FINAL

Remedial Action Management Plan
Work Plan

In Situ Thermal Remediation
(Electrical Resistance Heating)
East Gate Disposal Yard
Ft. Lewis, Washington
DACA67-02-C-0218

THERMAL REMEDIATION SERVICES, INC.

Contract No. DACA67-02-C-0218

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Abbreviations and Acronyms

AH	OWS separation surface area
API	American Petroleum Institute
bgs	below ground surface
BTU	British thermal unit
COC	contaminant of concern
CPVC	chlorinated polyvinyl chloride
CQCP	Contractor Quality Control Plan
°C	degrees Celsius
dBA	decibels, A-weighted scale
°F	degrees Fahrenheit
DMP	Data Management Plan
DNAPL	dense nonaqueous phase liquid
DQO	data quality objective
DRMO	Defense Reutilization Marketing Office
EE/CA	engineering evaluation/cost analysis
EGDY	East Gate Disposal Yard
EPP	Environmental Protection Plan
ERH	electrical resistance heating
FIR	Final Investigation Report
FSP	Field Sampling Plan
ft/ft	horizontal foot per vertical foot
gph	gallons per hour
gpm	gallons per minute
HCW	hydraulic control well
kW	kilowatt
lb/day	pounds per day
LNAPL	light nonaqueous phase liquid
LWMS	Liquid Waste Management Systems
MCL	maximum contaminant limit
mg/L	milligrams per liter
MPE	Multi-Phase Extraction
MW	monitoring well
µg/L	micrograms per liter
NAPL	nonaqueous phase liquid
OSHA	Occupational Safety and Health Administration
OWS	oil-water separator

PCBs	polychlorinated biphenyls
PCE	tetrachloroethene
PCU	power control unit
PID	photoionization detector
PMOM	Process Monitoring, Operations and Maintenance Plan
POL	petroleum, oil, and lubricant
PSCAA	Puget Sound Clean Air Agency
psi	pounds per square inch
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
QM	OWS inlet flow rate
RAMP	Remedial Action Management Plan
RI	remedial investigation
ROD	Record of Decision
SAP	Sampling and Analysis Plan
scfm	standard cubic feet per minute
SO	Specific gravity of oil (NAPL) phase
SSHP	Site Safety and Health Plan
SW	Specific gravity of water
TCA	1,1,1-trichloroethane
TCE	trichloroethene
TDH	total dynamic head
TMP	temperature monitoring point
TMS	temperature monitoring sensor
TOC	total organic carbon
TPH	total petroleum hydrocarbon
TPH-Dx	total petroleum hydrocarbons quantified as diesel extended
TPH-O	total petroleum hydrocarbons quantified as oil
TRS	Thermal Remediation Services
USACE	U.S. Army Corps of Engineers
UV	ultraviolet
V	volts
VC	vinyl chloride
VOCs	volatile organic compounds
VR	vapor recovery
WMP	Waste Management Plan
RAMP WP	Remedial Action Management Plan Work Plan

1.0 INTRODUCTION

This Remedial Action Management Plan (RAMP) describes the technical approach Thermal Remediation Services (TRS) and the project team members (Contractor) propose to remediate non-aqueous phase liquids (NAPL) contamination in areas 1, 2, and 3 at the East Gate Disposal Yard (EGDY), Ft. Lewis, Tacoma, Washington. This remediation work is being conducted for Ft. Lewis under the direction of the U.S. Army Corps of Engineers, Seattle District (USACE), Contract No. DACA67-02-C-0218. The remediation technology is an *in-situ* thermal process of electrical resistance heating (ERH). The work will be conducted in phases starting with the treatment of NAPL Area 1. Based on the performance of the ERH system at NAPL Area 1, USACE and Ft. Lewis will determine if the process will be continued for treatment of the subsequent NAPL Areas. The ERH project at Ft. Lewis is a performance-based contract and, as such, this RAMP provides the necessary plans to construct, install, operate, and monitor all aspects in order to determine if performance criteria have been met in accordance with the specifications outlined in the contract.

The ERH and Liquid Waste Management Systems (LWMS) will be the main components of the thermal remediation system at the Ft. Lewis EGDY. A hydraulic control system will be used to maintain a near static flow of groundwater within the treatment area, to minimize migration, and to monitor the effectiveness of the ERH system during operations. This system will create a groundwater depression effect within the treatment area, essentially eliminating lateral and vertical migration of suspected NAPL. The collected NAPL will be temporarily stored at the EGDY for transport offsite by the Defense Reutilization Marketing Office (DRMO).

The ERH project at Ft. Lewis EGDY will be a complex and dynamic process. As such, this RAMP and all of the supporting plans are viable documents that have been written to provide a basis for the construction, operation, and monitoring of the remediation system.

The plans address all three areas of concern at the EGDY: NAPL Treatment Areas 1, 2 and 3. Information obtained during the construction, installation and operation of the ERH system at NAPL Treatment Area 1 will be used to modify construction and monitoring processes for the remaining two treatment areas. The project team and the USACE will work together to implement changes in project protocol as the remediation effort progresses. It is quite possible that sampling and monitoring procedures and locations will change over the course of the project.

A project website will contain daily, weekly and monthly reporting of data and analytical results. USACE will use this information to determine if the project is meeting contract specifications, and as a platform to determine if changes to the protocols provided in the RAMP could maximize the efficiency of field operations and remediation system monitoring.

The RAMP has been produced as a team effort among the Contractors, with USACE providing input and editorial comments throughout the draft development phases. A series of systematic planning meetings have been implemented to present materials developed at milestones. The meetings provided a forum for discussion of project objectives and performance monitoring and presentations. The RAMP is divided into multiple sections and volumes for easy reference. The separate volumes of the RAMP contain the Site Safety and Health Plan (SSHP) and the Sampling and Analysis Plan (SAP), which is comprised of the Field Sampling Plan (FSP) and the Quality Assurance Project Plan (QAPP). This volume of the RAMP contains the Work Plan (RAMP WP); Data Management Plan (DMP); Process Monitoring, Operations and Maintenance Plan (PMOM); Waste Management Plan (WMP); Contractor Quality Control Plan (CQCP); and the Environmental Protection Plan (EPP). Each of these plans is provided within separate sections of this volume of the RAMP.

2.0 PROJECT DESCRIPTION

2.1 Site Description

The Logistics Center is located in Pierce County, Washington, approximately 11 miles south of Tacoma and 17 miles northeast of Olympia. It occupies about 650 acres of the Fort Lewis Military Reservation. The EGDY is located southeast of the Logistics Center in an otherwise undeveloped portion of Fort Lewis. The EGDY is now loosely defined as the area southeast of the intersection of Rainier Avenue and East Lincoln Drive in which landfill trenching and disposal activities historically took place. The approximate location of the EGDY site where the ERH remediation will be conducted was a previously fenced area of approximately 13.5 acres. Figure 1, EGDY Location Map, provides an overview of the EGDY in relationship to Ft. Lewis.

The Logistics Center and EGDY are situated on an extensive upland glacial drift plain that occupies much of central Pierce County. Overall, most portions of the EGDY are relatively flat. The southwestern most portion of the EGDY is approximately 5 to 10 feet higher in elevation than the rest of the site. Natural surficial drainage systems have not developed in the area due to the high infiltration capacity of the soils and the level topography.

