Biosparge Remediation System Plan

Agrium US, Inc.
Kenai Nitrogen Operations

Prepared by

Cook Inlet Environmental, Inc.

June 8, 2022

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1.0 Introduction and Objectives

This plan defines the objectives, design, standards and procedures for the installation and monitoring of a biosparge remediation system at the south complex unconfined and semiconfined groundwater aquifer nitrogen plumes at the Agrium Kenai Nitrogen Operations Plant (KNO). KNO is located on the shoreline of Cook Inlet within the North Kenai industrial area shown on Figure 1.

The principal objective of installing a biosparge system at KNO is to accelerate mass removal of ammonia, through naturally occurring aerobic degradation processes, in the southern plume area of the site.

Agrium is undertaking this initiative to accelerate ammonia degradation in the southern plume area to supplement the natural attenuation process. While the approved corrective action, monitored natural attenuation (MNA), continues to be effective at mitigating risk to potential downgradient receptors in this area, Agrium is looking to invest in accelerated cleanup of ammonia as a means of reducing the duration of long-term liability for the site overall.

2.0 Site History & Current Regulatory Status

In consultation with, and under approval from the ADEC DSPAR contaminated sites program, KNO has completed extensive subsurface investigations, hydrogeologic studies, fate and transport modelling, human and ecological risk assessment, conceptual site model development, feasibility studies, an air-sparge pilot study, a remedial action plan, and a long-term groundwater monitoring program which dates back to 1974.

In 2006, ADEC Contaminated sites issued a decision that site characterization is complete, the conceptual site model is sufficiently developed, remedial alternatives have been reasonably considered with respect to effectiveness and cost. ADEC determined that effective implementation of monitored natural attenuation (MNA) sufficiently mitigates the risk to human and ecological receptors at potential exposure points located at the high tide line of Cook Inlet within a reasonable time frame.

Annual groundwater monitoring results collected since 2006 have continuously documented that MNA is working effectively through multiple lines of evidence as follows:

- Exponentially decreasing trends for urea sitewide that correspond with transient increases in microbially mediated urea hydrolysis products, including ammonium and carbonate.
- After formation, ammonium and carbonate have shown exponentially decreasing trends which correspond with increases in ammonia nitrification products including nitrite, nitrate, and decreased pH.
- pH decreases site wide have resulted in groundwater arsenic concentrations that have attenuated to levels that fluctuate at or below the marine water quality standard (30 ppb) at the high tide line of Cook Inlet.

While downgradient receptors are currently protected under MNA, Agrium is looking to proactively invest in mass reduction of residual ammonia in the upgradient portions of southern plume area to reduce the time frame for reaching the default water quality standard of 1 mg/L at the Cook Inlet high tide line. By undertaking this initiative Agrium is seeking to reduce the duration of risk to receptors, and accordingly it's long-term liability at the site.

3.0 Biosparge System Design

The biosparge system was designed in accordance with the EPA Air Sparging Design Paradigm (Battelle 2002). Table 1 summarizes the design parameters for the system and the specifications for the compressor, manifold, and air sparge wells. Figures 2 and 3 are layout maps showing the locations of the air sparge wells in the unconfined and semi-confined aquifers respectively. Figure 4 is a cross section of the southern plume area showing the ammonia plume, and the locations of the injection and monitoring wells within the proposed treatment areas.

Air sparge well locations were selected in upgradient portions of the unconfined and semi-confined ammonia plumes, which have ammonia levels exceeding 300 mg/L, to maximize mass removal rates. New monitoring well locations were selected downgradient of the air sparge wells, to allow the establishment of mass removal trends within the 18-month project operation timeframe. The air sparge system will consist of a compressor and instrument air transmission piping connected to two manifolds. Figure 5 is a drawing showing the construction details of the air injection manifolds. Each of the two manifolds will inject air into seven sparge wells installed into the UA and SCA as shown on Figures 2 through 4, for a total of fourteen operating sparge wells.

4.0 Baseline and Performance Monitoring

Baseline monitoring will consist of field measured water level, dissolved oxygen, temperature, pH, sampling, and laboratory analysis of urea, ammonia, nitrite, and nitrate. Baseline monitoring will be performed on all thirty-one (31) new and existing wells within the south plume area unconfined and semiconfined aquifers. Baseline monitoring results will be used to designate and finalize the preliminary air sparging and monitoring configurations shown on Figures 2 through 4.

