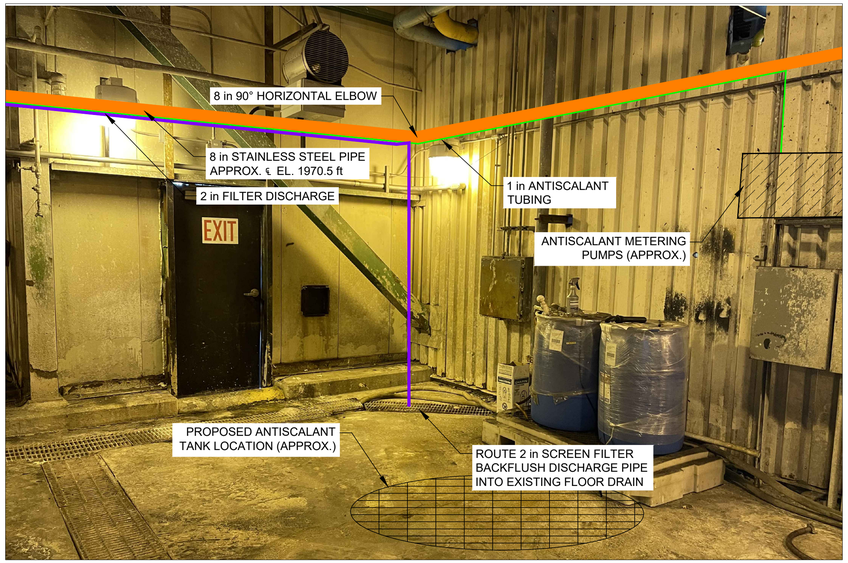


PHOTO 2. NORTH ROOM, LOOKING SOUTHEAST

LEGEND

- PROPOSED INJECTATE SUPPLY PIPING (STAINLESS STEEL)
- PROPOSED SUMP DISCHARGE PIPING (STAINLESS STEEL)
- PROPOSED AUTOMATIC SCREEN FILTER BACKFLUSH DISCHARGE PIPING (STAINLESS STEEL)
- PROPOSED ANTISCALANT TUBING

NOTE(S)

1. PHOTOS WITHIN THE LIME PREP BUILDING WERE TAKEN BY GOLDER DURING A SITE VISIT ON JUNE 21, 2021.
2. THE PROPOSED PIPING ALIGNMENT AIMS TO AVOID EXISTING INFRASTRUCTURE WITHIN THE LIME PREP BUILDING AS IDENTIFIED DURING SITE VISITS CONDUCTED BY GOLDER ON JUNE 21, 2021 AND OCTOBER 14, 2021, AND AS SHOWN IN THE THREE-DIMENSIONAL MODEL PROVIDED BY MPC. DEVIATIONS FROM THE PROPOSED PIPE ALIGNMENT MAY BE NECESSARY TO AVOID CONFLICTS WITH EXISTING INFRASTRUCTURE. ALL PROPOSED DEVIATIONS FROM THE PROPOSED ALIGNMENT SHALL BE APPROVED BY THE OWNER'S REPRESENTATIVE DURING CONSTRUCTION.
3. ALL PROPOSED PIPING WITHIN THE LIME PREP BUILDING SHALL BE SCHEDULE 40 STAINLESS STEEL PIPE, UNLESS OTHERWISE NOTED. PIPE SHALL TRANSITION TO HDPE IPS DR11 PIPE UPON EXITING THE BUILDING.
4. ALL PIPING OUTSIDE OF THE LIME PREP BUILDING SHALL BE HEAT TRACED AND INSULATED WHEN ABOVE FROST DEPTH (APPROXIMATELY 5 FEET BELOW GROUND SURFACE).



PHOTO 3. SOUTH ROOM, LOOKING NORTHEAST

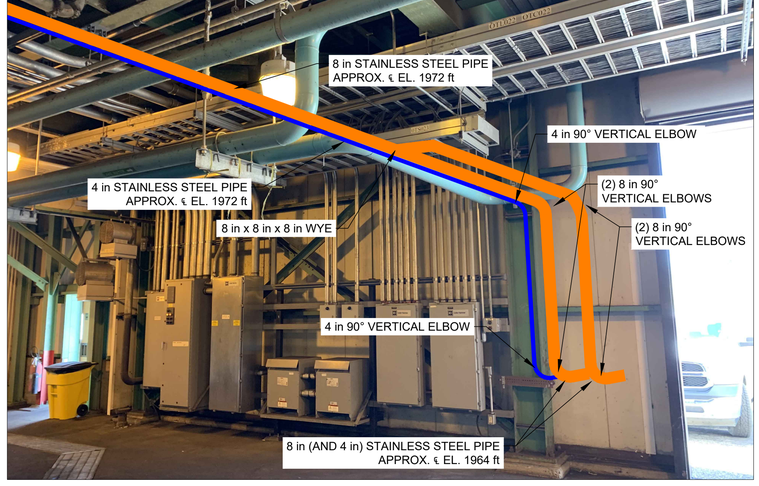


PHOTO 4. SOUTH ROOM, LOOKING SOUTH

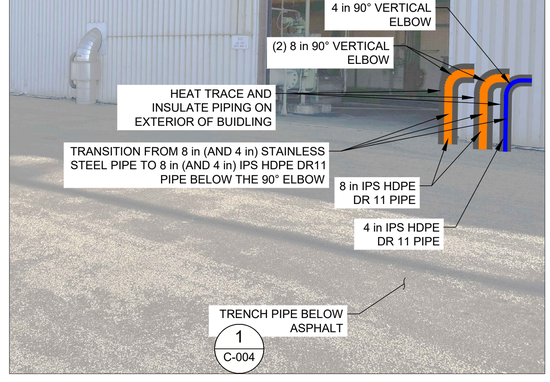


PHOTO 5. OUTSIDE OF SOUTH ROOM, LOOKING NORTHWEST

NOT FOR CONSTRUCTION

ISSUED FOR 60% DESIGN

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
C	2022-07-08	ISSUED FOR 60% DESIGN	BJP	BJP	AMS	TJS
B	2022-06-16	REVISED ISSUED FOR CLIENT REVIEW	BJP	BCB	AMS	TJS
A	2022-02-07	ISSUED FOR CLIENT REVIEW	BJP	BJP	AMS	TJS

CLIENT
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CENTER, NORTH DAKOTA

CONSULTANT
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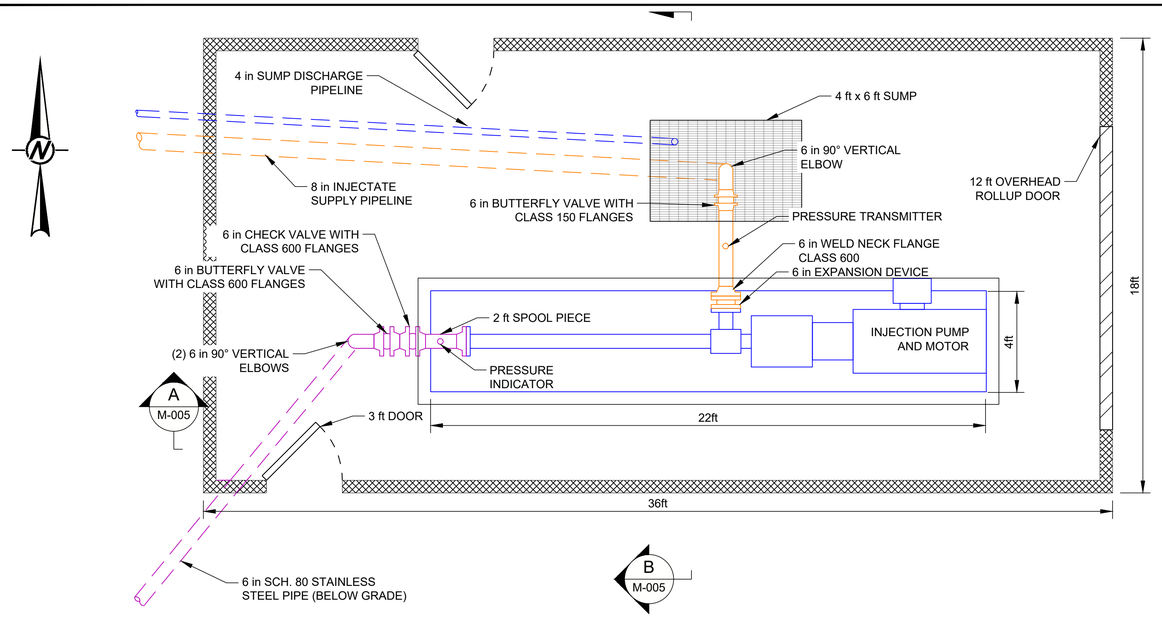
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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

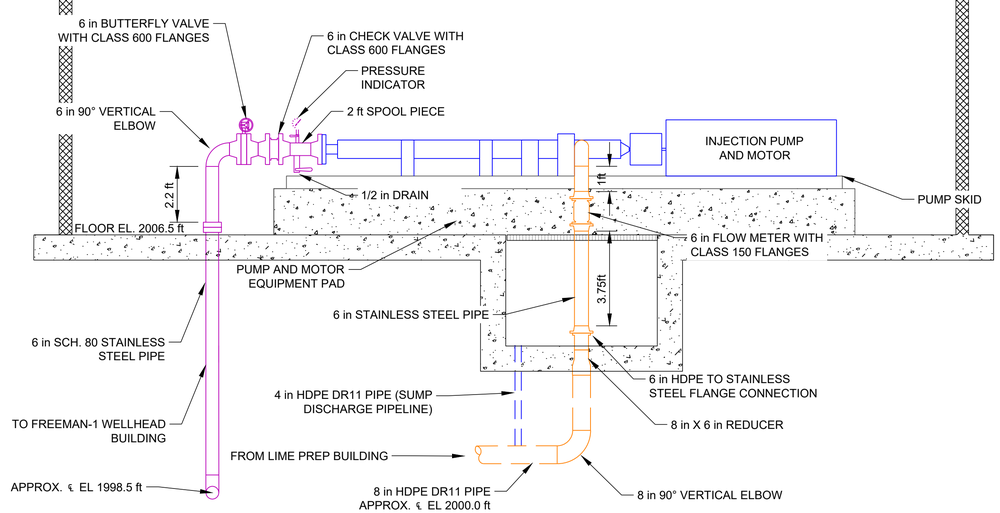
TITLE
LIME PREP BUILDING SECTION PHOTOS

PROJECT NO. 19122669 | REV. C | DRAWING M-004

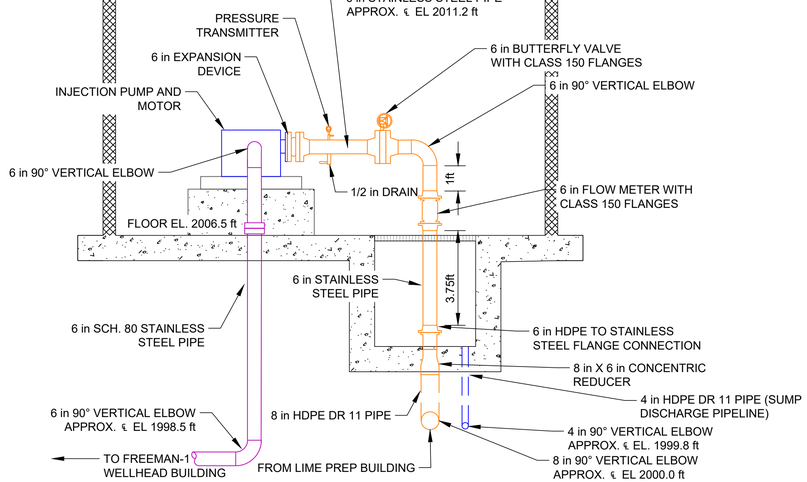
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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
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SCALE 1" = 3' (1 / M-005) PUMPHOUSE BUILDING PIPING PLAN



SCALE 1" = 3' (A / M-005) PUMPHOUSE BUILDING PIPING SECTION



SCALE 1" = 3' (B / M-005) PUMPHOUSE BUILDING PIPING SECTION

LEGEND

- PROPOSED INJECTATE SUPPLY PIPELINE (SCH. 40 STAINLESS STEEL) (NOTE 3)
- PROPOSED INJECTATE SUPPLY PIPELINE (HDPE)
- PROPOSED INJECTATE SUPPLY PIPELINE (SCH. 80 STAINLESS STEEL) (NOTE 4)
- PROPOSED SUMP DISCHARGE PIPELINE (HDPE)
- PROPOSED INJECTION PUMP BUILDING STRUCTURES
- PROPOSED CONCRETE

NOTE(S)

1. UNDERGROUND PIPING FROM THE LIME PREP BUILDING TO THE INJECTION PUMP BUILDING SHALL BE HDPE IPS DR11 PIPE UNLESS OTHERWISE NOTED.
2. ALL PIPING WITHIN THE INJECTION PUMP BUILDING SHALL BE STAINLESS STEEL PIPE.
3. PIPING ON THE SUCTION SIDE OF THE INJECTION PIPE SHALL BE SCHEDULE 40 STAINLESS STEEL PIPE. FLANGES ON THE SUCTION SIDE OF THE INJECTION PUMP SHALL BE CLASS 150.
4. PIPING ON THE DISCHARGE SIDE OF THE INJECTION PUMP SHALL BE SCHEDULE 80 STAINLESS STEEL PIPE. FLANGES ON THE DISCHARGE SIDE OF THE INJECTION PUMP SHALL BE CLASS 600. UNDERGROUND PIPING ON THE DISCHARGE SIDE OF INJECTION PUMP SHALL ALSO BE SCHEDULE 80 STAINLESS STEEL PIPE.