The greater EGDY area is vegetated; however, all trees and shrubs have been cleared from the former disposal trench locations, and only a few tree stumps remain in the portions of the EGDY slated for *in-situ* thermal remediation.

2.2 General Site History

Trichloroethene (TCE) was used as a degreasing agent at the Logistics Center until the mid-1970s, when its use was replaced with 1,1,1-trichloroethane (TCA). Waste TCE was disposed of with waste oils at several locations. The EGDY was used between 1946 and the mid 1970s as a waste disposal site. Trenches were excavated in the yard and reportedly received TCE and petroleum, oils, and lubricants (POL) from cleaning and degreasing operations. This material was transported to the EGDY in barrels and vats from the various use areas. About six to eight barrels of waste TCE and POL may have been disposed of per month (Shannon & Wilson 1986). At times this material was used to assist in burning other waste products. In 2000, these trenches were opened and approximately 1,087 55-gallon drums, 92 35-gallon drums, and 1,285 5-gallon containers were removed from the EGDY. However, dense and light nonaqueous phase liquids (DNAPLs and LNAPLS, respectively) remain in the EGDY.

The EGDY is the source area for widespread TCE contamination at the Fort Lewis Logistics Center. Soil and groundwater at the EGDY site are contaminated primarily with chlorinated and nonchlorinated hydrocarbons, including TCE. TCE contamination exists in the subsurface as free-phase product, dissolved in groundwater, and adsorbed onto solids. The final engineering evaluation/cost analysis (EE/CA) for the EGDY and the Logistics Center at Fort Lewis (URS 2001a) recommends *in-situ* thermal technologies to remediate the free-phase product and optimization of the existing groundwater pump-and-treat system to remove remaining dissolved-phase contamination (Final Investigation Report 2002).

2.3 Project Overview

The ERH project at Ft. Lewis will employ two *in-situ* remediation processes at the EGDY: ERH and Multi-Phase Extraction (MPE). The project will be completed by a multidisciplinary team of remediation experts from four companies, with Thermal Remediation Services serving as the Prime Contractor. The Contractors will include AMEC Earth & Environmental, Inc. (AMEC), Camp Dresser McKee (CDM), and Garry Struthers Associates (GSA). The project will include the remediation of NAPL Areas 1, 2, and 3. The construction and installation process for Area 1 is slated to begin during Summer 2003. NAPL Areas 2 and 3 will be remediated after operations at Area 1 have been completed and evaluated by USACE. The remediation of Areas 1, 2, and 3 will include presentation of daily, weekly, and monthly reports regarding sample and process monitoring data. Reports shall be presented in an electronic format on the project website, enabling USACE and the ERH team to analyze and monitor the progress of the remediation. This RAMP provides the basic procedures for construction, installation, and monitoring of the remediation of Areas 1, 2, and 3; however, some of the information presented in this document may be specific to remediation of Area 1 because it is the first treatment area. Information developed from Area 1 will be used to modify the procedures for monitoring the remediation of Areas 2 and 3 to maximize the efficiency of the remediation process.

The ERH *in-situ* remediation project at the EGDY has been implemented to achieve specification requirements set forth in the USACE contract:

1. Establish, maintain, and verify subsurface temperatures of 90ºC and 100ºC for the vadose and saturated zones, respectively, for a minimum of 60 days,

2. Establish, maintain, and verify control of groundwater, contaminant migration, vapors, and air emissions,

3. Minimize the time to implement the remedy,

4. Provide the required level of performance and compliance monitoring, and

5. Provide a system for near-real-time data delivery and project communications.

2.4 Treatment Areas

According to the October 2002 Final Investigation Report (FIR) Phase II Remediation Investigation conducted by URS Corporation for Ft. Lewis Public Works and USACE, the total remaining mass of source area NAPL is estimated at 800,000 lb, assuming an average porosity of 30% and a 5% average NAPL saturation (i.e., 5% of the void space filled with NAPL). However, due to the relatively low level of NAPL saturation within the soil matrix, no measurable DNAPL or light nonaqueous phase liquid (LNAPL) has been observed in the monitoring wells installed to date (FIR 2002).

<u>NAPL Area 1</u>

Area 1 is approximately 25,400 square feet (0.6 acre) in size and up to 33 feet in depth, for a total volume of approximately 30,900 cubic yards. Chlorinated solvents and oils are the primary contaminants. An estimated 210,000 pounds (lbs) of NAPL remain in the subsurface (FIR 2002).

NAPL Area 2

Area 2 is approximately 51,100 square feet (1.2 acres) in size and up to 47 feet in depth; the average depth is approximately 28 feet. The total volume of NAPL Area 2 is approximately 52,200 cubic yards. A component of NAPL Area 2 has migrated with groundwater flow toward the southwest; consequently, the downgradient NAPL is generally shallower than the NAPL beneath the disposal trenches associated with NAPL Area 2. The primary contaminants found within NAPL Area 2 are cis-1,2-DCE and, to a lesser extent, TCE. An estimated 400,000 lbs. of NAPL remain in the subsurface (FIR 2002).

NAPL Area 3

NAPL Area 3 is approximately 18,200 square feet (0.4 acre) in size and up to 30 feet in depth, for a total volume of approximately 20,100 cubic yards. Chlorinated solvents (primarily TCE) are the predominant contaminants. At NAPL Area 3, an estimated 140,000 lbs. of NAPL remain in the subsurface. NAPL observed in Area 3 is present in lower saturation percentages compared to NAPL Areas 1 and 2, and is more interspersed throughout the soil matrix in globules or ganglia than in the other two areas (FIR 2002).

2.5 Technical Approach

Based on the information presented in Section 2.4, the ERH Project Team developed a design remedy employing ERH in conjunction with MPE. A liquid waste management system was designed to effectively treat the NAPL-contaminated groundwater and separate the extracted NAPL for storage, transport, and offsite disposal. Additionally, to meet contract specifications, a hydraulic control system has been developed to ensure the detention of groundwater within each treatment area, to eliminate any potential NAPL migration, and to assist in the monitoring and evaluation of the progress of the ERH system.

The ERH design was developed by TRS to provide sufficient remedy criteria for each area. The table below provides the general ERH design parameters for the three areas of concern at the Ft. Lewis EGDY.

Table 1: ERH Design Criteria for NAPL Areas 1, 2, and 3 Ft. Lewis EGDY

Criterion	Area 1	Area 2	Area 3
Electrical Resistance Heating Treatment Area	25,400 sq. ft.	51,100 sq. ft.	18,200 sq. ft.
Average Shallow Extent of ERH	0 ft	4.2 ft	0 ft
Average Deep Extent of ERH	33 ft	31.7 ft	30 ft
Average Depth to Groundwater	7 ft	8 ft	7 ft
Treatment Volume	31,040 cu yds	52,100 cu yds	20,200 cu yds
Soil Organic Carbon Content	<1%	<1%	<1%
Estimated Number of Electrodes	106	210	76
Estimated Distance Between Electrodes	17 ft	17 ft	17 ft
Average Total Depth of Electrodes	38 ft	36.7 ft	35 ft
Average Depth to Top of Electrodes	2 ft	5.1 ft	2 ft
Number of Temperature Monitoring Points (includes monitoring wells and thermocouples)	30	50	20
Estimated Number of Vapor Recovery Wells	106	210	76
Piping and Well Installation	Above grade	Above grade	Above grade
Vapor Recovery Air Flow Rate	920 scfm	1335 scfm	920 scfm
Vapor Extraction Blower	55 horsepower	80 horsepower	55 horsepower
Vapor Treatment Method	oxidizer	oxidizer	oxidizer
MPE Liquid Pumping Rate	20 gpm	40 gpm	20 gpm
Controlling Contaminant	TCE	TCE	TCE
Maximum Expected Temperature	100 - 117°C	100 - 116°C	100 - 116°C
Average Electrical Heating Power Input	1300 kW	2600 kW	1300 kW
Days to Heat-Up Treatment Volume	80	69	51
Heat-up and 60 Day Boiling Energy	5,800,000 kW-hr	9,900,000 kW-hr	4,300,000 kW-hr