After startup of the sparge system, performance monitoring will be completed for thirteen (13) designated UA monitoring wells and six (6) designated SCA monitoring wells. Performance monitoring will consist of semi-monthly field measured dissolved oxygen, temperature, ammonia, nitrite, and nitrate, and quarterly sampling and laboratory testing for urea, ammonia, nitrite, and nitrate.

Baseline and performance monitoring will be completed in accordance with the standards and procedures outlined in the approved KNO Groundwater Sampling and Analysis Plan (SAP) dated January 2007, and the Quality Assurance Project Plan for Groundwater Monitoring (QAPP) dated December 2009.

Section 5 shows a schedule for the Project, which is planned through the end of 2023. At this time, baseline and performance monitoring results will be used to calculate dissolved oxygen transfer rates, ammonia mass removal rates, and degradation product formation rates relative to baseline conditions. Agrium will use this information to assess the system's effectiveness, along with its capital and operating costs to determine if this investment has merit.

5.0 Project Schedule

The following schedule shows the principal project tasks numbered in order of their dependencies, estimated start and end dates, and the current progress status of each.

Task No.	Description	Estimated Start Date	Estimated End Date	Progress Status
1	System Design & Engineering	4/7/22	5/10/22	Complete
2	Procure & Receive Materials & Equipment	5/1/22	7/1/22	In progress, subject to supply chain delays.
3	Construction	5/1/22	7/7/22	In progress, subject to supply chain delays.
4	Baseline Monitoring	6/13/22	6/30/22	Scheduled
5	Startup	7/15/22	7/16/22	Scheduling delayed by task 2, 3 & 4 dependencies.
6	Performance Monitoring	7/16/22	12/30/23	Scheduling delayed by task 5 dependency.
7	Operation & Maintenance	7/16/22	12/30/23	Scheduling delayed by task 5 dependency.
8	Document Project, Evaluate Data, Optimize Operation, Assess overall effectiveness.	7/16/22	12/30/23	Scheduling delayed by task 5 dependency.

Tables

Table 1

Biosparge System Design Basis & Specifications

Agrium KNO

Aquifer characteristics **Design Parameter:**	**Unconfined Aquifer**	**Semi-confined Aquifer**
Groundwater apparent velocity (K_{sat}) (ft/day):	2	0.146
Aquifer pH range (su):	5.5-9.5	8.0-9.5
Aquifer Temperatures (deg C)	9-12	6-8
Aquifer Thickness (ft):	9-22 feet	75-85 feet
Treatment area (NH_3-N >300 ppm):	65,000 ft^2	36,000 ft^2

Target aerobic nitrification conditions:	**Unconfined Aquifer**	**Semi-confined Aquifer**
pH:	7.5-8.0	7.5-9.0
Minimum Temperature (deg C):	7	5
NH_3-N treatement area concentrations (mg/L):	100-865	20-390
Urea-N treatment area concentrations (mg/L):	10-180	10-65
DO Saturation (mg/L):	6.8-8.4	6.8-8.4
Aerobic nitrification rates (λ)($days^{-1}$):	0.6 - 0.7	0.6-0.7

Air sparge well design basis:	**Unconfined Aquifer**	**Semi-confined Aquifer**
Well depths (feet below ground):	72-79	140
Well diameters (in):	2	2
Screen length (ft):	5	5
Screen size (in):	0.010	0.010
Screen depth (below water):	15-20	25-30
Well back pressure (psig):	7-10	12-15
Nominal single well airflow (scfm):	6	10
Max single well airflow (scfm):	8	12
Estimated single well radius of influence (ft):	10-22	18-32

Air Compressor Sizing Estimates:	**Unconfined Aquifer**	**Semi-confined Aquifer**	**Combined Demand (scfm)**	**IR 30 HP Compressor Supply (scfm)**	**Atlas 50 HP Compressor Supply (scfm)**
Number of air sparge wells (S. Plume):	7	6			
Nominal flow @ 100 psig (scfm)	42	60	102	106 (73% duty)	106 (25% duty)
Max flow @ 100 psig (scfm):	56	72	128	130 (87% duty)	130 (45% duty)
Nominal working pressure (psig):	100	100			
Max working pressure (psig):	125	125			

Figures

FIGURE 1

Site Location Map

AGRIUM U.S., INC.
KENAI NITROGEN OPERATIONS PLANT
KENAI, ALASKA

Cook Inlet Environmental Inc.