NOT FOR CONSTRUCTION

ISSUED FOR 60% DESIGN

0 3 6
1" = 3' FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
C	2022-07-08	ISSUED FOR 60% DESIGN	BJP	BJP	AMS	TJS
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A	2022-02-07	ISSUED FOR CLIENT REVIEW	BJP	BJP	AMS	TJS

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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

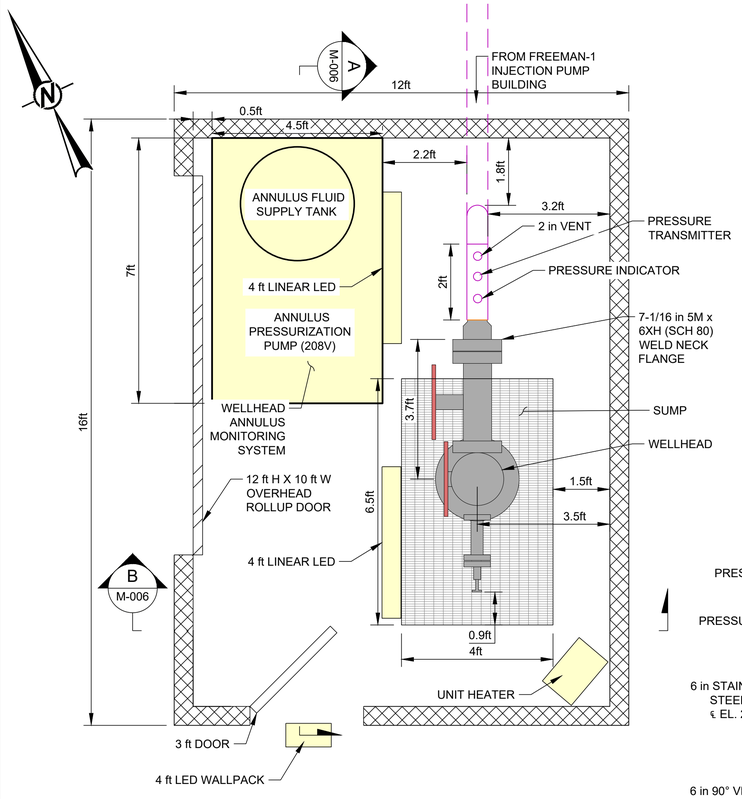
TITLE
INJECTION PUMP BUILDING PIPING

PROJECT NO. 19122669 | REV. C | DRAWING M-005

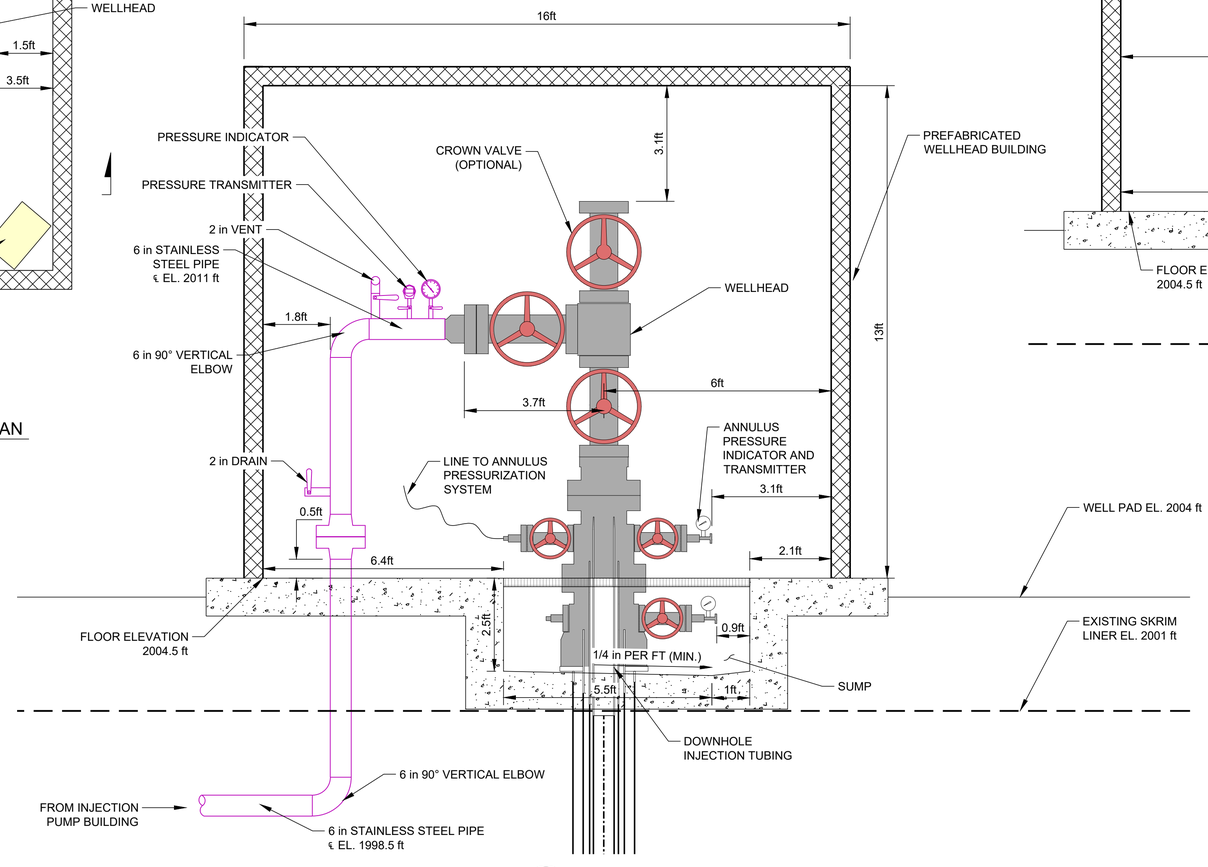
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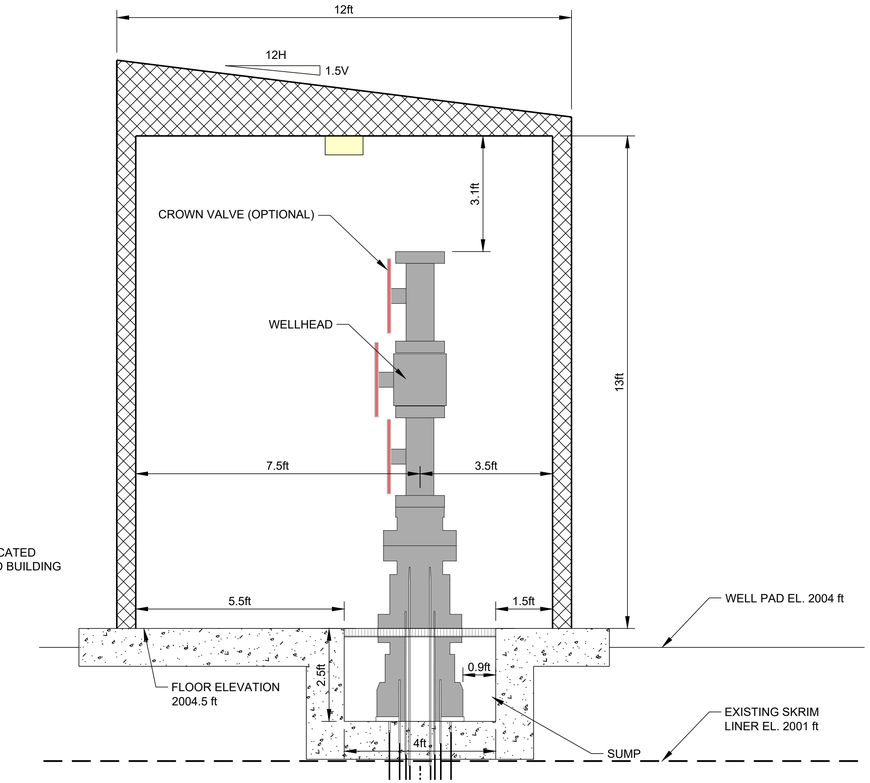
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SCALE 1" = 2' (1 / M-006) WELLHEAD BUILDING PIPING PLAN



SCALE 1" = 2' (A / M-006) WELLHEAD BUILDING PIPING SECTION A



SCALE 1" = 2' (B / M-006) WELLHEAD BUILDING SECTION B

LEGEND

- EXISTING WELL PAD
- EXISTING SKRIM LINER
- PROPOSED INJECTATE SUPPLY PIPELINE (SCHEDULE 80 STEEL) (NOTE 1)
- PROPOSED WELLHEAD BUILDING STRUCTURES
- PROPOSED CONCRETE
- PROPOSED GRATING
- PROPOSED EQUIPMENT

NOTE(S)

1. PIPING ON THE DISCHARGE SIDE OF THE INJECTION PUMP (INCLUDING UNDERGROUND PIPING) SHALL BE SCHEDULE 80 STEEL PIPE. ALL FLANGES ON THE DISCHARGE SIDE OF THE INJECTION PUMP SHALL BE RATED TO AT LEAST CLASS 600.

NOT FOR CONSTRUCTION

ISSUED FOR 60% DESIGN

0 2 4
1" = 2' FEET

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B	2022-06-16	REVISED ISSUED FOR CLIENT REVIEW	BJP	BCB	AMS	TJS
A	2022-02-07	ISSUED FOR CLIENT REVIEW	BJP	BJP	AMS	TJS

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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
WELLHEAD BUILDING PIPING

PROJECT NO. 19122669 | REV. C | DRAWING M-006

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

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INSTRUMENTATION SYMBOLS

NORMALLY ACCESSIBLE TO OPERATOR *

FIELD MOUNTED	PRIMARY LOCATION	AUXILIARY LOCATION
DISCRETE INSTRUMENTATION	DISCRETE INSTRUMENTATION	DISCRETE INSTRUMENTATION
SHARED DISPLAY, SHARED CONTROL	SHARED DISPLAY, SHARED CONTROL	SHARED DISPLAY, SHARED CONTROL
COMPUTER FUNCTION	COMPUTER FUNCTION	COMPUTER FUNCTION
PROGRAMMABLE LOGIC CONTROL	PROGRAMMABLE LOGIC CONTROL	PROGRAMMABLE LOGIC CONTROL

* INACCESSIBLE OR BEHIND THE PANEL DEVICES OR FUNCTIONS DEPICTED BY USING SAME SYMBOLS BUT WITH DASHED HORIZONTAL BAR

EN — EN ETHERNET

INSTRUMENTATION SUPPLY

PNEUMATIC

ELECTRICAL

HEAT TRACE

SOFTWARE LINK

HYDRAULIC SIGNAL

CAPILLARY TUBING

FLEX HOSE

UNDEFINED LOGIC INTERLOCK

XX INSTRUMENT TYPE

XX INSTRUMENT NUMBER

IDENTIFICATION LETTERS

	FIRST-LETTER		SUCCEEDING-LETTERS		
	MEASURED OR INITIATING VARIABLE	MODIFIER	READOUT OR PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER
A	ANALYSIS		ALARM		
B	BURNER, COMBUSTION		USER'S CHOICE	USER'S CHOICE	USER'S CHOICE
C	USER'S CHOICE			CONTROL	
D	USER'S CHOICE	DIFFERENTIAL			
E	VOLTAGE		SENSOR (PRIMARY ELEMENT)		
F	FLOW RATE	RATIO (FRACTION)	GLASS, VIEWING DEVICE	RATIO (FRACTION)	
G	USER'S CHOICE				
H	HAND				HIGH
I	CURRENT (ELECTRICAL)		INDICATE		
J	POWER	SCAN			
K	TIME, TIME SCHEDULE	TIME, RATE OF CHANGE		CONTROL STATION	
L	LEVEL		LIGHT		LOW
M	USER'S CHOICE	MOMENTARY			MIDDLE, INTERMEDIATE
N	USER'S CHOICE		USER'S CHOICE	USER'S CHOICE	USER'S CHOICE
O	USER'S CHOICE		ORIFICE, RESTRICTION		
P	PRESSURE, VACUUM		POINT (TEST) CONNECTION		
Q	QUANTITY	INTEGRATE TOTALIZE			
R	RADIATION		RECORD		
S	SPEED, FREQUENCY	SAFETY		SWITCH	
T	TEMPERATURE			TRANSMIT	
U	MULTIVARIABLE		MULTIFUNCTION	MULTIFUNCTION	MULTIFUNCTION
V	VIBRATION			VALVE, DAMPER LOUVER	
W	WEIGHT, FORCE		WELL		
X	UNCLASSIFIED	X AXIS	UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED
Y	EVENT, STATE OR PRESENCE	Y AXIS		RELAY, COMPUTE CONVERT	
Z	POSITION, DIMENSION	Z AXIS		DRIVER, ACTUATOR UNCLASSIFIED FINAL CONTROL ELEMENT	

NOTES:

1. SYMBOLS SHOWN ON THIS DRAWING ARE PER AMERICAN NATIONAL STANDARD INSTRUMENTATION SYMBOLS AND IDENTIFICATION (ANSI/ISA-S5.1-1984).
2. ALL SYMBOLS SHOWN MAY NOT BE INCORPORATED IN THIS PROJECT.

PIPE SERVICE ABBREVIATION

ABBV.	SERVICE
AS	ANTISCALANT

GENERAL ABBREVIATIONS

ABBV.	
DC	DOUBLE CONTAINED
HT	HEAT TRACE

PIPE SPECIFICATION DESIGNATION

ABBV.	
HDPE	HIGH DENSITY POLYETHYLENE
ST40	316L STAINLESS STEEL - SCH. 40
ST80	316L STAINLESS STEEL - SCH. 80
TU	TUBING

EQUIPMENT ABBREVIATIONS

ABBV.		ABBV.	
FL	FILTER	PRV	PRESSURE RELIEF VALVE
M	MOTOR	TK	TANK
P	PUMP	V	VALVE
PCV	PRESSURE CONTROL VALVE	VP	VENDOR PACKAGE

METERS

M FLOW METER

ACTUATORS

E/H ELECTRO/HYDRAULIC

M MOTOR OPERATED

PRESSURE REDUCING REGULATOR

PIPING SYMBOLS

VALVES

NC BALL

NC BUTTERFLY

SWING CHECK

4-WAY

LPD L.P.D. (LOW POINT DRAIN)

VALVE END TYPES

FLANGED

THREADED / UNSPECIFIED

LINE TYPES

MAIN PROCESS FLOW
MAJOR FLOW ARROW

SECONDARY FLOW
SECONDARY FLOW ARROW

ELECTRIC SIGNAL

VENDOR PACKAGE

LEAK PATH TO SUMP

PIPING SYMBOLS

2"-PPET INSULATION & HEAT TRACE

INSULATION THICKNESS & TYPE & TRACE TYPE

INSULATION ABBREVIATIONS

IC -INSULATE AGAINST COLD
IH -INSULATE TO RETAIN HEAT
PP -PERSONNEL PROTECTION
IS - SAFETY INSULATION
AU - ACOUSTIC INSULATION
AS - ANTI-SWEAT INSULATION
ET - ELECTRIC TRACE

FLANGE

CONCENTRIC REDUCER

ECCENTRIC REDUCER

TANK VENT TO ATMOSPHERE

PRESSURE INDICATORS

PI 1"-.-. 1"-.-. PI 1"-.-. PI 1"-.-. 3/4"-.-. 1"-.-.