2.6 Conceptual Site Model

Site geology in the EGDY consists of interbedded lenses of gravel, silty gravel, sands, and silty sands. Groundwater is encountered at approximately 7 feet below ground surface (bgs). NAPL is known to exist in both vadose zone soil and the underlying aquifer. Because the NAPL is comprised of a mixture of chlorinated and petroleum hydrocarbons, it varies in density and is found as LNAPL floating on the water table, as DNAPL resting on low permeability lenses, and as NAPL of moderate density suspended in the water table. *In-situ* remediation efforts for the three NAPL areas at the EGDY are presented in Table 1, Section 2.5.

Detailed descriptions of the regional and site geology, as well as a conceptual site model for the EGDY, are provided in Section 5.0 of the Final Investigation Report, Phase II Remediation Investigation, 2002.

2.7 Regulatory Requirements

During construction, installation, and operations of the ERH project, Occupational Safety and Health Administration (OSHA) regulations will be implemented to provide guidelines and protocols for a safe working environment. Special protocols have been developed to address safety issues pertaining to the electricity and steam present during the ERH project. The safety protocols and guidelines are provided in the SSHP of this RAMP. The SSHP, due to its size, is presented as a separate volume.

The ERH system will produce steam and vapors as it remediates the areas of concern. Regulatory requirements for vapor will include adhering to the substantive standards of Puget Sound Clean Air Agency (PSCAA) and the project-specific requirements for site-wide air monitoring. Emissions will be monitored at the oxidizer discharges (see Process Flow diagram for monitoring points) and measurements will be plotted on a graph to compare emission results with the annual criteria (per PSCAA, annual emissions of TCE cannot exceed 1391 lb/yr). Additionally, the specifications and regulations of OSHA with respect for personnel exposure through inhalation will be implemented (see SSHP).

Groundwater samples will be collected regularly during remediation operations to monitor the NAPL removal mass and rate. Treated groundwater will be sampled at the header to the infiltration wells weekly and analyzed at the on-site laboratory for the chlorinated contaminants of concern/volatile organic compounds (COC/VOCs). If regulatory limits are exceeded, the operations of the LWMS system will be adjusted. Maximum contaminant limits (MCLs) will be based on the Record of Decision (ROD).

Table 2: MCLs for Ft. Lewis EGDY

Parameter	Concentration
PH	6.5-8.5
TCE	5 µg/L
PCE	5 µg/L
cis 1,2 DCE	70 µg/L
vinyl chloride L	2 µg/L
1,1,1 TCA	200 µg/L

The analytical results from the air and groundwater sample collection will be posted on a daily, weekly, and monthly basis on the project website.

3.0 TREATMENT TECHNOLOGY DESCRIPTION AND SYSTEM DESIGN

3.1 Electrical Resistance Heating

ERH is an electrical technology that uses *in-situ* resistance heating and steam stripping to accomplish subsurface remediation. The technology has proven capable of remediating NAPL from both the vadose and saturated zones, regardless of soil permeability or heterogeneity.

The ERH Power Control Unit (PCU) uses sets of conventional 60-hertz utility transformers to direct three-phase electricity from a municipal power line into the subsurface treatment region. The electricity is delivered throughout the subsurface treatment volume by electrodes installed using standard drilling techniques.

Electrodes are connected to the PCU so that adjacent electrodes are in electrical contact, but out of phase, with each other. Because each electrode is electrically out of phase with the electrodes surrounding it, current flows between it and all adjacent electrodes. In this manner, a volume of subsurface surrounded by ERH electrodes is saturated by the electrical current moving between the electrodes. It is the resistance of the subsurface to this current movement that causes heating.

While all soils in the targeted treatment volume are heated, electricity prefers to take pathways of lower resistance when moving between electrodes and these pathways are heated slightly faster. Examples of low resistance pathways in the subsurface include silt or clay lenses and areas of higher free ion content. As chlorinated compounds sink through the lithology, they tend to become trapped on these same silt and clay lenses. Over time, trapped solvents undergo natural dehalogenation processes that produce daughter compounds and free chloride ions. Thus, at chlorinated hydrocarbon sites, the most impacted portions of the subsurface are also the low resistance electrical pathways that are preferentially treated by ERH. Subsequently, low permeability soils and solvent hot spots heat, and clean up, slightly faster than other soils during ERH remediation.

By increasing subsurface temperatures to the boiling point of water, ERH speeds the removal of contaminants by two primary mechanisms: increased volatilization and steam stripping. As subsurface temperatures begin to climb, contaminant vapor pressure and the corresponding rate of contaminant extraction increases by a factor of about 30. However, the ability of ERH to produce steam *in-situ* represents its most significant advantage over other subsurface heating techniques. Through preferential heating, ERH creates steam from within silt and clay stringers and lenses. The physical action of steam escaping these tight soil lenses drives contaminants out of those portions of the soil matrix that tend to lock in contamination via low permeability or capillary forces. Released steam then acts as a carrier gas, sweeping contaminants to the multi-phase extraction (MPE) wells.

As the subsurface is heated by ERH, NAPL trapped in the subsurface will mobilize due to changes in the physical properties of the NAPL and will begin to move to the top of the groundwater table. Movement of NAPL to the top of the groundwater table will be the result of two primary forces that are very complementary. As the TCE component in the NAPL is volatilized, NAPL density will decrease and NAPL will float to the surface through buoyancy. Additionally, steam bubbles produced *in-situ* by ERH will lift NAPL to the surface in a process very similar to the dissolved air floatation methods used by water treatment plants to remove impurities and particulates. Once on the surface of the groundwater table, the NAPL can be easily recovered by MPE.

3.2 Multi-Phase Extraction

MPE is a robust and well-developed technology used throughout the remediation industry for LNAPL recovery and groundwater cleanup. At the EGDY site, MPE will be accomplished using vacuum induced air entrainment to lift the NAPL and groundwater from the subsurface. In addition, the MPE system will also be used to recover steam and soil vapors from the vadose zone beneath the asphalt vapor cap covering the remediation area. The advantages of MPE are that it can be used to “slurp” NAPL from the top of the groundwater table, while simultaneously removing soil vapor and steam from the vadose zone. MPE can be deployed at various subsurface depths, from just above, to well below the groundwater table. Depending on the applied vacuum and set depth of the “slurp pipe”, any combination of soil vapor, NAPL, and groundwater can be recovered from the subsurface. These capabilities make MPE a very aggressive and flexible remediation tool.

For the EGDY site, the MPE wells will be constructed inside the electrode borings. This will allow the MPE system to pull groundwater to the electrodes to keep them wetted and prevent the buildup of steam pressure in the electrode boreholes.