DATE August 2018
CHKD
DRAWN AC

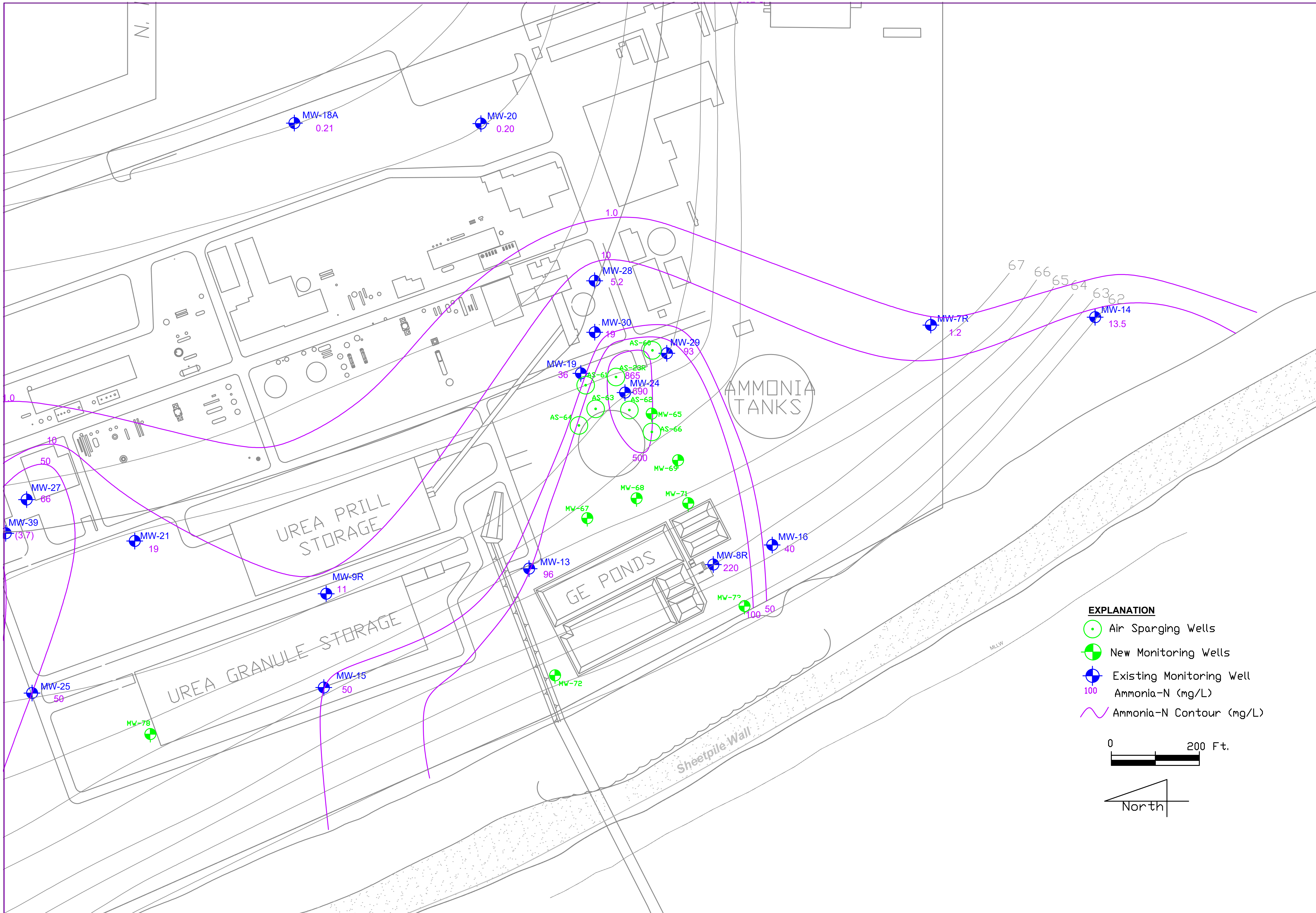


FIGURE 2

well Layout
Unconfined Aquifer

AGRIUM US, INC.
KENAI NITROGEN OPERATIONS PLANT

Cook Inlet Environmental, Inc.