TO or FROM ON-OFF PAGE CONNECTOR. (PROCESS LINES)

SPEC BREAK

PULSATION DAMPER

EQUIPMENT

PUMPS

CENTRIFUGAL PUMP

DIAPHRAGM PUMP

METERING PUMP

MIXER

INLINE STATIC MIXER

MOTOR

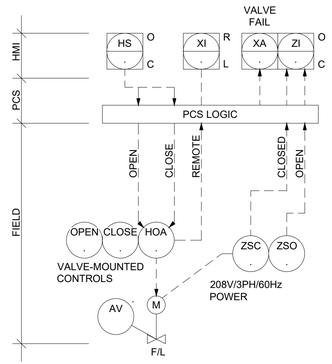
M ELECTRIC MOTOR ACUTATOR

TANK

DOUBLE WALL TANK

TYPICAL VALVE DETAILS

MISCELLANEOUS SYMBOLS



ELECTRIC ON/OFF VALVE DETAIL

F/L = FAIL LAST

NOT FOR CONSTRUCTION

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REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2022-07-08	ISSUED FOR 60% DESIGN	JCS	BCB	AMS	TJS
A	2022-06-16	ISSUED FOR CLIENT REVIEW	JCS	BCB	AMS	TJS

CLIENT
MINNKOTA POWER COOPERATIVE
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CENTER, NORTH DAKOTA

CONSULTANT
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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN

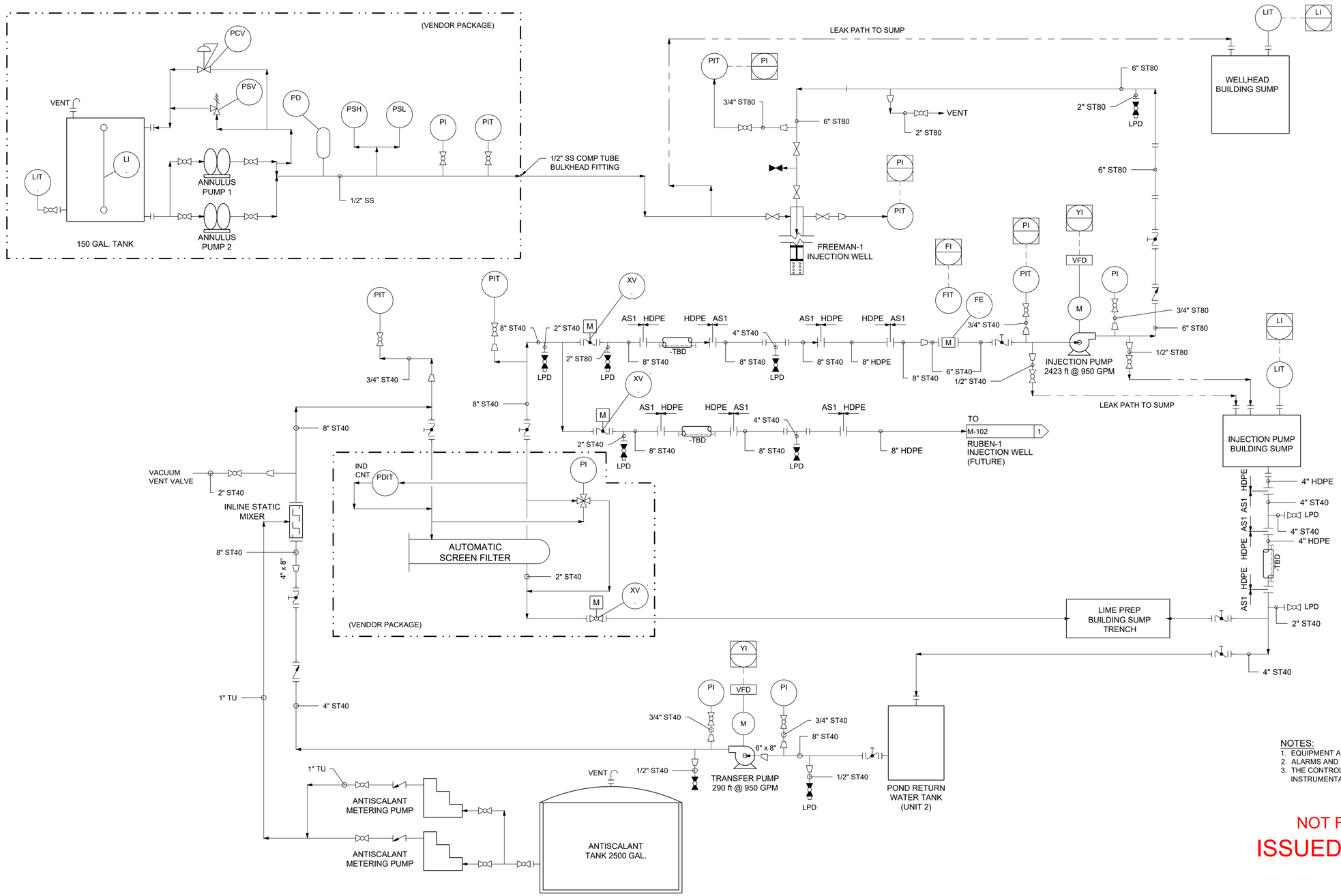
TITLE
PIPING AND INSTRUMENTATION DIAGRAM SYMBOLS AND ABBREVIATIONS

PROJECT NO.	REV.	of	DRAWING
19122669	B		M-007

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NOTES:
1. EQUIPMENT AND INSTRUMENTATION WITHIN THE SKID WILL BE BY OTHERS.
2. ALARMS AND INTERLOCKS WILL BE SHOWN ON THE "DETAILED DESIGN" P&ID.
3. THE CONTROL SIGNAL LINES BETWEEN EQUIPMENT AND INSTRUMENTATION WILL BE SHOWN ON THE "DETAILED DESIGN" P&ID.

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REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
C	2022-07-08	ISSUED FOR 60% DESIGN	JCS	BJP	AMS	TJS
B	2022-06-16	REVISED AND ISSUED FOR CLIENT REVIEW	JCS	BJP	AMS	TJS
A	2022-02-04	ISSUED FOR CLIENT REVIEW	JCS	BJP	AMS	TJS

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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN

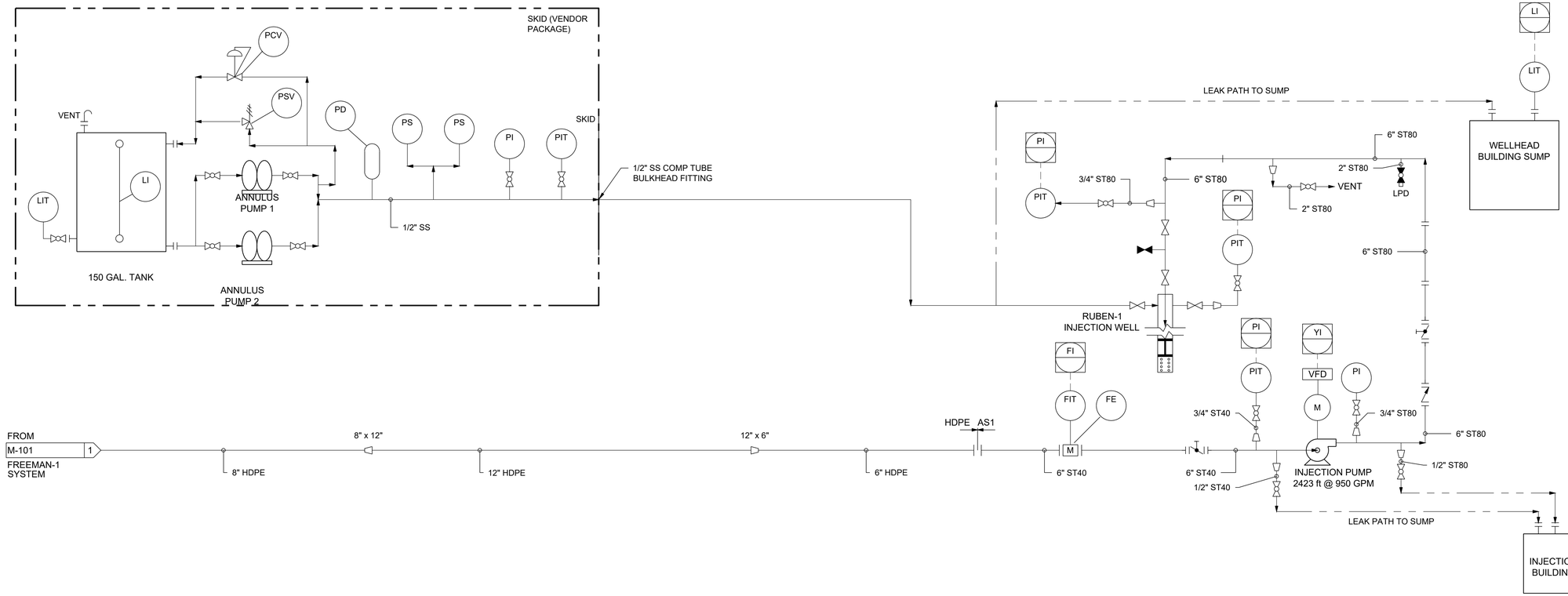
TITLE
PIPING AND INSTRUMENTATION DIAGRAM
FREEMAN-1 SYSTEM

PROJECT NO. 19122669 | REV. C | of | DRAWING M-008

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NOTES:
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C	2022-07-08	ISSUED FOR 60% DESIGN	JCS	BJP	AMS	TJS
B	2202-06-16	REVISED AND ISSUED FOR CLIENT REVIEW	JCS	BJP	AMS	TJS
A	2022-06-01	ISSUED FOR CLIENT REVIEW	JCS	BJP	AMS	TJS

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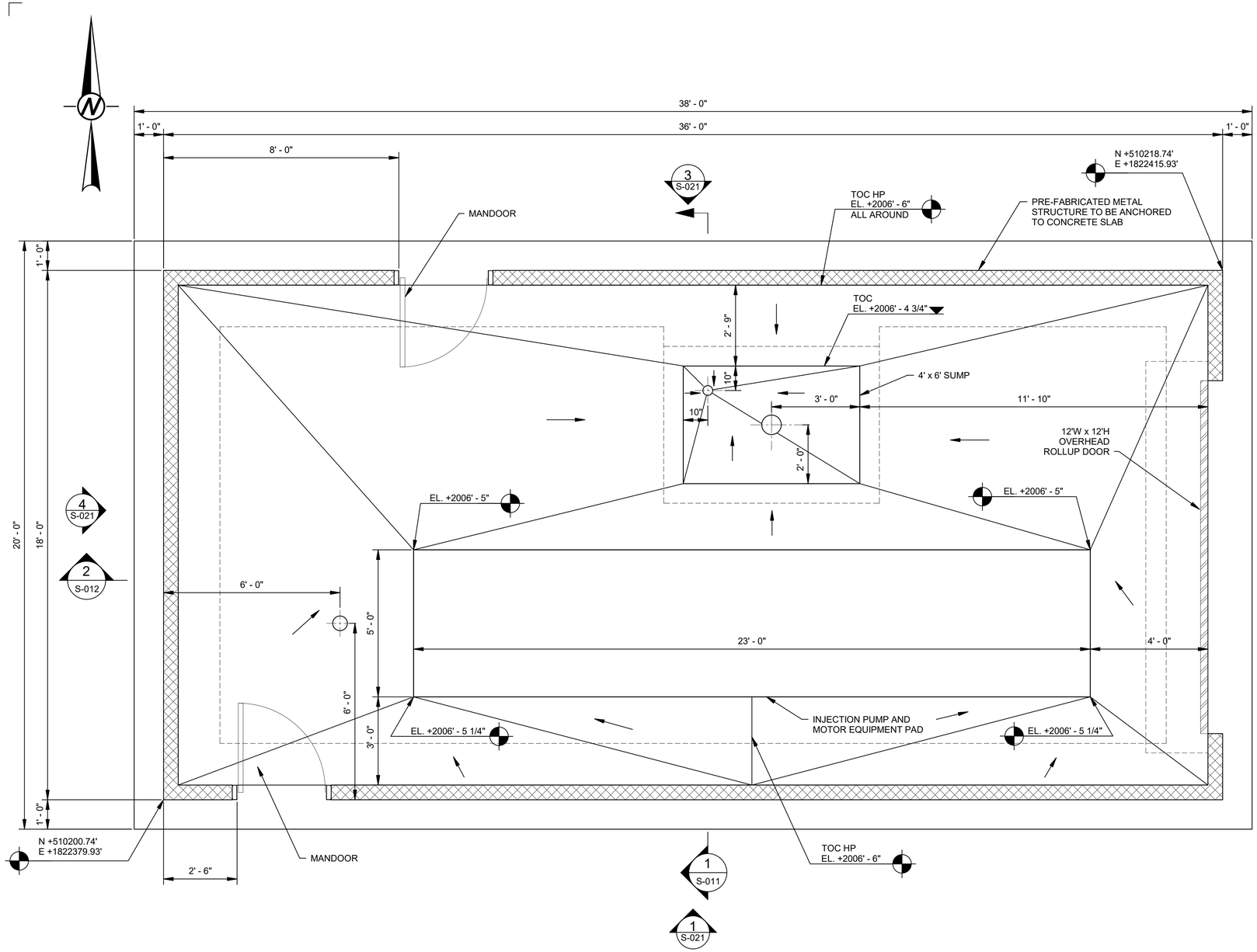
PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN

TITLE
PIPING AND INSTRUMENTATION DIAGRAM
RUBEN-1 SYSTEM

PROJECT NO. 19122669 | REV. C | of | DRAWING M-009

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FOUNDATION AND SLAB SLOPE PLAN

SCALE: 1/2" = 1'-0"

ABBREVIATIONS

@	AT	g	GRAVITATIONAL ACCELERATION	R	RADIUS
&	AND	GA	GAUGE	RD	ROOF DRAIN
'	FOOT	GALV	GALVANIZED	REF	REFERENCE
"	INCH	GEN	GENERAL	REINF	REINFORCEMENT
#	NUMBER	Gr	GRADE	REQD	REQUIRED
		GRTG	GRATING	REV	REVISION
ADD	ADDITIONAL	GYP	GYPSUM		
ADJ	ADJACENT			s	SECONDS
ALT	ALTERNATE	HEE	HOOKED EACH END	SCHED	SCHEDULE
ANC	ANCHOR	HEX	HEXAGON	SEC	SECTION
AR	ANCHOR RODS	HK	HOOK	SFD	STEP FOOTING DOWN
ARCH	ARCHITECT	HOR	HORIZONTAL	SHT	SHEET
AWS	AMERICAN WELDING SOCIETY	HP	HIGH POINT	SIM	SIMILAR
		HPFS	HIGH POINT FINISHED SURFACE	SOG	SLAB ON GRADE
BCD	BOLT CIRCLE DIAMETER	HR	HANDRIAL	SPCD	SPACED
BLDG	BUILDING	HSB	HIGH STRENGTH BOLTS	SPCG	SPACING
BLKG	BLOCKING			SPCS	SPACES
BM	BEAM	ID	INSIDE DIAMETER	SPEC	SPECIFICATIONS
BO	BOTTOM OF	INC	INCLUDE	SQ	SQUARE
BOF	BOTTOM OF FOOTING	INS	INSULATION	STON	SHORT TON
BOS	BOTTOM OF STEEL	INT	INTERIOR	STD	STANDARD
BOT	BOTTOM			STIFF	STIFFENER
BP	BASE PLATE	JST	JOIST	STL	STEEL
BRG	BEARING	JT	JOINT	STRUCT	STRUCTURAL
BS	BOTH SIDES			SUPP	SUPPORT
BTWN	BETWEEN	KB	KNEE BRACE	SYMM	SYMMETRICAL
		kg	KILOGRAM	T	TOP
C	ROLLED CHANNEL	kips	KILOPOUNDS	T=	TENSION LOAD
C=	COMPRESSION LOAD	kN	KILONEWTON	THK	THICK
C/C	CENTER TO CENTER	kNm	KILONEWTON METER	THRD	THREAD
C/W	COMPLETED WITH	kPa	KILOPASCAL	TJ	TIED JOIST
CANT	CANTILEVER	ksi	KILOPOUNDS PER SQUARE INCH	TO	TOP OF
CHKD	CHECKERED			TOC	TOP OF CONCRETE
CJ	CONTROL JOINT			TOF	TOP OF FOOTING
CJP	COMPLETE JOINT PENETRATION-GROOVE WELD	L	ROLLED ANGLE	TOG	TOP OF GRATING
		lb	POUND	TON	IMPERIAL TON
CL OR	CENTERLINE	LG	LONG	TONNE	METRIC TON
CLR	CLEAR OR CLEARANCE	LL	LIVE LOAD	TOS	TOP OF STEEL
CMU	CONCRETE MASONRY UNIT	LLH	LONG LEG HORIZONTAL	TOW	TOP OF WALL
		LLV	LONG LEG VERTICAL	TYP	TYPICAL
COL	COLUMN	LOC	LOCATION	T&B	TOP AND BOTTOM
CONC	CONCRETE	LP	LOW POINT		
CONN	CONNECTION	LPFS	LOW POINT FINISH SURFACE	U.N.O.	UNLESS NOTED OTHERWISE
CONSTR	CONSTRUCTION			U/S	UNDER SIDE
CONT	CONTINUOUS	m	METER	UT	ULTRA-SONIC TESTING
		MAX	MAXIMUM		
DET	DETAIL	MC	MOMENT CONNECTION	VER	VERTICAL
DIA	DIAMETER	MECH	MECHANICAL		
DIM	DIMENSION	MFR	MANUFACTURER	W	ROLLED WIDE FLANGE BEAM
DL	DEAD LOAD	MIN	MINIMUM	W/	WITH
DN	DOWN	mm	MILIMETER	W/O	WITHOUT
DWG	DRAWING	MISC	MISCELLANEOUS	WP	WORK POINT
DWL	DOWEL	MPa	MEGAPASCAL	WT	WEIGHT
		MTL	METAL	WWF	WELDED WIRE FABRIC
EA	EACH	NDT	NON DESTRUCTIVE TESTING	x	BY (as 2x4)
EE	EXTENDED ENDS	NIC	NOT IN CONTRACT		
EF	EACH FACE	No.	NUMBER		
EJ	EXPANSION JOINT	NPS	NOMINAL PIPE SIZE		
EL	ELEVATION	NS	NEAR SIDE		
EMBD	EMBEDMENT	NTS	NOT TO SCALE		
EQ	EQUAL OR EQUALLY				
EQL	EARTHQUAKE LOAD	OC	ON CENTER		
EQP	EQUIPMENT	OD	OUTSIDE DIAMETER		
EW	EACH WAY	OPN	OPENING		
EXTG	EXISTING	OPP	OPPOSITE		
EXP	EXPANSION				
EXT	EXTERIOR	P	PROJECTION		
		PC	PRECAST		
FAB	FABRICATE	PED	PEDESTAL		
FABR	FABRICATOR	PIL	PILASTER		
FB	FLAT BAR	PL OR	PLATE		
FD	FLOOR DRAIN	PLAT	PLATFORM		
FDN	FOUNDATION	PLCS	PLACES		
FIN	FINISH	PROJ	PROJECTION		
FLG	FLANGE	psf	POUNDS PER SQUARE FOOT		
FLR	FLOOR	psi	POUNDS PER SQUARE INCH		
FP	FIREPROOF				
FS	FAR SIDE				
ft	FOOT				
FTG	FOOTING				