3.3 Liquid Waste Management System

The LWMS treats the groundwater, steam condensate, and extracted NAPL liquids from both the MPE system and the hydraulic control system. Concentrations of chlorinated VOCs in water are to be reduced to less than MCLs (see Section 2.7) prior to reinjection. The LWMS is designed to accomplish the remediation of all three NAPL Treatment Areas without being modified or moved after NAPL Treatment Area 1 system installation activities are complete.

All liquids at the LWMS are passed through a coalescing plate oil-water separator (OWS), which collects NAPL and pumps it to a dual-contained NAPL storage tank for disposal. Water is passed through the OWS, adjusted for pH if needed, and air sparged in a NAPL stream sparge tank. The surge tank, OWS, and NAPL stream sparge tank are all vented to the ERH condenser and vapors from these tanks are routed to the thermal oxidizer for treatment. The VOCs discharging from the NAPL stream sparge tank will be conveyed to the condenser for treatment by the thermal oxidizer. VOCs discharging from the main air sparge tanks do not require treatment according to the PSCAA. Scrubber discharge water, due to its high chloride content, is discharged to the sanitary sewer system.

4.0 PROJECT OBJECTIVES

4.1 Remediation Objectives

The objective of the EGDY remediation effort is to design and implement an *in-situ* thermal treatment system that will allow for sequential treatment of NAPL Treatment Areas 1, 2, and 3. Operational data collected during remediation will allow decisions to be made concerning incremental expansion of each NAPL Treatment Area.

4.1.1 Major Performance Requirements

The *in-situ* thermal system design will maximize NAPL recovery, minimize time to implement, and meet the required temperatures and treatment duration for NAPL Treatment Area 1. These requirements are that the system will provide energy sufficient to increase the soil and groundwater temperature in each NAPL Treatment Area as follows:

- 100 degrees Celsius (°C) (212 degrees Fahrenheit (°F)) in the saturated zone, and
- 90°C (194°F) in the vadose zone soil.

These temperatures will be maintained in each NAPL Treatment Area for 60 days.

The upper 5 feet of soil (ground surface to 5 feet bgs) in each NAPL Treatment Area is excluded from the minimum vadose zone soil, provided that adequate energy is demonstrated to reach that soil zone to capture mobilized COCs.

Additionally, the *in-situ* thermal remediation system design shall accomplish the following:

- Control *in-situ* pressure to prevent the migration of steam, vapors, or water to the ground surface,
- Control hydraulic gradient in the NAPL Treatment Area being remediated and prevent NAPL migration out the treatment area,
- Treat water and condensate to specified standards,
- Re-inject the treated effluent into the subsurface,
- Cool, condense, and separate NAPL for collection and off-site disposal,
- Capture and treat vapors to remove, recover, or destroy COCs,
- Operate the vapor treatment components of the remediation system to meet atmospheric discharge standards, and
- Manage process waste.

The remediation design will include instrumentation and control systems that allow timely data acquisition, reporting, interpretation, and decision making to verify that operational requirements are being met, to optimize each component of the remediation system. These systems will also ensure that the treatment progress is accurately tracked, that the rate and volumes of COCs removal are measured, and that regulatory standards are being complied with.

4.2 Data Quality Objectives

Data quality objectives (DQOs) have been established for the media of concern for all three NAPL Areas associated with this project:

- Water Data Quality
- Air Data Quality
- Solid Waste Data Quality
- Total Mass Removed (mass and composition of VOCs and TPH in NAPL)
- Electricity and Heat Monitoring
- General System Operations

Eleven questions have been developed in order to determine if the DQOs for the project are met during the construction, installation, and operational phases of this project.

1. Have the temperature performance requirements of the contract been met?
2. Is heating contained within the NAPL treatment area?
3. Does the multi-phase extraction (MPE) system control vapor migration?
4. Is gradient control across the NAPL treatment area demonstrated?
5. What is the mass and composition of VOCs in the vapor and liquid streams?
6. Are NAPL and dissolved phase VOC concentration in the subsurface declining?
7. Should the treatment area or depth be decreased or expanded?
8. Should the treatment be suspended or continued?
9. Are system operations within the regulatory requirements for water and vapor treatment?
10. Are the system operations within health & safety requirements?
11. Do system components require maintenance?

A sampling/monitoring strategy has been developed to address each DQO in support of decision-making during treatment. Further details regarding the DQOs and the protocols that have been established to answer the 11 questions as they pertain to the individual media are provided in the SAP.

5.0 SYSTEM DESIGN

5.1 General Site Preparation

General site preparation will include providing a temporary power supply to run the remediation equipment, preparing asphalt pads for the placement of equipment components and the office and storage area compound, erecting security fencing, and construction of the vapor cap over NAPL Treatment Area 1. The existing groundwater infiltration gallery will be abandoned and be replaced by a new infiltration gallery to the west of NAPL Treatment Area 2. Soil currently stockpiled in NAPL Area 2 will be spread out in NAPL Area 1 during grading (prior to site cap installation). There are no other surface structures or underground utilities in the immediate vicinity of the EDGY site that will interfere with the installation and operations of the ERH remediation system.

5.1.1 Electrical Power Source

The PCU will require up to 2,000 kilowatts (kW) of power for the NAPL Treatment Area 1 remediation. The power needed to remediate Areas 2 and 3 may be adjusted according to information developed during the treatment of Area 1. Electrical power will be obtained from the nearest available source, which is a 13.8 kilovolt (kV) electrical line just west of the EGDY site. Power poles will be installed to deliver electrical power to the PCU. The PCU will reduce the supply voltage from the utility lines to the appropriate level to apply to the subsurface (300 to 500 volts).

The subsurface heating load is pure electrical resistance. There is no “starting surge” with ERH as is typically found upon starting large motors. During ERH, the load is quite stable, changing slowly over a period of days. Because the PCU operates at greater than a 99% power factor, it produces no harmonic distortion and no electrical or radio frequency noise.

5.1.2 Asphalt Vapor Cap

An asphalt vapor cap will be constructed over NAPL Treatment Area 1 to prevent rainwater infiltration into the treatment area and prevent the release of fugitive vapors to the atmosphere during remediation. The cap will be placed before drilling activities commence and will be rated for the load of the drill rig. In order to maximize the effectiveness of the cap, it will be extended 10 feet beyond the boundary of the treatment area.

Cap construction will consist of grading existing soil to add at least 1 foot of elevation in the center of the treatment area and about 0.5 foot at the boundaries of the treatment area. In addition to the thickness requirements, a grade of approximately 2% over the cap will be established to drain rainwater. The soil cap will be covered with 4 inches of compacted road base and 4 inches of asphalt. A steel reinforcing mesh will be added to the asphalt cap to increase its strength and to provide an equipotential grid for personnel electrical safety.

5.2 Process Flow

During ERH, standard three-phase electrical power is taken from the utility grid by the PCU for controlled delivery to the subsurface. As the subsurface resists the movement of the electrical current between electrodes, it is heated to the boiling point of site groundwater.