DATE July 2021
CHKD JW
DRAWN LG

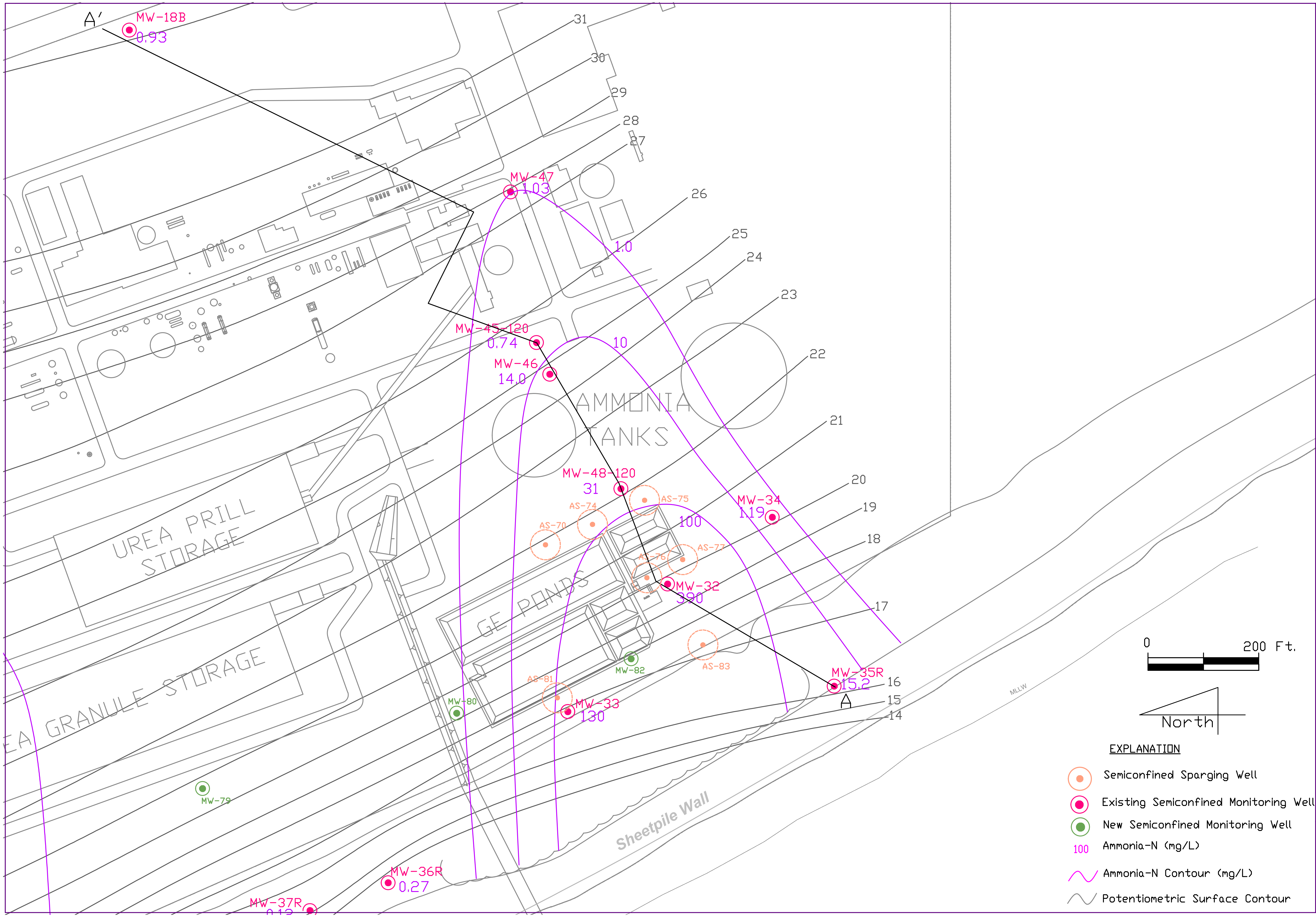


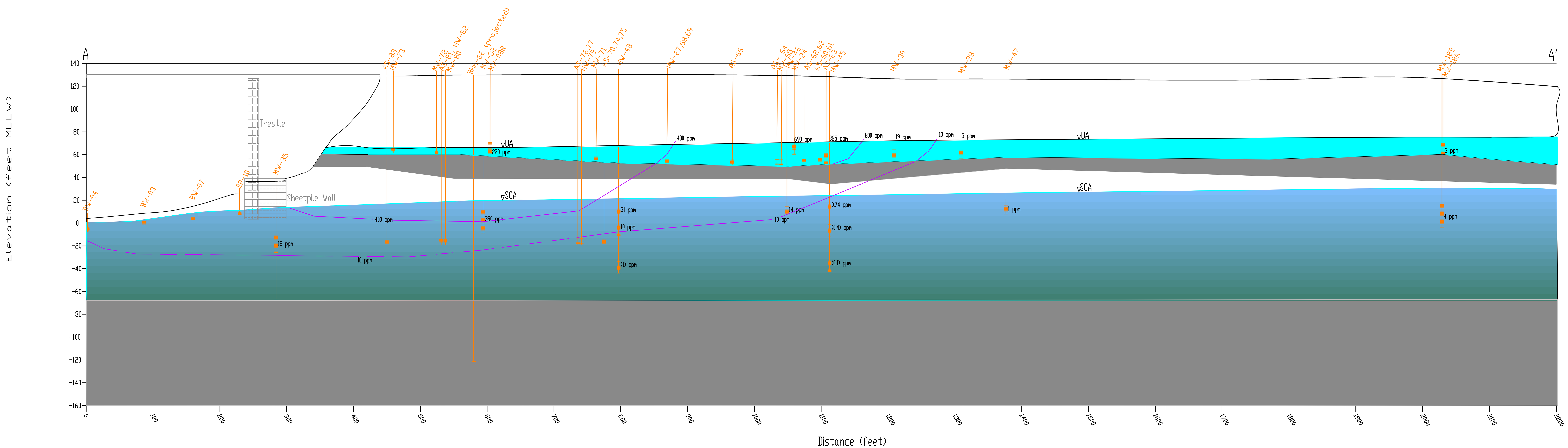
FIGURE 3

Well Layout
Semi Confined Aqufer

AGRIUM US, INC.
KENAI NITROGEN OPERATIONS PLANT

Cook Inlet Environmental, Inc.

DATE June 2022
CHKD JW
DRAWN LG



LEGEND

- UNSATURATED SAND AND GRAVEL
- AQUIFER (SILTY SAND)
- AQUIFER (SANDY SILT)
- AQUITARD (CLAY OR SILT)
- WELL OR BOREHOLE WITH SCREENED INTERVAL SHOWN
- AMMONIA CONTOURS INTERVAL SHOWN
- 100 ppm AMMONIA-N CONCENTRATION (mg/L)

FIGURE 4

Cross Section South Complex Area

AGRIUM US, INC.
KENAI NITROGEN OPERATIONS PLANT

Cook Inlet Environmental, Inc.