NOTES:

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2. FOUNDATION SLAB SHALL BEAR ON COMPACTED NON-FROST SUSCEPTIBLE STRUCTURAL FILL EXTENDING TO A MINIMUM OF 5'-0" BELOW GRADE.
3. REFER TO CIVIL DRAWINGS TO LOCATE THE FOUNDATION SLAB FOR UTILITY WELL BUILDING AND REQUIRED DRAINAGE SYSTEM.
4. ANCHORAGE DETAILS FOR PRE-FABRICATED METAL STRUCTURE TO CONCRETE SLAB, REFER TO SUPPLIER DRAWINGS.
5. FOR CONCRETE REINFORCEMENT, ASSUME 170 lb/yd^3 OF CONCRETE.
6. CONCRETE PARAMETERS:
   MINUMUM 28 DAY COMPRESSIVE STRENGTH - MIN 4000 psi
   CEMENT TYPE - ASTM C50 TYPE II CEMENT
   EXPOSURE CLASS - C-1
7. ALLOWABLE SOIL BEARING CAPACITY ASSUMED TO BE 2000 psf.

NOT FOR CONSTRUCTION

ISSUED FOR 60% DESIGN

Rev.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2022-07-08	ISSUED FOR 60% DESIGN	KL	MM	MA	TJS
A	2022-06-16	ISSUED FOR CLIENT REVIEW	KL	MM	MA	TJS

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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

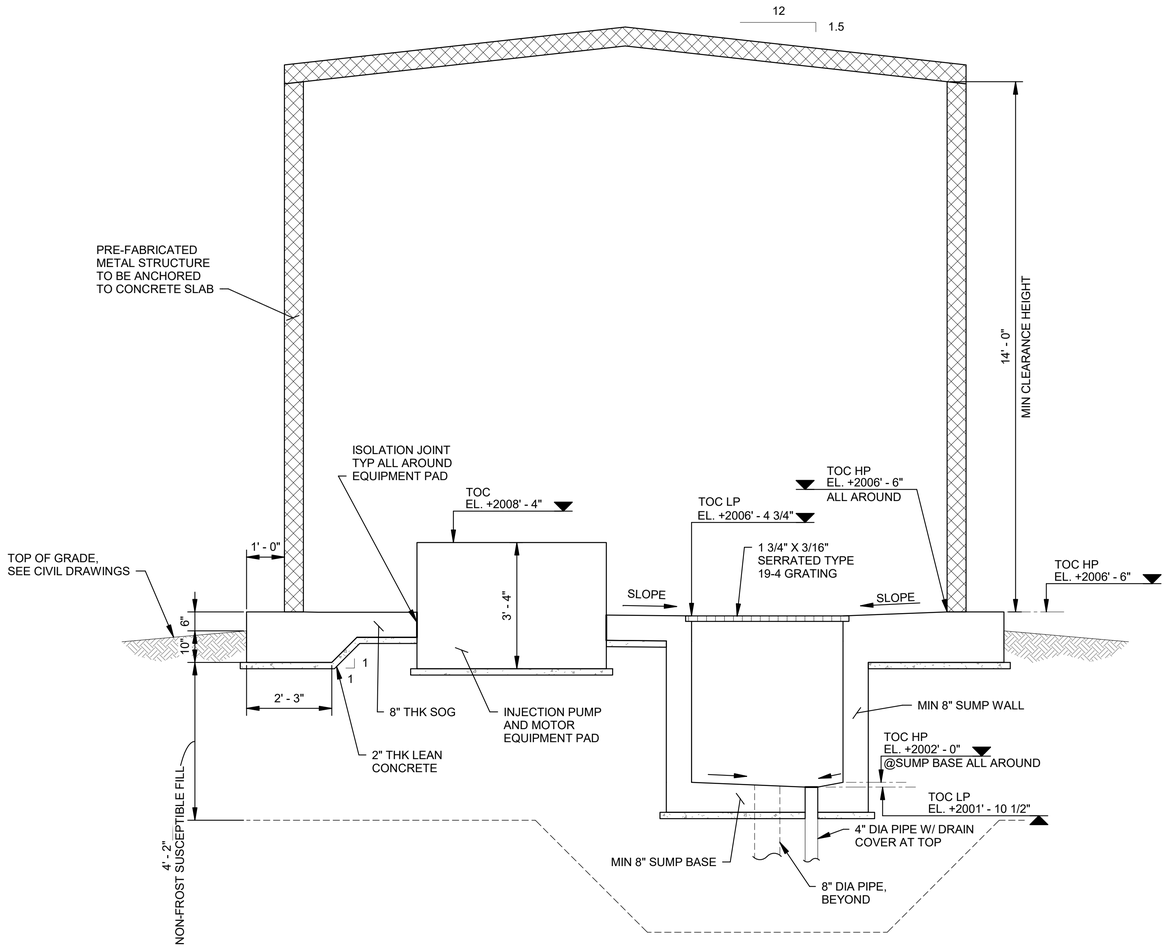
TITLE
INJECTION PUMP BUILDING
CONCRETE
FOUNDATION AND SLAB SLOPE PLAN

PROJECT No. 19122669
REV. B
S-010

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

0 1 in



1 SECTION
S-011

SCALE: 1/2" = 1'-0"

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   EXPOSURE CLASS - C-1
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B	2022-07-08	ISSUED FOR 60% DESIGN	KL	MM	MA	TJS
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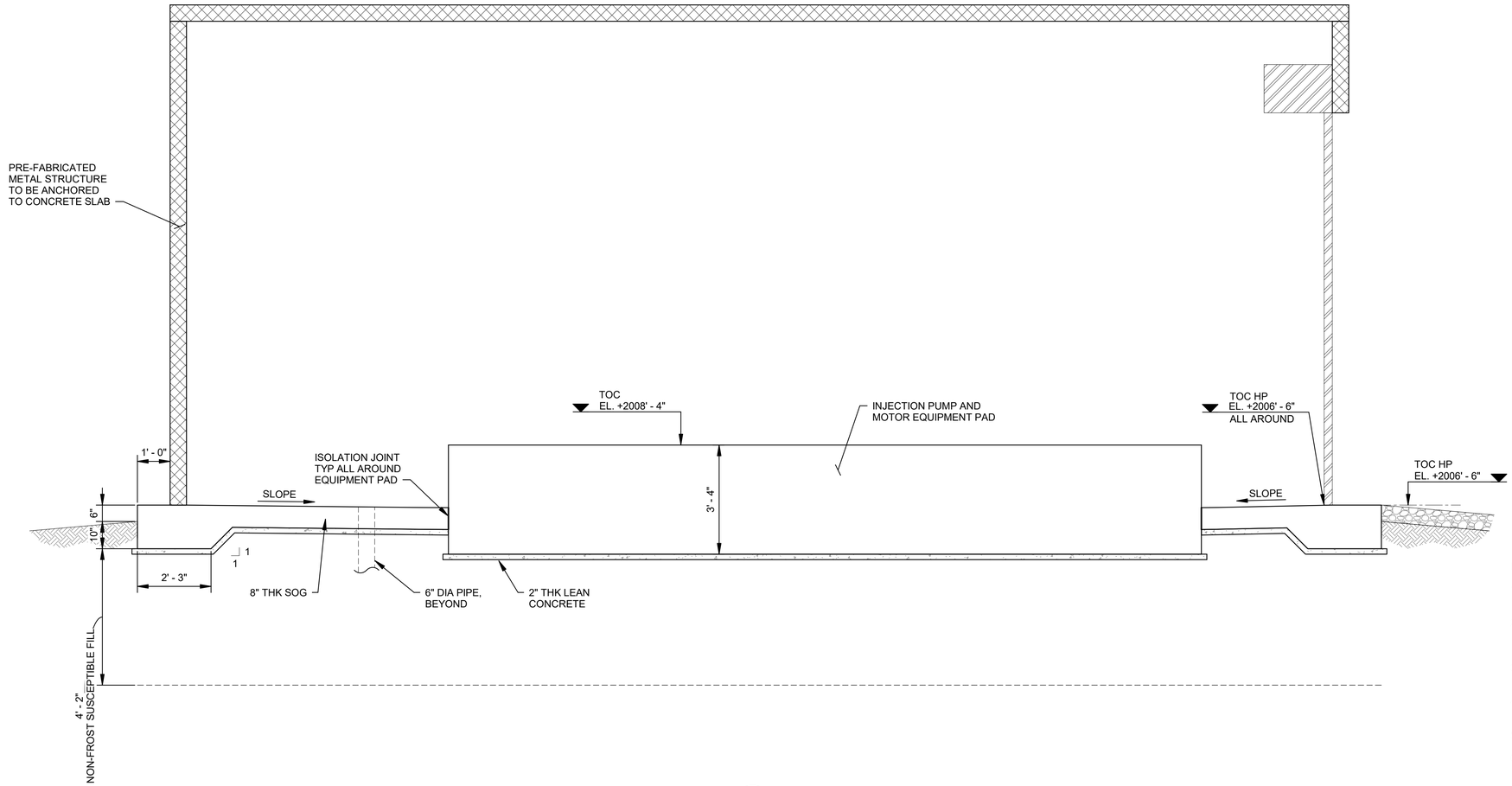
PROJECT
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SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
INJECTION PUMP BUILDING
CONCRETE
SECTION (1 OF 2)

PROJECT No. 19122669
REV. B
S-011

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2 SECTION
SCALE: 1/2" = 1'-0" S-012

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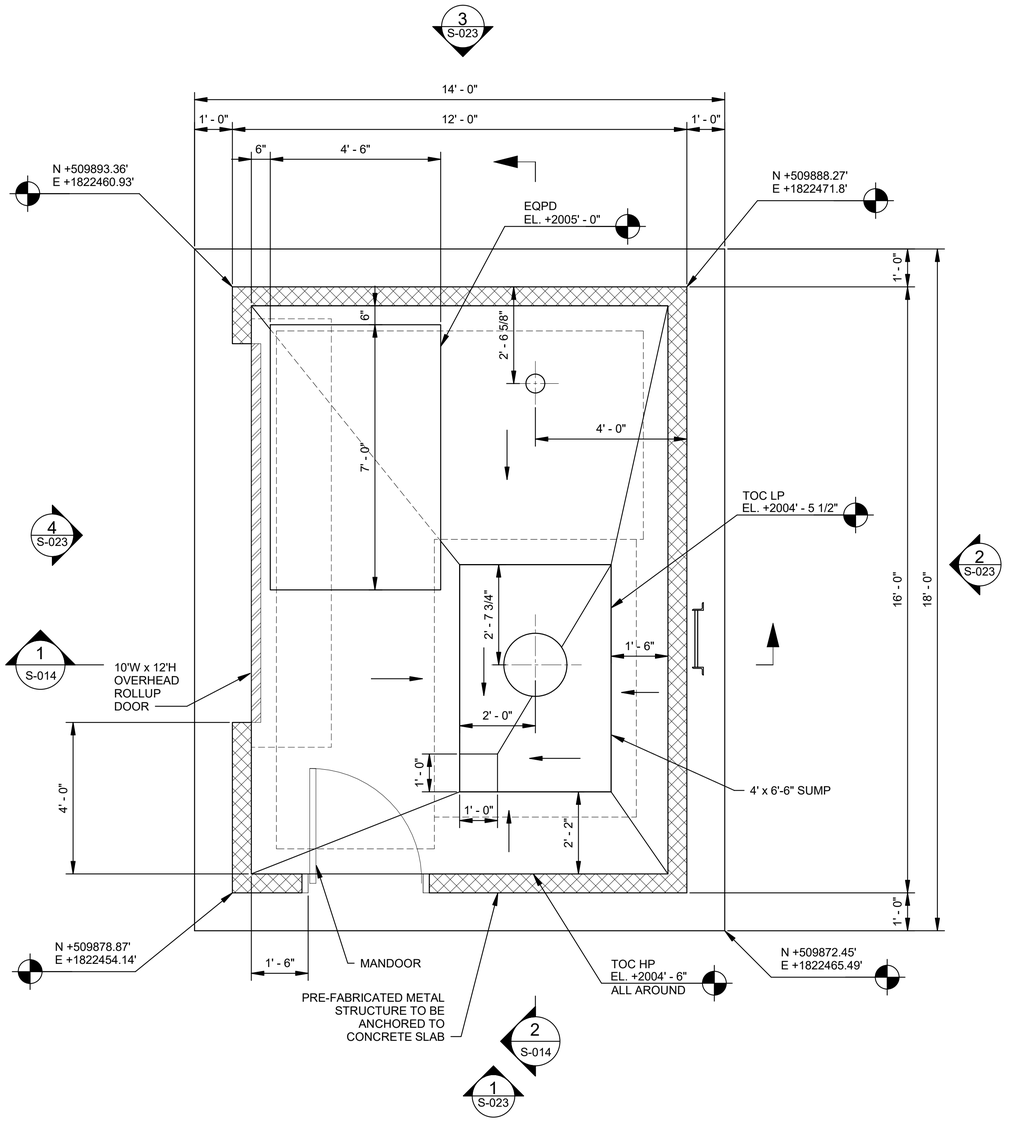
PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
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TITLE
INJECTION PUMP BUILDING
CONCRETE
SECTION (2 OF 2)

PROJECT No. 19122669
REV. B
S-012

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FOUNDATION AND SLAB SLOPE PLAN

SCALE: 1/2" = 1'-0"