For remediation of NAPL Treatment Area 1, three phases of electrical energy will be applied to the electrode over the depth interval of 2 to 38 feet bgs. Because current has a tendency to fan out slightly in the vertical plane as it travels between the electrodes in a uniformly contaminated region, strong heating will extend about 3 feet above and below the electrode conductive zone. The tendency for current to spread slightly can be counterbalanced by the contaminant distribution at the site; more contaminated regions are more electrically conductive and thus “attract” additional current for stronger heating. This effect may limit the heating near and below the bottom of the electrodes. As this subsurface interval is heated, VOCs will be volatilized and steam-stripped from the soil matrix. Volatilized VOCs and steam will be collected at MPE wells located within the electrode boreholes. Screened from 3.5 to 23.5 feet bgs, the MPE wells are equipped with “slurp pipes” designed to allow the recovery of soil vapors, volatilized VOCs, NAPL, and groundwater from the subsurface. The MPE blowers provide the vacuum necessary to recover these media from the subsurface and to move them through the MPE system. A process flow diagram for the ERH remediation system is presented as Figure 2.

Once collected at the MPE wells, vapors, steam, and liquids are transported through the MPE piping system to a vapor-liquid separator. Vapors and steam pass through the separator to the ERH condenser, while NAPL and groundwater are collected and pumped to the LWMS. The ERH condenser includes an integral inlet vapor liquid separator that provides automatic back up in the event that the external vapor-liquid separator fails. At the ERH condenser, steam is condensed to water, while vapors pass through to the MPE blowers. Condensate collected in the condenser is pumped to the LWMS. Soil vapors and volatilized VOCs pass through the MPE blowers and are routed to a chlorinated thermal oxidizer, where VOCs in the vapor stream are destroyed. Treated vapors leaving the thermal oxidizer are cooled by a water quench and treated by an acid gas scrubber. By adding sodium hydroxide (NaOH) to the water quench and packed tower adsorber, hydrochloric acid (HCl) gas generated during the combustion of chlorinated hydrocarbons is removed from the vapor stream and converted to salt water.

Liquids pumped from the vapor-liquid separator and the ERH condenser enter the LWMS at a surge tank. The layout of the LWMS is such that, if necessary, an acid cracking step can be inserted before the surge tank to treat any emulsions that might form in the liquids. From the surge tank, liquids are passed through a coalescing plate OWS, which collects NAPL and pumps it to a dual-contained NAPL storage tank for disposal. Water is passed through the OWS, adjusted for pH if needed, and air sparged in a NAPL stream sparge tank. The surge tank, OWS, and NAPL stream sparge tank are all vented to the ERH condenser and vapors from these tanks are routed to the thermal oxidizer for treatment.

Water exiting the NAPL stream sparge tank is combined with groundwater from the three hydraulic control extraction wells, routed through three main sparge tanks, air stripped of VOCs, and reintroduced to the subsurface at the hydraulic control injection wells. The stripping air from the four main sparge tanks is emitted to the atmosphere via a 16-foot stack.

5.3 ERH Power Control Unit

The electrical energy deliver system consists of the PCU, the cables from the PCU to the electrodes, and the electrodes. The PCU adjusts the voltage applied to the subsurface for optimum heating. For remediation of NAPL Treatment Area 1, a single PCU rated for 2,000 kW (7 Million British thermal units (BTU)/hr) will be mobilized to the site, placed on a level asphalt pad, and connected to the temporary power supply. The PCU is designed to allow local utility power to be connected directly to the PCU input disconnect and is equipped with a kW/hour meter to measure energy use.

Manufactured specifically for use in ERH applications, the PCU is designed for 100% duty cycle. Over the course of the NAPL Treatment Area 1 remediation, the average output from the PCU will be approximately 65% of the rated capacity, based upon an estimated 80% uptime factor at operations of 80% of rated capacity. A 2,000 kW PCU is capable of adjustable voltage outputs from 0 to 800 volts (V). During the NAPL Treatment Area 1 remediation, the applied electrode voltage is anticipated to vary between 300 and 500 V. Electrical requirements for the operation of the 2,000 kW PCU are 100 ampere service at between 12 and 14kV. This service will be sufficient to not only power the PCU, but also all other components of the remediation system.

Power control and data acquisition is performed on a dedicated computer. Remote data acquisition software is used to collect and store temperatures at selected locations throughout the ERH system, the power, voltage, and current being applied to the electrode field by the PCU, and the operating status of the PCU. Operations personnel can access the data acquisition system and download data or monitor and control the heating process either directly or remotely by telephone modem. The total ERH power input rate for the site is monitored continuously. The voltage and current applied at the electrodes is measured by field personnel and used to calculate the power-input rates at the individual electrodes. During remediation of NAPL Treatment Area 1, the PCU will operate at an average output of about 1,300 kW. Energy requirements to complete the remediation, including energy loss to the environment, are presented Table 3.

Table 3: Estimated NAPL Treatment Area 1 Energy Requirements

Energy Application	Estimated Amount of Energy (kW-hr)[a]
Heat-up treatment volume [b]	1,600,000
Remediate VOCs and *in-situ* steam generation	1,700,000
Heat spread by thermal conduction	300,000
Energy required to heat the MPE air flow	100,000
Energy lost from soil surface to atmosphere	400,000
Energy extracted as hot groundwater	1,200,000
Energy lost to rainfall percolation cooling	None
Energy for powering other system components [c]	500,000
Remediation Totals	**5,800,000**

Notes:
[a]Based upon an average energy input of 1,300 kW.
[b]Energy required to heat the entire treatment volume to the boiling point of water at depth.
[c]Allows time for startup.

Cables used to connect the PCU to the electrodes will be Type W extra hard usage cords (a.k.a. "mining cable"). These cables are rated for routine foot traffic and occasional vehicle traffic.

Based on the size of the NAPL Area 2 and the potential volume of NAPL to remediate, TRS plans to incorporate two PCUs into the treatment system. It is assumed at this time that NAPL Area 3 equipment requirements will mirror NAPL Area 1.

5.4 Electrode Design

A total of 106 electrodes, placed on 17-foot spacing, will be used to heat NAPL Treatment Area 1. Similarly, 210 electrodes are planned for Area 2 and 76 electrodes are planned for Area 3. An Area 1 and Area 2 plot plan with electrode locations is shown on Figure 3a and an Area 3 plot plan is shown on Figure 3b. The electrode design consists of ERH heating elements and MPE system components co-located in 10-inch diameter boreholes. Electrode elements are constructed of 4-inch diameter steel pipe extending to about 33 feet bgs. Active electrical resistance heating will span the subsurface interval from 2 to 38 feet bgs. To assist with MPE operations, the pipe interval from 3.5 to 23.5-feet bgs is slotted (0.020 inches). The borehole annulus from 2 to 38-feet bgs is filled with high permeability graphite and steel shot to expand the effective diameter of the electrode. Each borehole is then sealed with a 6-inch layer of bentonite and at least 3 feet of high temperature Class G grout (neat silica cement). Design details for these hybrid wells are shown on Figures 4a, 4b, and 4c.

The electrode elements are isolated electrically from the surface by an 8-inch diameter chlorinated polyvinyl chloride (CPVC) oversleeve and non-conductive nipples, to prevent personnel exposure to hazardous voltages. High temperature Class G grout is used to seal the CPVC oversleeve and electrode elements to the asphalt vapor cap and a bentonite seal just below the grout keeps it from flowing down into the graphite and steel shot during electrode construction. High temperature Class G grout has shown the capability to allow thermal expansion of the electrode elements without failure, and is an efficient barrier to steam flow upward along the outside of the casings. Materials of construction are steel, temperature rated plastics, and cement grout. These materials have been proven to withstand a combination of elevated temperature, pressure, and chemical attack. The use of bentonite is minimized in order to prevent well seal failures at elevated temperatures.