DATE June 2022
CHKD JW
DRAWN LG

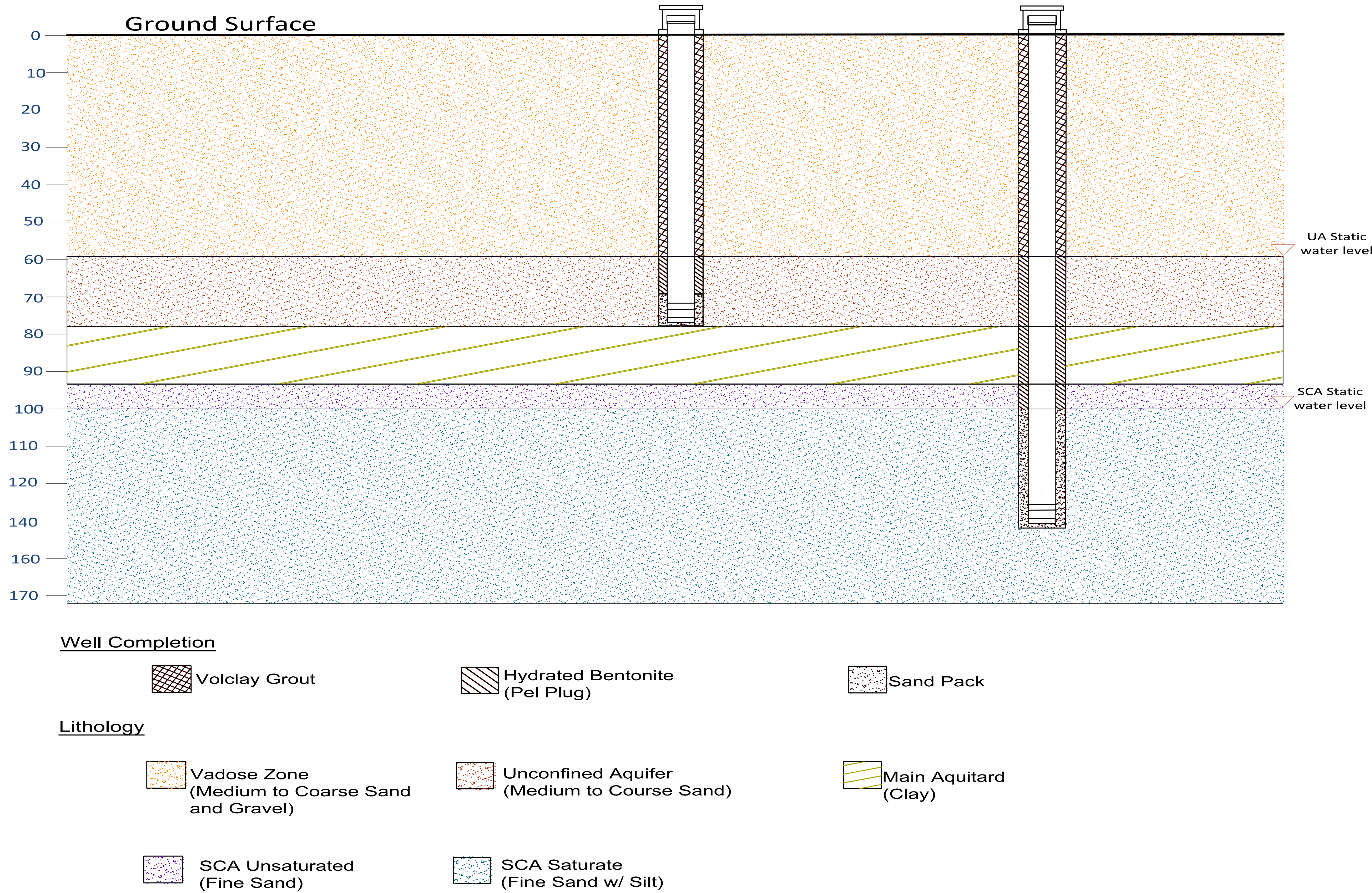


FIGURE 5

Well Construction Details

AGRIUM US, INC.
KENAI NITROGEN OPERATIONS PLANT

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DATE June 2022