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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
WELLHEAD BUILDING
CONCRETE
FOUNDATION AND SLAB SLOPE PLAN

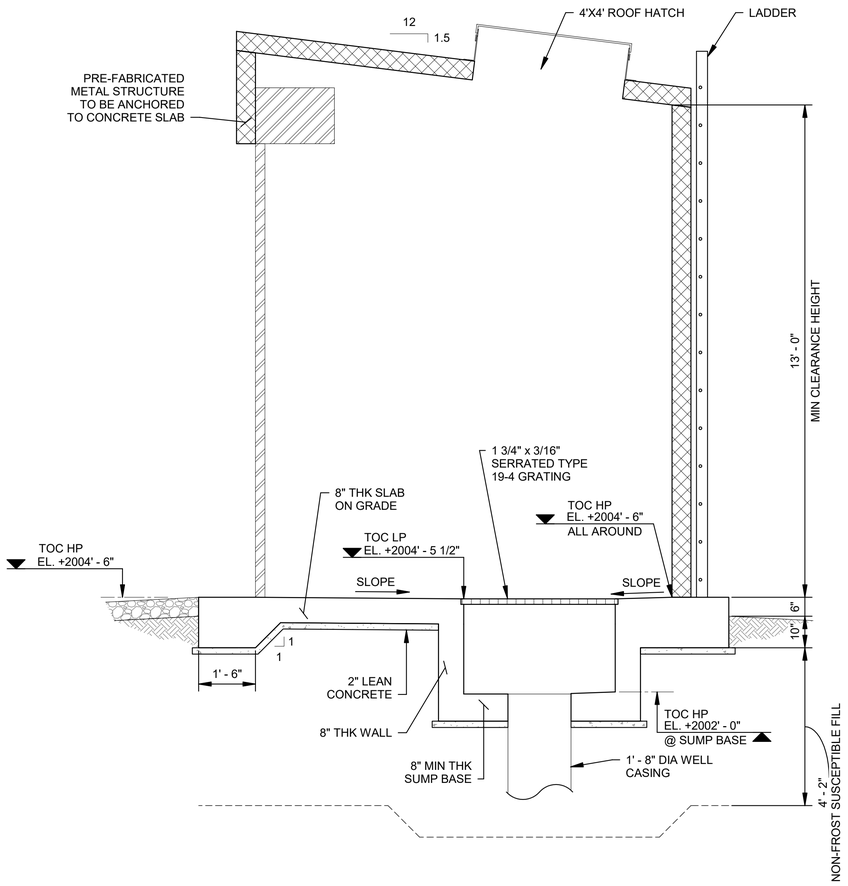
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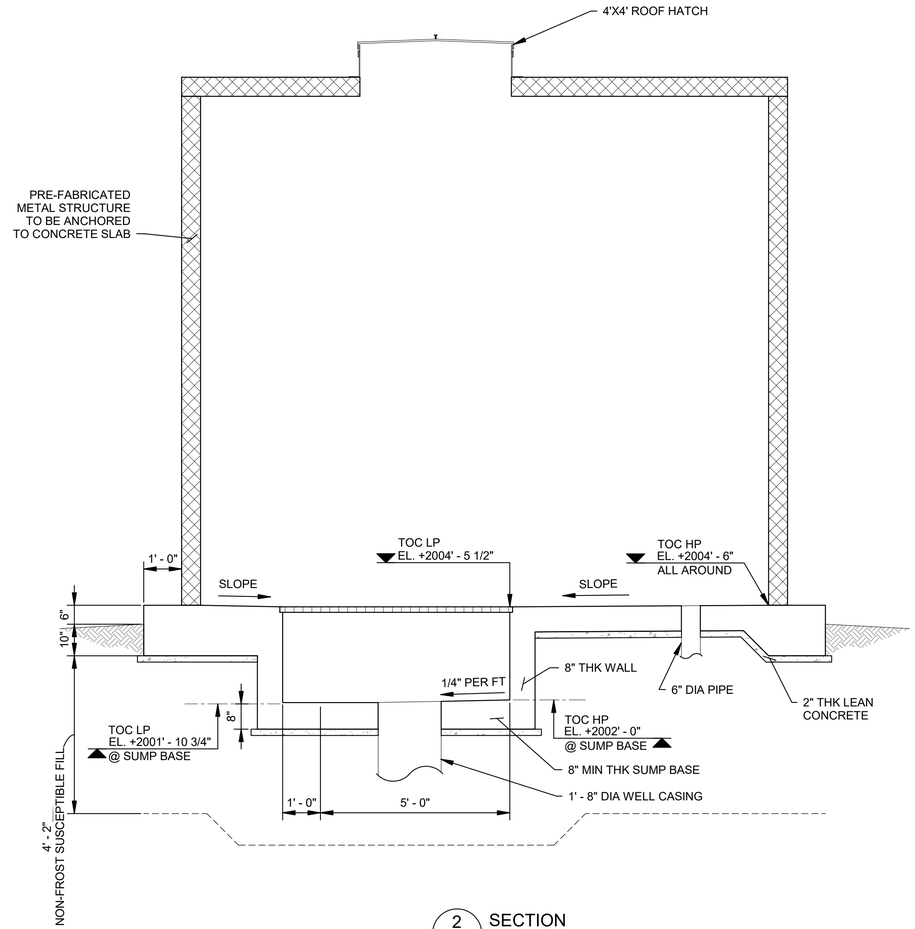
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1 SECTION
SCALE: 1/2" = 1'-0" S-014



2 SECTION
SCALE: 1/2" = 1'-0" S-014

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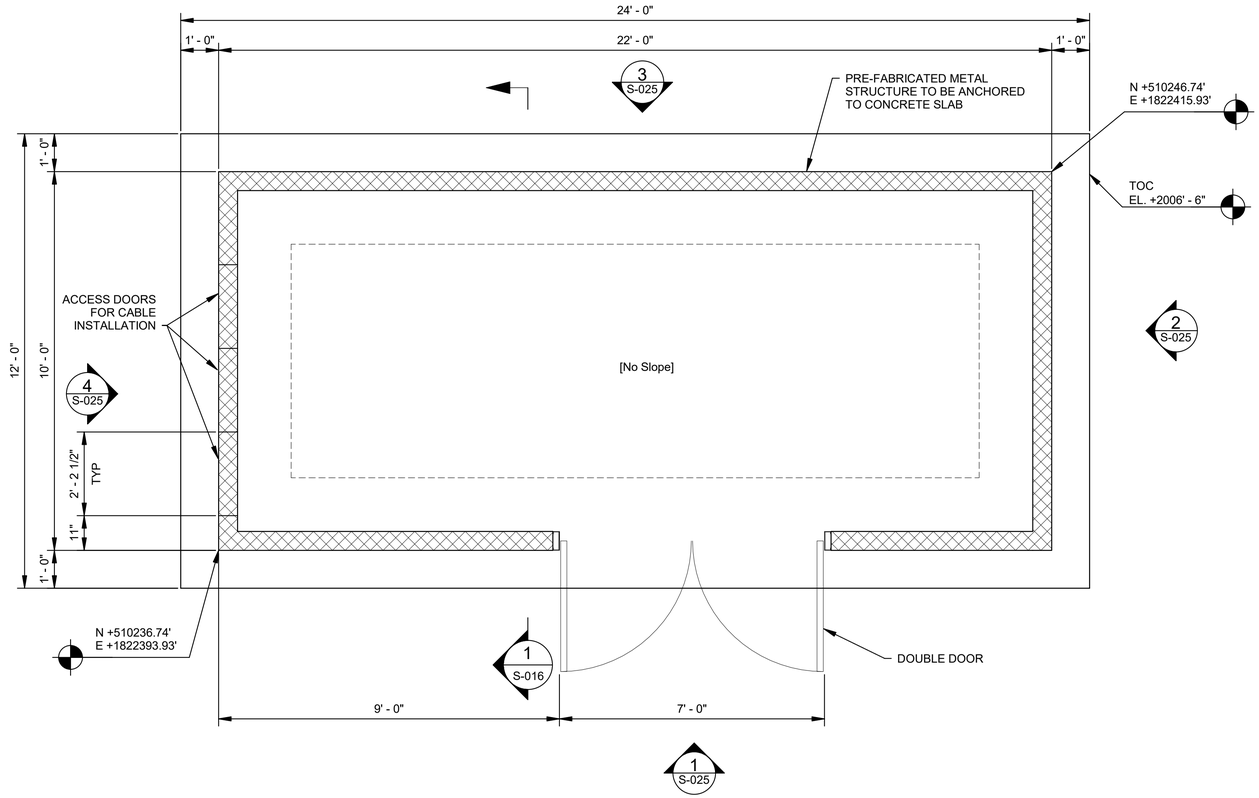
PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
WELLHEAD BUILDING
CONCRETE
SECTIONS

PROJECT No. 19122669
REV. B
S-014

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

N:\Minnkota Power Cooperative\10_CADD\REVIT\19122669CA\19122669CA WELLHEAD BUILDING.rvt



FOUNDATION PLAN

SCALE: 1/2" = 1'-0"

NOTES:

1. THIS DRAWING TO BE READ IN CONJUCTION WITH PROJECT GENERAL NOTES, TYPICAL DETAILS & CONSTRUCTION SPECIFICATIONS.
2. FOUNDATION SLAB SHALL BEAR ON COMPACTED NON-FROST SUSCEPTIBLE STRUCTURAL FILL EXTENDING TO A MINIMUM OF 5'-0" BELOW GRADE.
3. REFER TO CIVIL DRAWINGS TO LOCATE THE FOUNDATION SLAB FOR UTILITY WELL BUILDING AND REQUIRED DRAINAGE SYSTEM.
4. ANCHORAGE DETAILS FOR PRE-FABRICATED METAL STRUCTURE TO CONCRETE SLAB, REFER TO SUPPLIER DRAWINGS.
5. FOR CONCRETE REINFORCEMENT, ASSUME 170 lb/yd^3 OF CONCRETE.
6. CONCRETE PARAMETERS:
   MINIMUM 28 DAY COMPRESSIVE STRENGTH - MIN 4000 psi
   CEMENT TYPE - ASTM C150 TYPE II CEMENT
   EXPOSURE CLASS - C-1
7. REFER TO ELECTRICAL DRAWINGS FOR ELECTRICAL BUILDING LAYOUT.
8. ALLOWABLE SOIL BEARING CAPACITY ASSUMED TO BE 2000 psf.

NOT FOR CONSTRUCTION

ISSUED FOR 60% DESIGN

Rev.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2022-07-08	ISSUED FOR 60% DESIGN	KL	MM	MA	TJS
A	2022-06-16	ISSUED FOR CLIENT REVIEW	KL	MM	MA	TJS

CLIENT
MINNKOTA POWER COOPERATIVE INC.
MILTON R. YOUNG STATION
CENTER, NORTH DAKOTA

CONSULTANT
GOLDER ASSOCIATES USA INC.
7245 WEST ALASKA DRIVE, SUITE 200
LAKEWOOD, COLORADO
USA
(303) 980 0540
www.golder.com

PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
ELECTRICAL BUILDING
CONCRETE
FOUNDATION PLAN

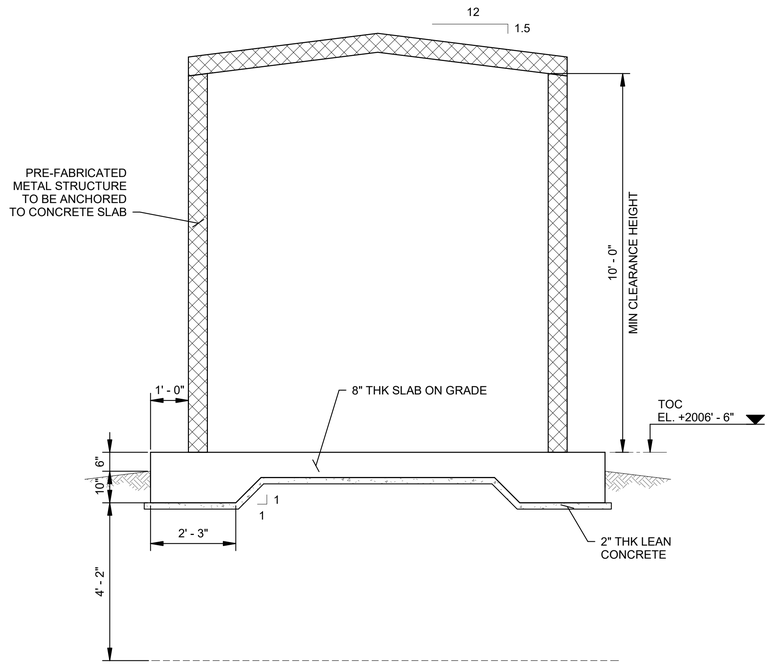
PROJECT No. 19122669

REV. B

S-015

N:\Minnkota Power Cooperative\10_CADD\REVIT\19122669CA\19122669CA ELECTRICAL ROOM BUILDING.rvt

0 1 in IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D



1 SECTION
S-016

SCALE: 1/2" = 1'-0"

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   EXPOSURE CLASS - C-1
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8. ALLOWABLE SOIL BEARING CAPACITY ASSUMED TO BE 2000 psf.