The tight spacing of the electrodes will ensure power delivery to the subsurface and electrodes have been located to provide active electrical resistance heating slightly beyond the established boundaries of the treatment area. The electrode elements extend the entire depth of the treatment volume to ensure that subsurface heating is applied evenly and uniformly.

5.5 MPE Well Design

During the ERH process, the movement of steam becomes the driving mechanism for the transport of contaminant vapors and NAPL to the surface of the groundwater table. Because steam is produced *in-situ* during ERH, and not injected under pressure, the only driving force for steam bubble migration is gravity or buoyancy. The effect of gravity on steam below the water table is to force it directly upward toward the surface. The gravity driven forces of buoyancy are very strong, and unless the steam is trapped under a truly impermeable and continuous soil lens, it will find an upward path to the MPE wells. No such impermeable lenses are found in the treatment region.

The ERH and MPE processes result in the net extraction of water from the heated zone. Once the entire volume of NAPL Treatment Area 1 has reached boiling temperatures, water extraction from the subsurface, in the form of steam, will be about 5 gallons per minute (gpm). Additionally, the MPE system will remove up to 20 gpm of liquids from the subsurface.

Water that is removed from the subsurface either directly or as steam can be replaced only by groundwater flow in from the bottom and sides of the treatment volume. Over the course of the remediation, the amount of water removed from the treatment volume will be about 5,000,000 gallons, causing about two and one-half pore exchanges of groundwater.

By applying a vacuum to the 106 electrode elements, the MPE system can simultaneously recover soil vapors, volatilized VOCs, steam, and NAPL from the subsurface. Soil vapors and volatilized VOCs are recovered in the vadose zone through the shallow screened portions of the electrode elements. Steam venting is accomplished through the long and continuous deeper screened portions of the electrode elements. LNAPL is recovered using entrainment pipes lowered to the level of groundwater in the electrode elements. This flexible recovery system supplies vacuum to the entire electrode boring to assist in vapor recovery from the vadose zone, steam venting, and provides an aggressive LNAPL and sheen removing mechanism.

The 106 MPE wells will be extended above the asphalt vapor cap, and wellheads consisting of a 90-degree elbow and valve will be constructed of CPVC pipe and fittings. The diameter of the MPE wellhead instrument run will be 1.5 inches and includes a ball valve. The instrument run will include a thermocouple to measure the temperature of the extracted vapors and a quick-connect port to allow vacuum monitoring and vapor sampling.

5.6 Vapor-Liquid Separator

Vapors, steam, NAPL, and groundwater recovered at the MPE well heads will be routed under vacuum to the vapor-liquid separator. The separator will provide for liquid knockout and be equipped with a mist eliminator that is 99% efficient in removing droplets to a size of 10 microns. Steam and vapor will pass through the separator to the condenser, while liquids will be retained in the separator for automatic pumping to the LWMS surge tank. The skid-mounted unit will be mobilized to the site and installed on the asphalt equipment pad. The separator is sized for 125% of the expected flow of air from the MPE well field and instrumented to allow the liquid stream exiting the separator to be sampled, measured for temperature, and totalized. The pressure drop across the separator is less than 0.25 pounds per square inch (psi), which is equivalent to approximately 0.5 inches of mercury (in. Hg) vacuum.

5.7 ERH Condenser

Once any portion of the subsurface reaches the boiling point of water, steam generation will begin. As steam rises into the vadose zone, it is collected at the MPE wells and routed to the ERH condenser. The skid-mounted ERH condensers are sized and manufactured to accommodate the PCU used in the remediation effort. The condenser package will be mobilized to the site and placed on the level asphalt equipment pad.

The condenser performs as a back-up vapor-liquid separator, separates soil vapors from steam condensate, provides automated condensate pumping functions and cools the soil vapors to ambient temperatures. The vapor outlet of the condenser contains a mist eliminator that is 99% efficient in removing droplets to a size of 10 microns. When connected to a vacuum blower, the pressure drop across the condenser is less than 0.5 psi, which is equivalent to approximately 1 in. Hg vacuum.

The expected volumes of steam, soil vapors, and condensate passing through the condenser during the remediation of NAPL Treatment Area 1 are summarized in Table 4. Once the treatment volume is completely heated, the MPE system will capture approximately 1,790 standard cubic feet per minute (scfm) of steam and soil vapors from the subsurface. This combined flow will be composed of 870 scfm of steam and 920 scfm of soil vapors.

Steam, groundwater, and NAPL extraction will remove water from the subsurface at a rate of about 25 gpm. Of this, 20 gpm will be extracted liquids and about 4.9 gpm will be extracted steam. Some of the steam will condense within the recovery piping and join with the extracted liquids to be captured by the vapor-liquid separator and pumped directly to the LWMS, and about 3 gpm will remain in the form of steam, which will pass through the separator to the ERH condenser.

Table 4: Estimated Flow Rates and Volumes of Steam and Condensate

Process Stream	Maximum Flow Rate [a]	Total Volume Over the Entire Remediation Period (gal)
Combined steam and vapor flow	1,790 scfm	NA
Steam from the subsurface	870 scfm	NA
Air and vapors from the subsurface	920 scfm	NA
Water recovered from the subsurface as steam	5 gpm	900,000 gal

Notes:

[a]Flow rates achievable when the heated region is at design temperatures

NA = Not Applicable

The conditions within the condenser are a good application of Henry's Law. Based on Henry's Law, and borne out by experience at previous ERH sites, 99.6% of the TCE vapor will remain in the vapor phase as it passes through the condenser. Only 0.4% of the TCE will become dissolved in the steam condensate for treatment in the LWMS. Condensate exiting the condenser will not be cooled prior to delivery to the LWMS surge tank, as it is expected that keeping the condensate at temperature will discourage the formation of NAPL emulsions and improve VOC stripping.

The condenser is water-cooled. The heat that is removed from the steam in condensation is reflected in a temperature rise of the recirculation cooling water. The heat is then removed from the recirculation water using a cooling tower in which a portion of the recirculation water evaporates with each pass.

Based on the size of the NAPL Area 2 and the potential volume of NAPL to remediate, TRS plans to incorporate two condensers into the treatment system. It is assumed at this time that NAPL Area 3 equipment requirements will mirror NAPL Area 1.

5.8 Multi-Phase Extraction (MPE) System

Vapor recovery (VR) from vadose zone soil is an established remediation technology that is commonly used to extract volatile compounds from unsaturated soil. During VR, a vacuum is applied to an extraction well to lower the pressure in the vicinity of the well. Lowering the pressure at the extraction well induces an advective flow of soil vapors from regions of higher pressure to the extraction point. This process can enhance the volatilization of contaminants and promote the diffusion of sorbed contaminants into soil pores where they can be extracted along with soil vapors.

By extending the screened interval of the extraction well below the groundwater table, it is also possible to use vacuum to recover liquids from the subsurface. By dropping a "slurp pipe" down the extraction well to the surface of the groundwater table, or below the groundwater table, NAPL and groundwater can be recovered through vacuum entrainment. The process of combining VR and slurping in a single well is referred to as multi-phase extraction. During the NAPL Treatment Area 1 remediation, MPE will be used to remediate VOCs from shallow unsaturated soil, recover VOC vapors and steam created by the ERH process, skim NAPL from the top of the groundwater table, and keep the soil immediately adjacent to the electrode boring saturated.