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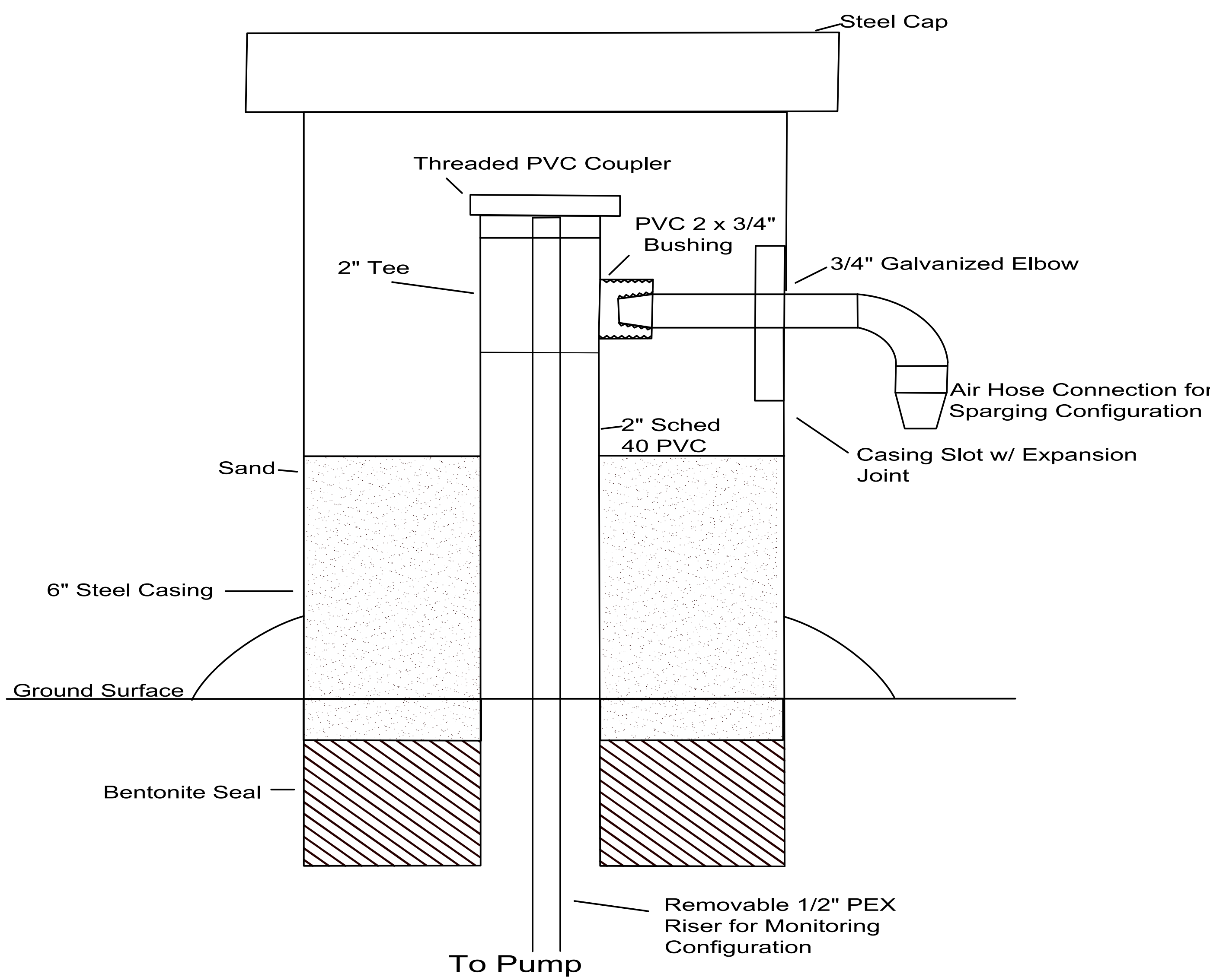
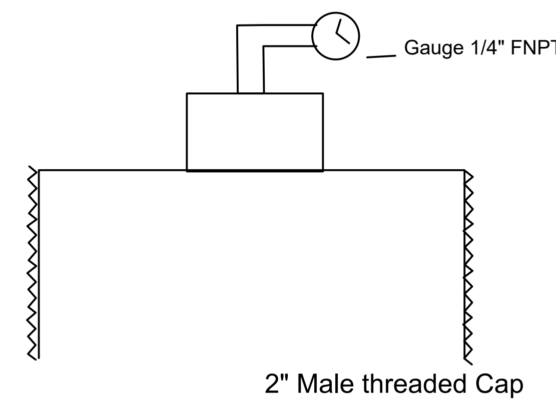
Muli-use Sparge/Monitoring Well Surface Finish



Sparging Cap:

Air Sparge
PVC Cap Details



Monitoring Cap:

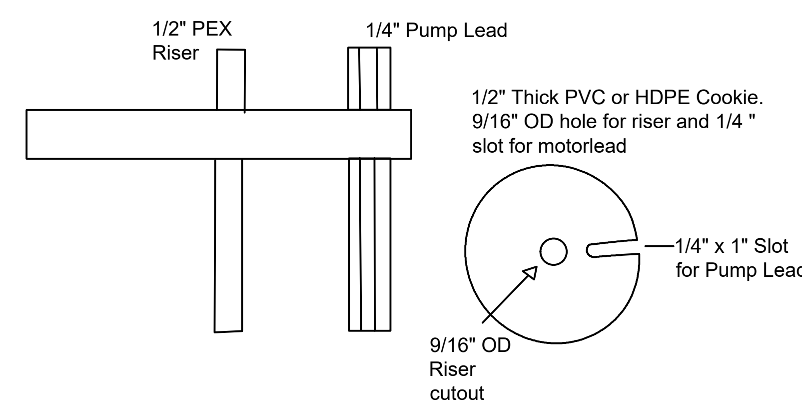


FIGURE 6

Well Head Details

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KENAI NITROGEN OPERATIONS PLANT

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DATE June 2022
CHKD JW
DRAWN LG

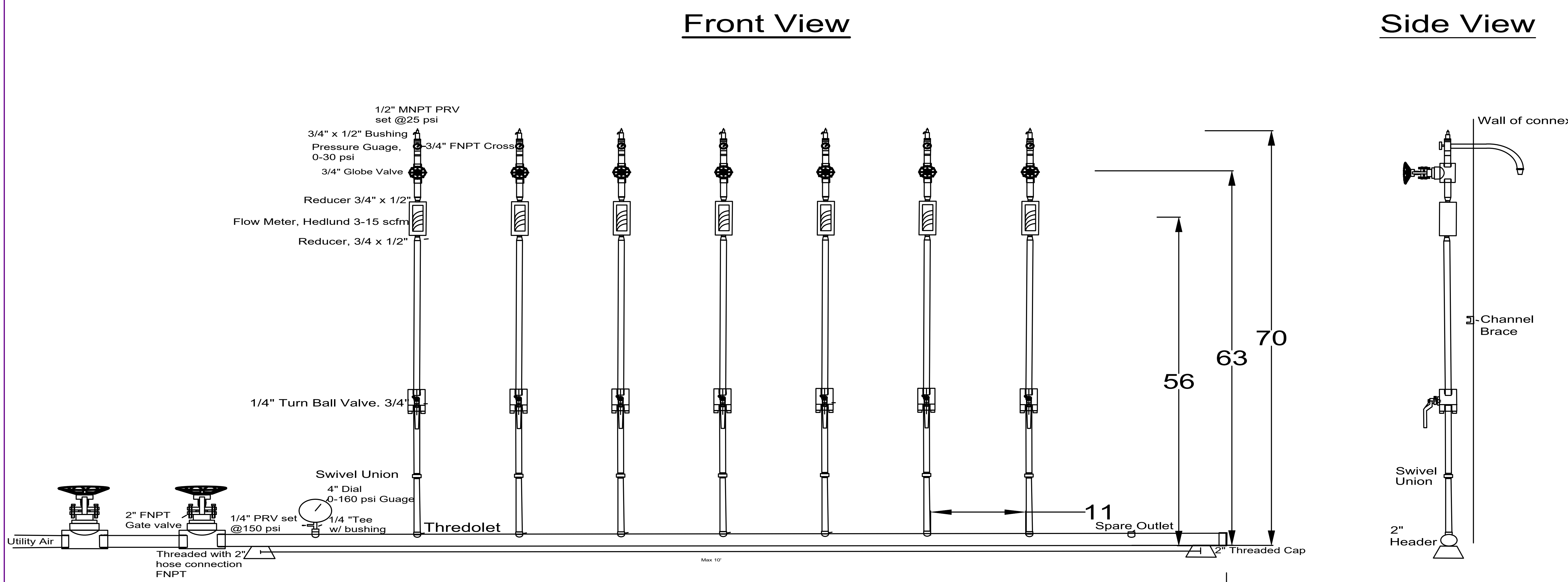

FIGURE 7

Air Sparge Manifold Details

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DATE June 2022
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DRAWN LG