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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
ELECTRICAL BUILDING
CONCRETE
SECTION

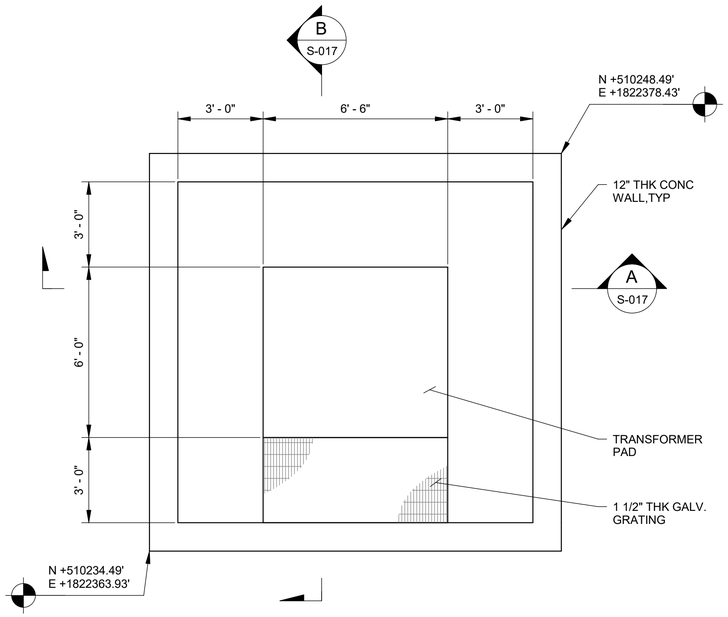
PROJECT No.
19122669

REV.
B

S-016

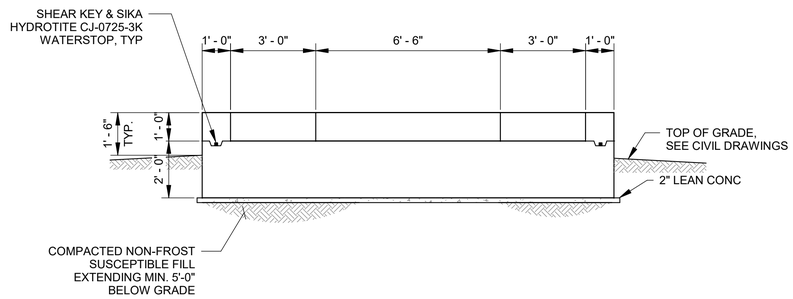
N:\Minnkota Power Cooperative\10_CADD\REVIT\19122669CA\19122669CA ELECTRICAL ROOM BUILDING.rvt

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
0 1 in

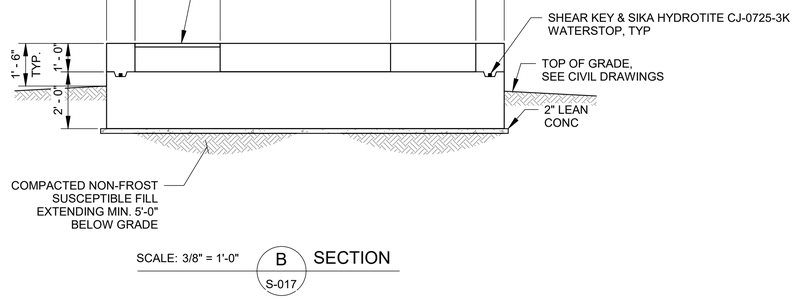


SLAB ON GRADE PLAN

SCALE: 3/8" = 1'-0"



SCALE: 3/8" = 1'-0" A S-017 SECTION



SCALE: 3/8" = 1'-0" B S-017 SECTION

NOTES:

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   EXPOSURE CLASS - C-1
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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
TRANSFORMER PAD
CONCRETE
TRANSFORMER PAD DETAILS

PROJECT No. 19122669

REV. B

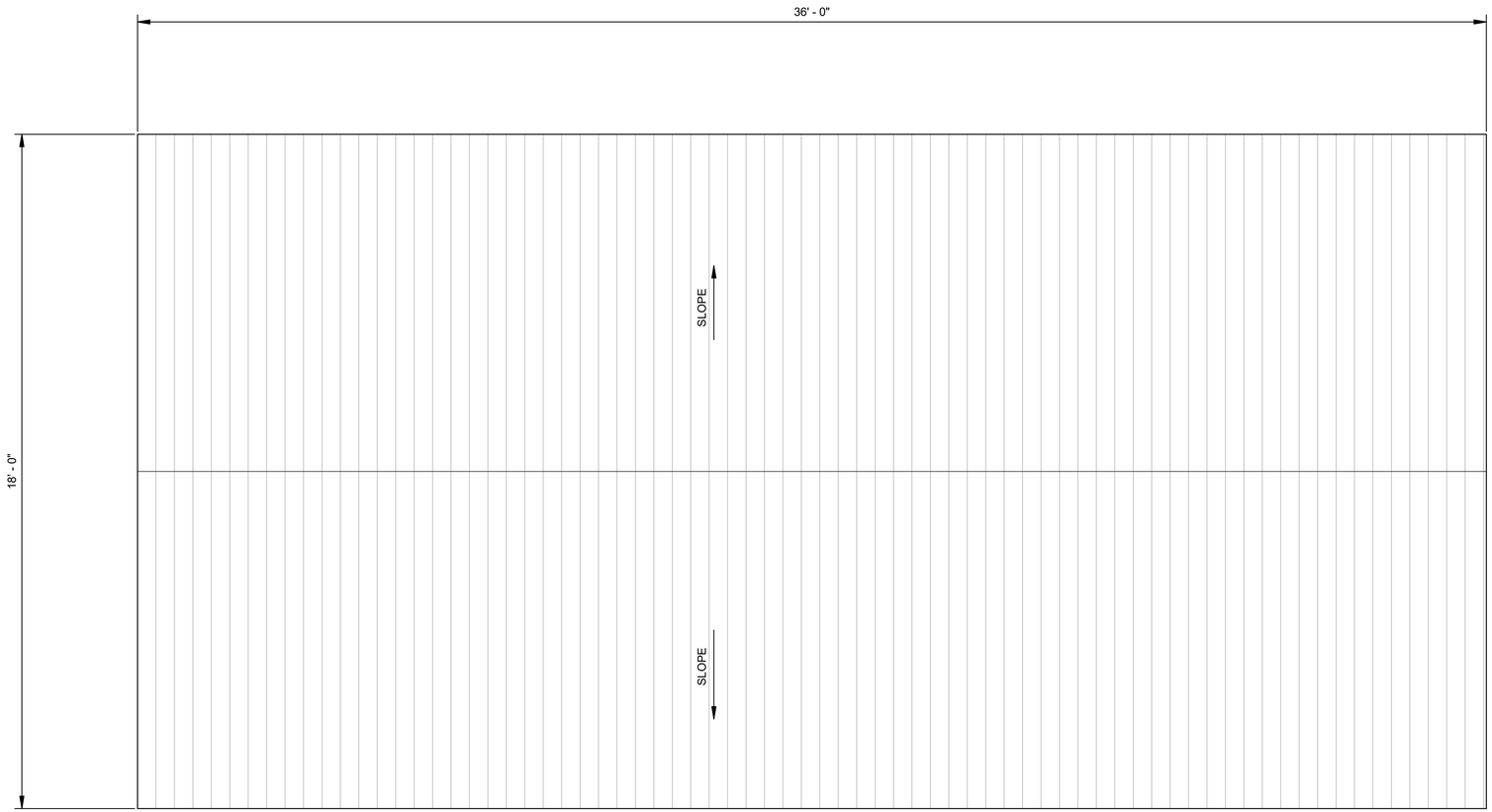
S-017

N:\Minnkota Power Cooperative\10_CADD\REVIT\19122669CA\19122669CA TRANSFORMER PAD.rvt

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

1 in

0



INJECTION PUMP BUILDING ROOF PLAN

SCALE: 1/2" = 1'-0"

NOT FOR CONSTRUCTION

ISSUED FOR 60% DESIGN

Rev.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2022-07-08	ISSUED FOR 60% DESIGN	KL	MM	MA	TJS
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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
INJECTION PUMP BUILDING

ROOF PLAN

PROJECT No. 19122669

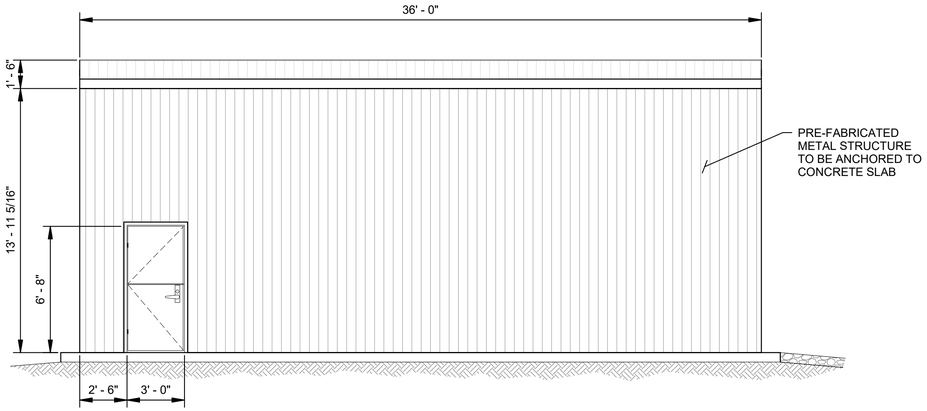
REV. B

S-020

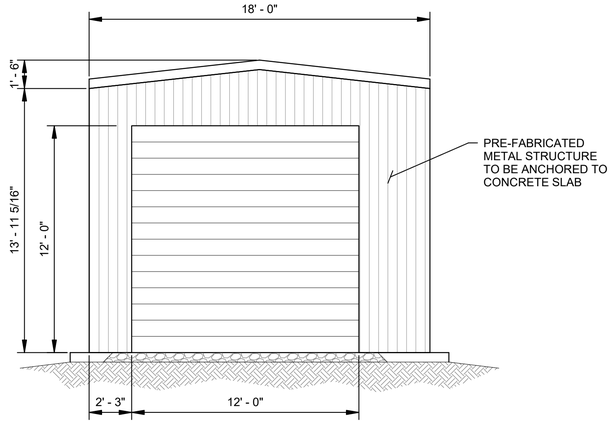
N:\Minnkota Power Cooperative\10_CADD\REVIT\19122669CA\19122669CA PUMP BUILDING.rvt

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

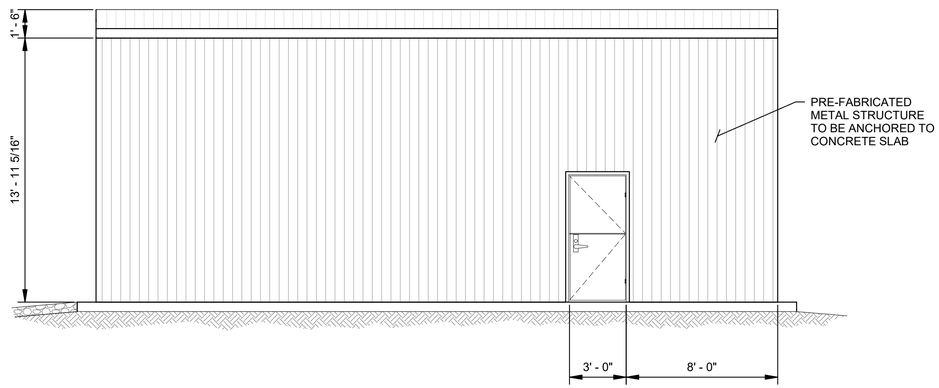
0 1 in



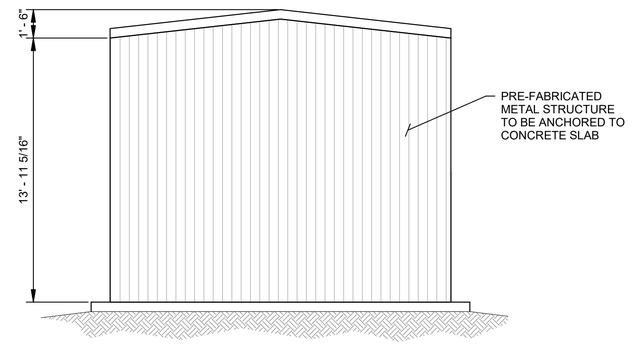
1 SOUTH ELEVATION
SCALE: 1/4" = 1'-0" S-021



2 EAST ELEVATION
SCALE: 1/4" = 1'-0" S-021



3 NORTH ELEVATION
SCALE: 1/4" = 1'-0" S-021



4 WEST ELEVATION
SCALE: 1/4" = 1'-0" S-021

NOT FOR CONSTRUCTION

ISSUED FOR 60% DESIGN

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B	2022-07-08	ISSUED FOR 60% DESIGN	KL	MM	MA	TJS
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CLIENT
MINNKOTA POWER COOPERATIVE INC.
MILTON R. YOUNG STATION
CENTER, NORTH DAKOTA

CONSULTANT
GOLDER ASSOCIATES USA INC.
7245 WEST ALASKA DRIVE, SUITE 200
LAKEWOOD, COLORADO
USA
(303) 980 0540
www.golder.com

PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

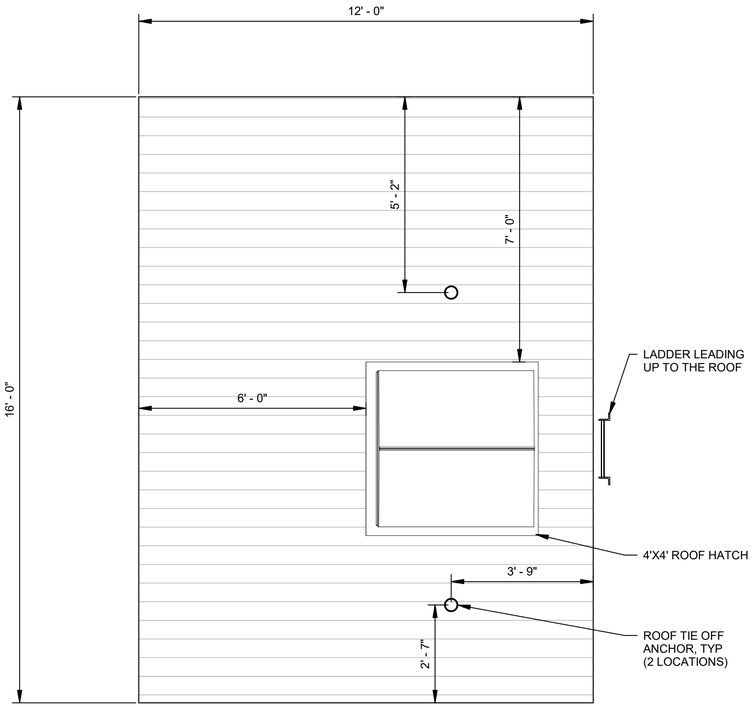
TITLE
INJECTION PUMP BUILDING

ELEVATIONS

PROJECT No. 19122669
REV. B
S-021

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
0 1 in

N:\Minnkota Power Cooperative\10_CADD\REVIT\19122669CA\19122669CA PUMP BUILDING.rvt



ROOF PLAN

SCALE: 1/2" = 1'-0"

NOT FOR CONSTRUCTION

ISSUED FOR 60% DESIGN

Rev.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
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A	2022-06-16	ISSUED FOR CLIENT REVIEW	KL	MM	MA	TJS

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CENTER, NORTH DAKOTA

CONSULTANT

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www.golder.com

PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
WELLHEAD BUILDING

ROOF PLAN

PROJECT No. 19122669

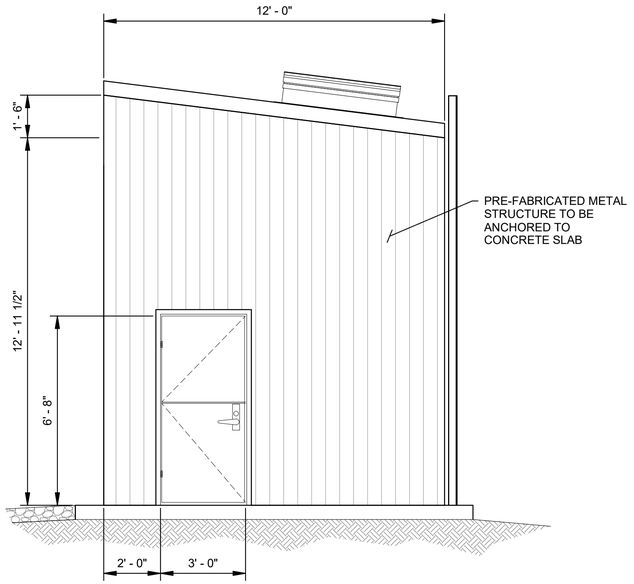
REV. B

S-022

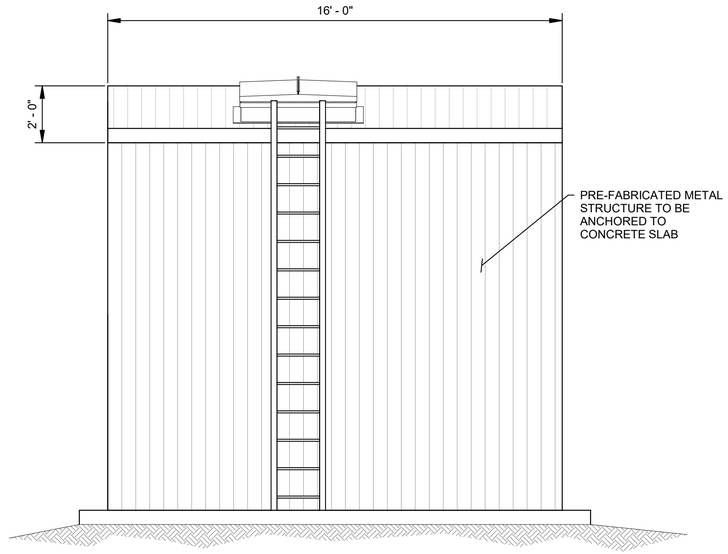
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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