A conservative VR system design assumes that subsurface vacuums decrease logarithmically with distance from the extraction points (Johnson et al. 1988; 1990). Lithologies similar to those at the EGDY usually exhibit radii of influence in excess of

30 feet. This implies that vacuum could be exerted over NAPL Treatment Area 1 using just nine extraction wells. However, the MPE design will incorporate an extraction well in every electrode borehole for a total of 106 MPE wells. This provides a great deal of reserve vacuum influence capacity while the tight extraction well spacing provides optimal NAPL extraction.

Design specifications for the vacuum blower and the vapor treatment systems used with ERH operations are based on the flow of air only. At startup of ERH, no steam is generated in the subsurface. The blower exerts a vacuum on the MPE wellheads and air in the subsurface flows towards the portion of the MPE well screens located in the vadose zone. As MPE continues, a small amount of steam is generated. That steam rises into the vadose zone and is swept toward the MPE wells by the air flowing to the screened sections of the MPE wells located in the vadose zone.

At the ERH condenser, steam is converted to water, thereby having no effect on the capacity of the MPE blowers regardless of the rate of steam production. The amount of steam generated during ERH is not, therefore, a component of the design specifications for the extraction blower or the vapor treatment system. As ERH progresses, and steam production increases, steam in the vadose zone will continue to move into the MPE well screens as it cannot migrate counter to the subsurface air flow created by the extraction blower. As the remediation volume approaches full steaming, and if the MPE system is used to entrain liquids from the subsurface, the vacuum applied by the blower to the MPE wells may increase slightly. This increase is due to head losses resulting from the increased total volumetric flow through the piping system. The subsurface air-flow pattern and vapor capture radii at the MPE wells, however, do not change. A positive displacement blower automatically increases vacuum in order to pump a constant volume of air, and no operator action is required to adjust the applied vacuum as steaming begins.

The extraction of 700 scfm of air from the subsurface will be sufficient to provide complete recovery of steam and heated soil vapors during the NAPL Treatment Area 1 remediation. In the relatively permeable vadose zone soil of the treatment area, vacuums of 5 to 10 inches of water column (in. w.c.) will be required to achieve capture radii of 30 to 40 feet at each MPE well. To ensure a conservative MPE design, criteria for flow and vacuum have been set at 920 scfm and 5 in. Hg (70 in. w.c.), respectively.

For an ERH remediation, MPE piping between the well heads and the condenser must be heat resistant and is constructed of CPVC. The temperature of the extracted steam/air mixture will be as high as 90°C (194°F). CPVC is a good thermal insulator and, based upon experience, the exterior surface temperature of the MPE header piping will remain below 50°C (120°F) and will not be a personnel hazard. The MPE piping must also be sized for the combined flow of air and steam and header pipe diameters are thus relatively larger than those used in standard MPE systems. Conveyance piping will be sized for a minimum of 125% of the expected flow. Header piping conveying the flow of a single MPE wells will measure 1.5 inches in diameter. Header piping diameter is increased to as much as 8 inches to carry the flow of multiple wells. MPE pipe routes and pipe sizes are shown on Figure 3c.

The piping to the MPE wells is routed to divide the MPE system into six regions with about 18 MPE wells each: Northwest, North Central, Northeast, Southwest, South Central, and Southeast. This piping division will allow vapor sampling in order to provide a qualitative analysis of the concentration being extracted from each region. The MPE phases or group of operations (i.e., switching from vapor to liquid extraction) is highlighted on Figure 3d. Details for NAPL Areas 2 and 3 will be developed from information obtained during the remediation of NAPL Area 1.

The vacuum loss between the condenser and the most distant MPE well is about 1.4 in. Hg at the design flow of 920 scfm of air and 550 scfm of steam. Under full steaming conditions, and an air flow of 920 scfm, the vacuum drop across the condenser is 0.5 to 1 in. Hg. If the maximum design vacuum of 5 in. Hg is applied to the subsurface, then the extraction blower will need to generate a maximum vacuum approaching 8 in. Hg.

Multiphase extraction will be performed using a 40-horsepower and a 15-horsepower positive displacement blower (Gardner-Denver 1986) placed in parallel. Positive displacement blowers are best suited for applications of high vacuum and relatively high flow. The 40-horsepower blower is rated for 880 scfm and the 15 horsepower blower is rated at 240 scfm at the design vacuum of 10 in. Hg. The use of two different sized blowers provides the operators with greater flexibility in adjusting vapor extraction rates: low (15-Hp), medium (40-Hp) and high (40-Hp and 15-Hp). The 15-horsepower blower will also be interlocked with the oxidizer to trip off line as the oxidizer approaches maximum loading conditions - this will increase the reliability of the vapor treatment and thus the MPE system. The inlets of both blowers will be manifolded to the condenser outlet and the blower outlets will be connected to the inlet of the thermal oxidizer. Piping from the condenser to the blowers and from the blowers to the oxidizer will be CPVC sized to 125% of expected flow. Sampling ports and gauges will be supplied to collect vapor samples and measure vacuum, flow, and temperature at the blower inlets and measure pressure and temperature at the blower outlets. Vacuum, pressure, and temperature will be measured by gauge, while flow is measured by hot wire anemometers or pitot tubes read with water-filled or digital manometers.

Based on the size of the NAPL Area 2 and the potential volume of NAPL to remediate, TRS plans to incorporate two 40 Hp blowers into the treatment system. It is assumed at this time that NAPL Area 3 equipment requirements will mirror NAPL Area 1.

5.9 Thermal Oxidizer

VOCs in the recovered vapor streams from the MPE well heads and the LWMS surge tank, OWS, and NAPL stream sparge tank will be treated using thermal oxidization. While catalytic oxidization allows the oxidation process to be accomplished at lower temperatures and correspondingly lower supplemental fuel consumption rates than thermal oxidization, catalysts can be poisoned by lead, bismuth, mercury, silicon, arsenic, antimony, and phosphorous and masked by several organic compounds (Johnson-Matthey 1996). These effects can significantly lower the destruction efficiencies of targeted contaminants and, in many cases, render catalytic oxidization technologies unusable. The varied nature of the NAPL constituents at the EGDY site make the use of catalytic oxidization, without prior pilot testing, an unacceptable risk.

The emissions of the oxidizer are limited to 639 kg of TCE per year. The oxidizer stack is the basis of the perimeter monitoring locations shown on Figure 3e: EGDY Plot Plan. PAM-01 through PAM-04 located at cardinal points 300 feet from the oxidizer stack. PAM-05 is located 300 feet downwind of the stack as determined by plume observations as sampling begins. PAM-06 is located at the Lincoln Avenue site access gates.

Contaminant and soil vapors are pulled from the MPE wells, through the condenser, and into the extraction blowers by vacuum. Upon exiting the extraction blowers, vapors are directed into the inlet of the thermal oxidizer. The oxidizer and acid gas scrubber include an induced draft discharge fan that exerts a slight vacuum on all vapor treatment components. Similarly, vapors from the LWMS are pulled into the ERH condenser by vacuum and then directed to the inlet of the oxidizer. These vapors are then destroyed at a temperature of between 900°C (1,650°F) and 1000°C (1,800°F) with the oxidation process being sustained by the combustion of propane as the supplemental fuel.