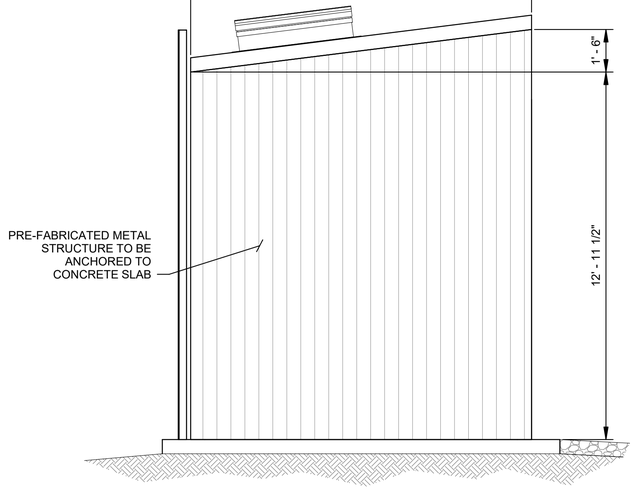
0 1 in



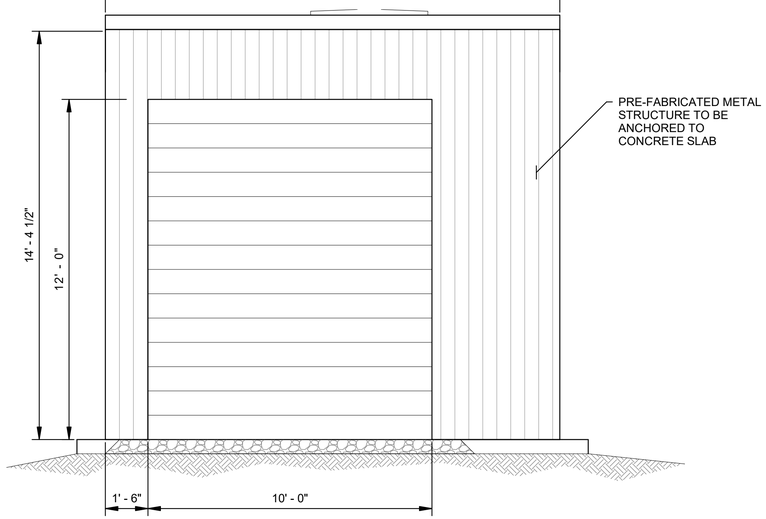
1 SOUTH ELEVATION
SCALE: 3/8" = 1'-0" S-023



2 EAST ELEVATION
SCALE: 3/8" = 1'-0" S-023



3 NORTH ELEVATION
SCALE: 3/8" = 1'-0" S-023



4 WEST ELEVATION
SCALE: 3/8" = 1'-0" S-023

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B	2022-07-08	ISSUED FOR 60% DESIGN	KL	MM	MA	TJS
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CLIENT
MINNKOTA POWER COOPERATIVE INC.
MILTON R. YOUNG STATION
CENTER, NORTH DAKOTA

CONSULTANT
GOLDER

GOLDER ASSOCIATES USA INC.
7245 WEST ALASKA DRIVE, SUITE 200
LAKEWOOD, COLORADO
USA
(303) 980 0540
www.golder.com

PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
WELLHEAD BUILDING

ELEVATIONS

PROJECT No. 19122669

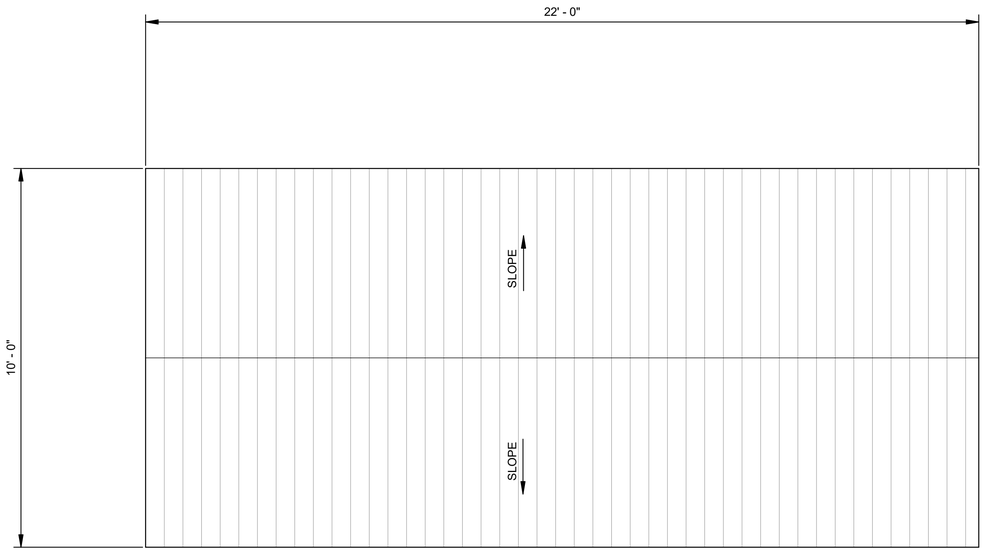
REV. B

S-023

N:\Minnkota Power Cooperative\10_CADD\REVIT\19122669CA\19122669CA WELLHEAD BUILDING.rvt

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

0 1in



ROOF PLAN

SCALE: 1/2" = 1'-0"

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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
ELECTRICAL BUILDING

ROOF PLAN

PROJECT No. 19122669

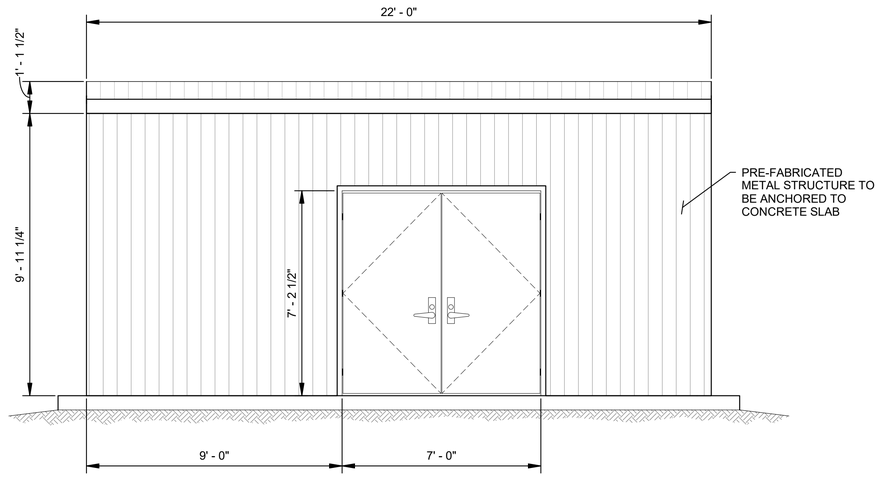
REV. B

S-024

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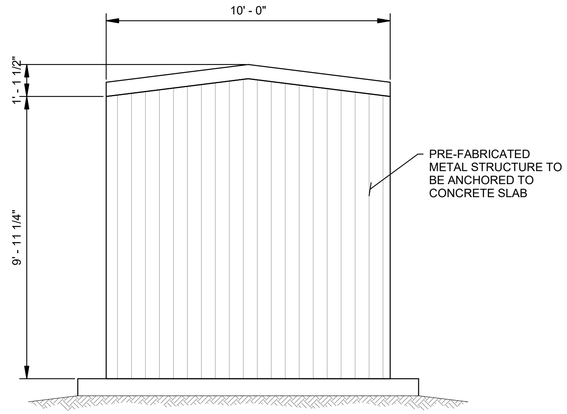
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

0 1 in



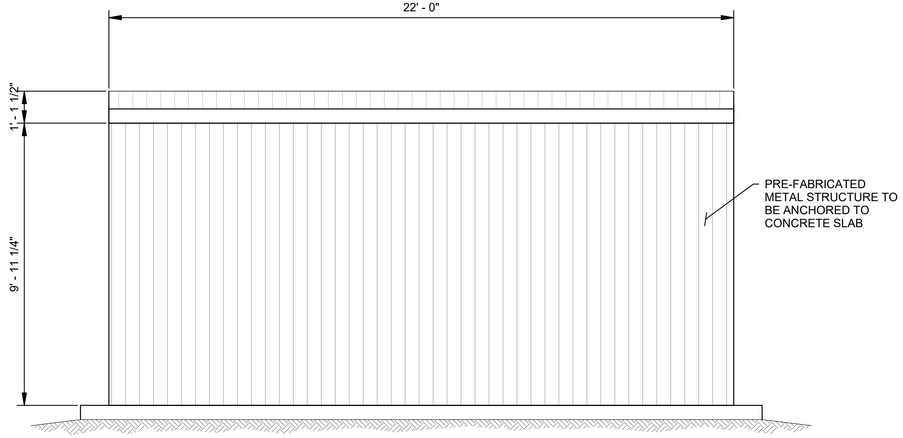
1 SOUTH ELEVATION

SCALE: 3/8" = 1'-0" (S-025)



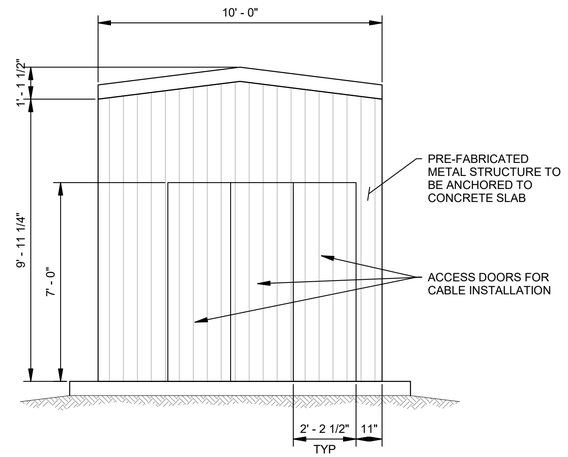
2 EAST ELEVATION

SCALE: 3/8" = 1'-0" (S-025)



3 NORTH ELEVATION

SCALE: 3/8" = 1'-0" (S-025)



4 WEST ELEVATION

SCALE: 3/8" = 1'-0" (S-025)

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CENTER, NORTH DAKOTA

CONSULTANT

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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
ELECTRICAL BUILDING

ELEVATIONS

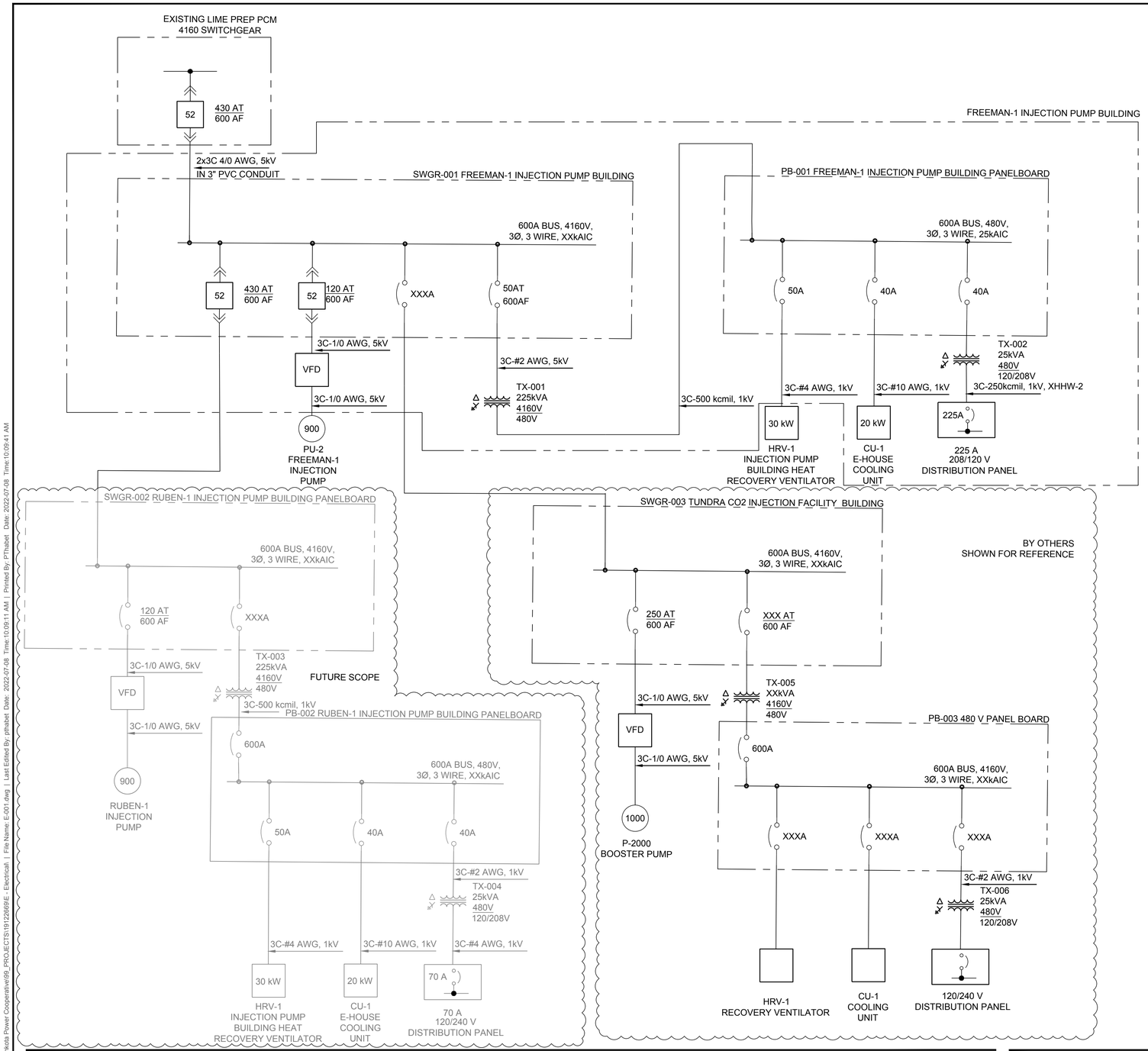
PROJECT No. 19122669

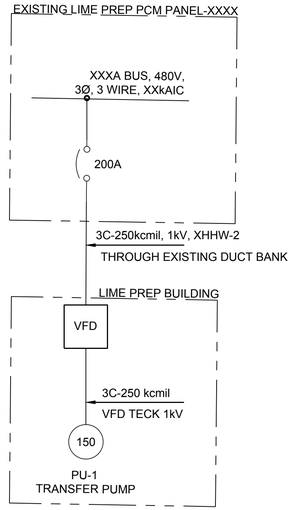
REV. B

S-025

N:\Minnkota Power Cooperative\10_CADD\REVIT\19122669CA\19122669CA ELECTRICAL ROOM BUILDING.rvt

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REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
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CLIENT
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MILTON R. YOUNG STATION
CENTER, NORTH DAKOTA

CONSULTANT
GOLDER

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7245 WEST ALASKA DRIVE, SUITE 200
LAKEWOOD, COLORADO
USA
[+1] (303) 980-0540
www.golder.com

PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
FREEMAN-1 INJECTION WELL
ELECTRICAL SINGLE LINE

PROJECT NO. 19122669 | REV. B | 1 of 1 | DRAWING E-001

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

0 1 in

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PANEL SIZE(AMPS): 225 A
PANEL VOLTAGE: 208 / 120 V, 3-PHASE
PANEL SCCR: 10 kAIC

PANEL TAG: DP-001
LOCATION: INJECTION PUMP BUILDING
DESCRIPTION: INJECTION WELL DP

FED FROM: TX-001
CABLE TAG: TX1-DP1-P
CABLE SIZE: 4C-#4/0

CABLE	DESCRIPTION	WATTS	Cct. Brk.	Cct. No.	PHASES A B C 225 A	Cct. No.	Cct. Brk.	WATTS	DESCRIPTION	CABLE
2C-#12	INJECTION PUMP BUILDING LIGHTING	700	15A	1		2	20A	1800	INJECTION PUMP BUILDING OUTLETS	2C-#12
2C-#12	MAGNETIC FLOW METER FOR INJECTION PUMP	300	15A	3		4	40A	3119	FREEMAN-1 WELLHEAD SUBPANEL	3C-#4
				5		6				
				7		8				
				9		10	15A	800	PLC PANEL	2C-#12
				11		12				
				13		14				
				15		16				
				17		18				

PHASE "A" WATTS	3540
PHASE "B" WATTS	1100
PHASE "C" WATTS	1040
TOTAL WATTS CONNECTED	5680

NOT FOR CONSTRUCTION
ISSUED FOR 60% DESIGN

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2022-07-08	ISSUED FOR 60% DESIGN	PLE	PT	DG	TJS
A	2022-06-16	ISSUED FOR REVIEW	PLE	PT	DG	TJS

CLIENT
MINNKOTA POWER COOPERATIVE INC.
MILTON R. YOUNG STATION
CENTER, NORTH DAKOTA

CONSULTANT
GOLDER ASSOCIATES USA INC.
7245 WEST ALASKA DRIVE, SUITE 200
LAKEWOOD, COLORADO
USA
[+1] (303) 980-0540
www.golder.com

PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
INJECTION PUMP BUILDING
DISTRIBUTION PANEL DP-001
PANEL SCHEDULE

PROJECT NO. 19122669
REV. B
1 of 1
DRAWING E-002

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
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PANEL SIZE(AMPS):
PANEL VOLTAGE: 240 / 120 V, 1-PHASE
PANEL SCCR:

PANEL TAG: TO BE ASSIGNED BY OWNER
LOCATION: LIME PREP BUILDING
DESCRIPTION: LIME PREP DISTRIBUTION PANEL

FED FROM:
CABLE TAG:
CABLE SIZE:

CABLE	DESCRIPTION	WATTS	Cct. Brk.	Cct. No.	PHASES L1 N L2 100 A	Cct. No.	Cct. Brk.	WATTS	DESCRIPTION	CABLE
2C-#12	AUTO SCREEN FILTER	700	15A	1		2	15A	600	MOTOR-OPERATED 8" BUTTERFLY VALVE	2C-#12
				3		4	15A	600	ANTISCALANT METERING PUMP	2C-#12
2C-#12	MOTOR-OPERATED 8" BUTTERFLY VALVE	600	15A	5		6	15A	700	HEAT TRACING FOR 8" LINE	2C-#12
2C-#12	ANTISCALANT METERING PUMP	600	15A	7		8	15A	400	HEAT TRACING FOR 4" LINE	2C-#12
2C-#12	HEAT TRACING FOR 8" LINE	700	15A	9		10				
				11		12				
				13		14				
				15		16				
				17		18				
				19		20				
				21		22				
				23		24				
				25		26				
				27		28				
				29		30				

PHASE "A" WATTS	3400
PHASE "B" WATTS	1600
TOTAL WATTS CONNECTED	5000

NOT FOR CONSTRUCTION
ISSUED FOR 60% DESIGN

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B	2022-07-08	ISSUED FOR 60% DESIGN	PLE	PT	DG	TJS
A	2022-06-16	ISSUED FOR REVIEW	PLE	PT	DG	TJS

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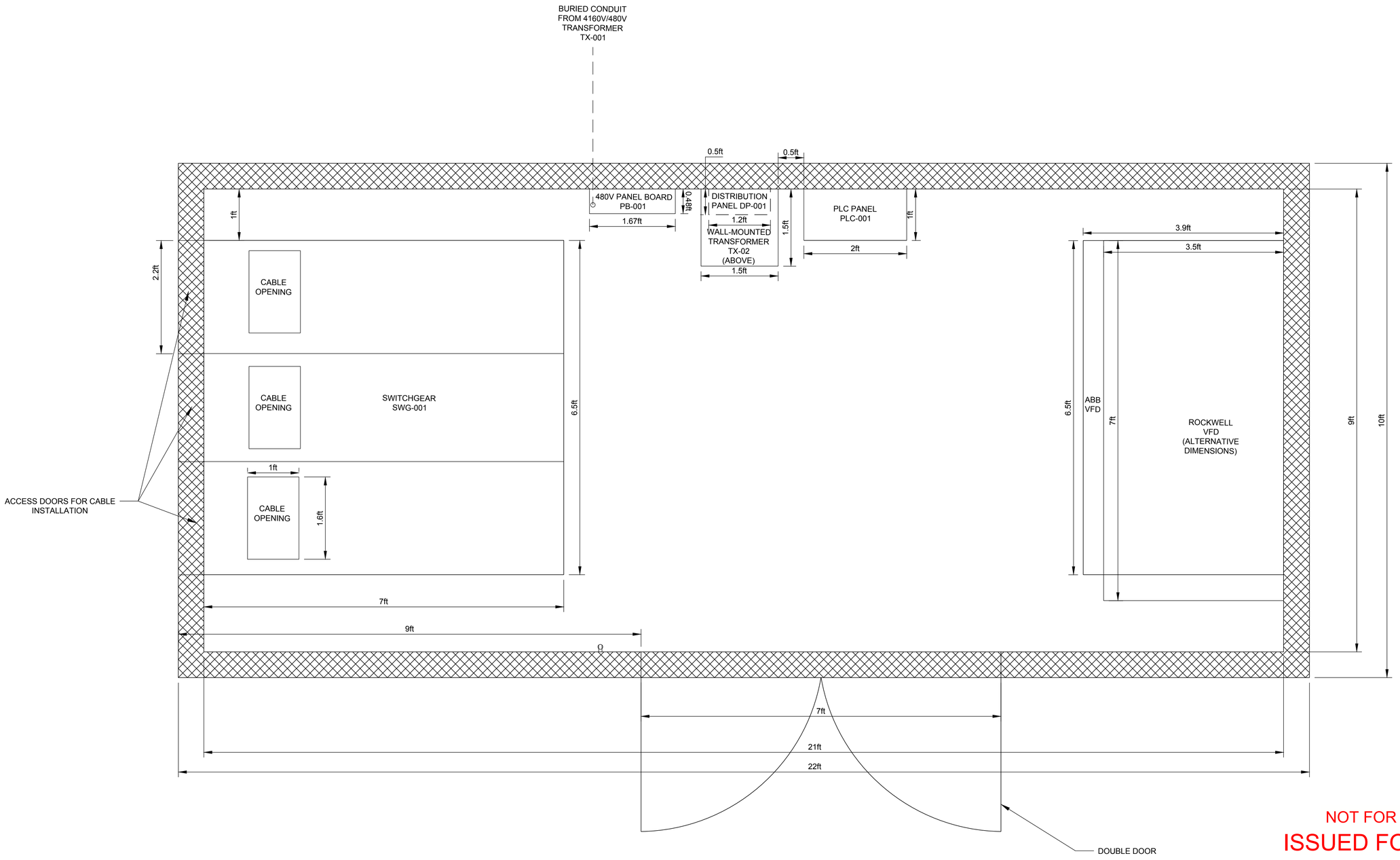
PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
LIME PREP BUILDING
DISTRIBUTION PANEL
PANEL SCHEDULE

PROJECT NO. 19122669
REV. B
1 of 1
DRAWING E-003

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

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REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2022-07-08	ISSUED FOR 60% DESIGN	PLE	PT	DG	TJS
A	2022-06-16	ISSUED FOR REVIEW	PLE	PT	DG	TJS

CLIENT
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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
ELECTRICAL BUILDING EQUIPMENT LAYOUT

PROJECT NO. 19122669 | REV. B | 1 of 1 | DRAWING E-004

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

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PANEL SIZE(AMPS): 60 A
PANEL VOLTAGE: 208 / 120 V, 3-PHASE
PANEL SCCR: 10 kAIC

PANEL TAG: DP-003
LOCATION: INJECTION PUMP BUILDING
DESCRIPTION: FREEMAN-1 WELLHEAD SUBPANEL

FED FROM: TX-001
CABLE TAG: TX1-DP1-P
CABLE SIZE: 4C-#4/0

CABLE	DESCRIPTION	WATTS	Cct. Brk.	Cct. No.	PHASES A B C 225 A	Cct. No.	Cct. Brk.	WATTS	DESCRIPTION	CABLE
2C-#12	WELLHEAD BUILDING LIGHTING	300	15A	1		2	15A	1400	WELLHEAD BUILDING OUTLETS	2C-#12
3C-#12	WELLHEAD BUILDING UNIT HEATER	300	15A	3		4	15A	1119	ANNULUS PRESSURIZATION PUMP	3C-#12
				5		6				
				7		8				
				9		10				
				11		12				
				13		14				
				15		16				
				17		18				
				19		20				
				21		22				
				23		24				
				25		26				
				27		28				
				29		30				

PHASE "A" WATTS	2173
PHASE "B" WATTS	473
PHASE "C" WATTS	473
TOTAL WATTS CONNECTED	3119

NOT FOR CONSTRUCTION
ISSUED FOR 60% DESIGN

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2022-07-08	ISSUED FOR 60% DESIGN	PLE	PT	DG	TJS
A	2022-06-16	ISSUED FOR REVIEW	PLE	PT	DG	TJS

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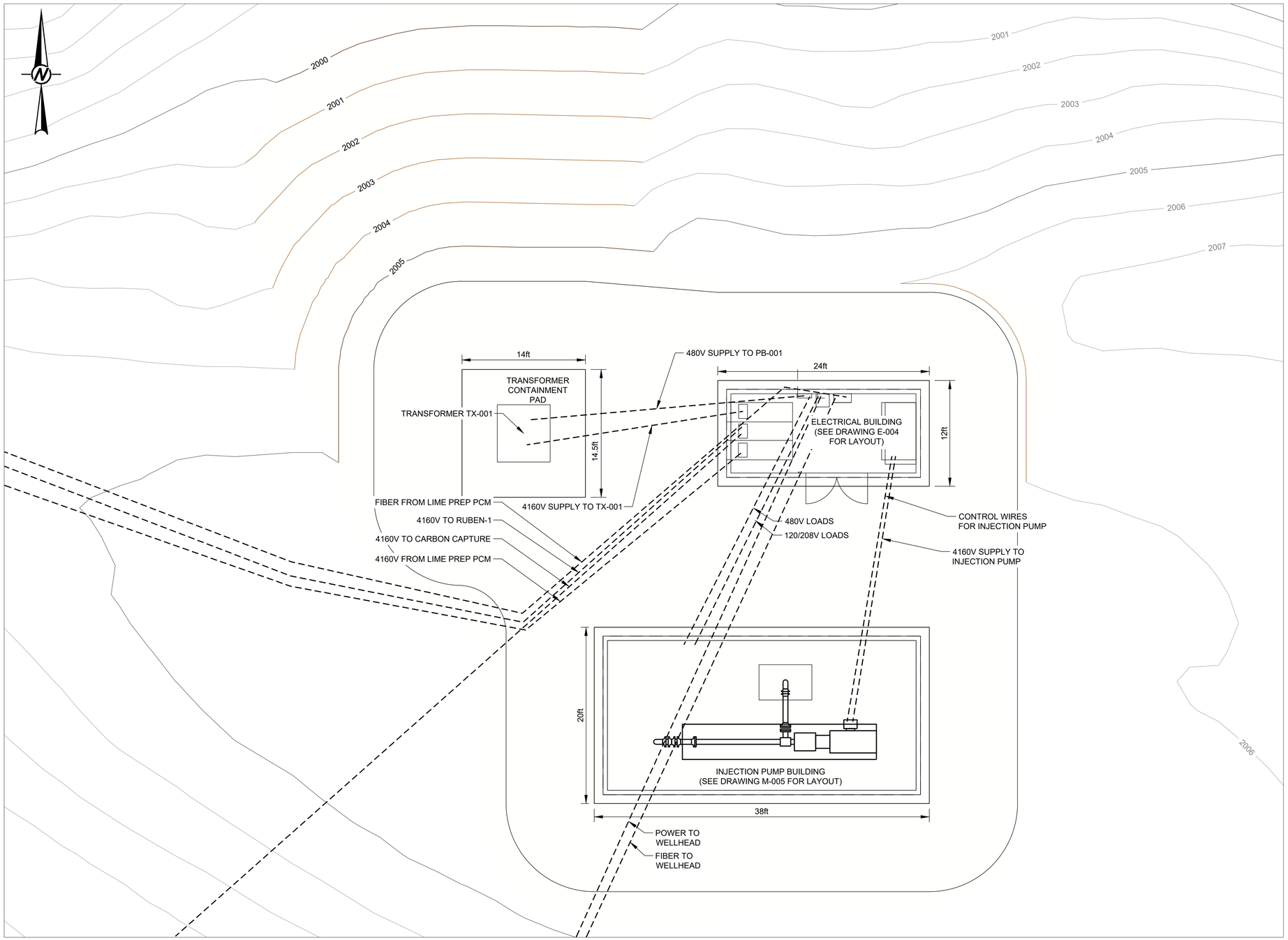
PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN
FEASIBILITY DESIGN

TITLE
FREEMAN-1 WELLHEAD
SUBPANEL DP-003
PANEL SCHEDULE

PROJECT NO. 19122669
REV. B
1 of 1
DRAWING E-005

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LEGEND

- 2000 EXISTING GRADES (REFERENCES 1 AND 2)
- 2000 PROPOSED GRADES
- BURIED CONDUITS

REFERENCE(S)

1. EXISTING GRADES PROVIDED BY MPC ON APRIL 4, 2021 (2021-04-06 Minnkota flight_elev1.0ft_res100cm_size20_DSM.dwg). EXISTING GRADES WERE OBTAINED USING AERIAL LIDAR. EXISTING BUILDING AND STRUCTURES WERE SCANNED AND HAVE NOT BEEN REMOVED FROM THE DATA SET.
2. EXISTING GRADES CONTOUR INTERVAL IS ONE FOOT.

NOTE(S)

1. CABLES WILL BE BURIED IN COMMON TRENCHES AND SHALL BE SPACED 12 INCHES FROM CABLES OF OTHER VOLTAGES AND FROM PIPELINES.

NOT FOR CONSTRUCTION

ISSUED FOR 60% DESIGN

0 6 12
1" = 6' FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2022-07-08	ISSUED FOR 60% DESIGN	PLE	PT	DG	TJS
A	2022-06-22	ISSUED FOR REVIEW	PLE	PT	DG	TJS

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PROJECT
CLASS I INJECTION WELL
SURFACE INFRASTRUCTURE DESIGN

TITLE
FREEMAN-1 INJECTION PUMP BUILDING CABLE ROUTING

PROJECT NO. 19122669 | REV. B | DRAWING E-006

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

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