Dilution air is fed into the oxidizer to maintain the total concentration of flammable contaminants at less than 25% of the lower explosive limit. This also prevents damage to the oxidizer from overheating. The requirement for dilution air must be taken into consideration when sizing an oxidizer system for a given vapor stream flow rate. Because the targeted contaminants at the EGDY site have low heats of combustion, it will be possible to introduce high concentrations of contaminants to the oxidizer with a limited need for dilution air. However, NAPL liquids may contain significant kerosene (jet fuel), which has both a high heat of combustion and significant volatility. The rate of ERH power input might have to be limited to prevent overloading the oxidizer if large amounts of volatile fuels are present in the subsurface.

VOC destruction efficiency is determined by sampling the vapor stream at the inlet and outlet of the oxidizer. Oxidization of chlorinated organic compounds produces HCl vapors that require removal by using a scrubber installed immediately downstream of the oxidizer. The scrubber system consists of two stages. A wet quench (water spray) cools the exhaust gases from approximately 400°C (750°F) to about 49°C (120°F), and captures some of the HCl. Next, a countercurrent wash with a caustic (NaOH) solution neutralizes the acid quench water and removes the remaining HCl by conversion to salt water.

Scrubber auxiliaries include a caustic solution holding and supply system, a saline discharge line that removes excess dissolved solids from the scrubber, and an induced-draft fan that draws treated vapors from the scrubber and discharges them through the exhaust stack. The scrubber has an automatic control that adjusts the caustic input and scrubber blowdown based on the TCE load within the system. The scrubber monitors pH and adjusts the flow of caustic to control the level of pH to approximately neutral. Conductivity of the recirculation water (i.e., mineral content) is also monitored by the system and the scrubber blowdown is engaged to disperse salt and add fresh water. A portion of the scrubber recirculation water will be blown down to the sanitary sewer to remove dissolved minerals from the system. The volume of saline water produced is proportional to the chlorinated VOC mass that is treated. It is estimated that 200,000 gallons of scrubber discharge will be generated during the remediation of NAPL Treatment Area 1. Scrubber discharge will contain approximately 3% salt and extremely low levels of residual TCE.

Thermal oxidation offers on-site destruction of VOCs at VOC destruction efficiencies of up to 99%. Once a thermal oxidation system has been installed, the operating costs for treating vapor streams that are low in fuel value are only slightly influenced by the concentration of contaminants in the vapor stream or the total pounds of contaminants treated. The possible presence of a significant mass of kerosene fuel at the EGDY may serve to reduce the requirement for propane supplemental fuel.

In sizing a thermal oxidizer for ERH remediation at NAPL Treatment Area 1, the maximum expected flow of air needing abatement matches the recovered flows from the MPE system and the LWMS. A single skid mounted thermal oxidization system rated for 1,000 scfm will be sufficient to treat these combined air streams. A 1,000 scfm thermal oxidizer can treat up to 1,500 pounds of TCE per day at up to 99% halogenated and non-halogenated VOC destruction efficiencies on all species including high vapor compounds such as vinyl chloride. The oxidizer will be equipped with an integral water quench and packed tower caustic scrubber capable of 99% removal of HCl vapors from the oxidizer exhaust.

The oxidizer system will be self-contained, located on the level asphalt pad, and rated for continuous unattended operations. The oxidizer requires a source of electrical power, propane, potable-quality water, and sodium hydroxide. A 1,000 scfm thermal oxidizer consumes approximately 11 gallons per hour (gph) of propane, which will be stored on-site adjacent to the unit. To reduce propane usage, the oxidizer is equipped with a 60% efficient heat exchanger system.

When operating at full capacity on NAPL Treatment Area 1, the oxidizer is expected to treat about 859 pounds per day (lb/day) of TCE, 384 lb/day of cDCE, and 257 lb/day of fuel hydrocarbons. This treatment rate will require 1,100 lb/day of sodium hydroxide and produce 1,609 lb/day of salt.

Based on the size of the NAPL Area 2 and the potential volume of NAPL to remediate, TRS plans to incorporate two oxidizers into the treatment system. It is assumed at this time that NAPL Area 3 equipment requirements will mirror NAPL Area 1.

5.10 Hydraulic Gradient Control System

This section describes the designs of the hydraulic gradient control systems to be operated during ERH remediation at each of the three NAPL areas. The components of the hydraulic gradient control systems were designed based on the performance requirements in the contract specifications, information provided by USACE, and on interactions with the USACE during the systematic planning and design process.

5.10.1 General Strategy for Hydraulic Gradient Control

The general approach to achieving hydraulic gradient control will be to create an area of uniform groundwater head elevations around each NAPL area, and then lower the groundwater head elevations inside each NAPL treatment area. Groundwater pumping wells and infiltration galleries located around the perimeters of each NAPL area will be used to “flatten” the natural gradient in these areas. Extracting groundwater from MPE wells located in the NAPL areas will create local groundwater head depressions within the “flattened” hydraulic gradient zones. The proposed groundwater pumping wells or hydraulic control wells (HCWs) will be located upgradient of each NAPL area, and the infiltration galleries will be located downgradient. Each HCW can be used as either extraction wells or injection wells for flexibility in optimizing the hydraulic gradient control system. This flexibility makes the hydraulic gradient control system design robust in regards to seasonal changes in the natural gradient direction.

The components of the proposed hydraulic gradient control systems for NAPL Areas 1 and 2 include six HCWs, groundwater pumping wells (HCW01 through 03 are extraction wells; HCW04 through 06 will be used initially as injection wells), 106 and 201 MPE wells, and one infiltration gallery located as shown on Figure 3a. Two contingency wells, HCW07 and HCW08, may be installed in the future depending on the performance of the initial design and the direction of the natural gradient during ERH remediation. The proposed locations for wells HCW01, HCW02, and HCW03 are in areas of low temperature and relatively less contaminated groundwater. Pumping equipment used in these wells can be compatible with conventional, ambient-temperature conditions, which will minimize the required operations and maintenance. Further decreases in the water treatment scope and treatment costs can be attained by maximizing the volume of relatively less contaminated groundwater.

During application of ERH in NAPL Area 1 or Area 2, groundwater would be extracted from upgradient pumping wells and the respective MPE wells and transferred to the treatment system. The treated water would be discharged to the subsurface by gravity drainage into infiltration gallery and/or injection through HCW04 through 06 located downgradient of NAPL Area 1.

The proposed hydraulic gradient control system for NAPL Area 3 will include components similar to the NAPL Area 1 and 2 systems. Three HCW wells and an infiltration gallery would be located as proposed on Figure 3b. During NAPL Area 3 treatment, groundwater would be pumped from HCWs and the MPE wells to the treatment system. The treated water would be discharged to the subsurface by gravity drainage into the infiltration gallery located downgradient of NAPL Area 3.

5.10.2 Hydraulic Gradient Control Modeling

AMEC performed groundwater flow modeling for each NAPL area to aid in the design of the hydraulic gradient control systems. The groundwater flow model software, Visual MODFLOW V3.0, was used to simulate site hydrogeologic conditions and various hydraulic gradient control scenarios.

5.10.3 Groundwater Model Input Parameters

Information incorporated into the groundwater flow models includes geologic, hydrogeologic, and physical parameters summarized in the USACE Phase II Remedial Investigation (RI) Report, dated October 2002 and in the Contract Document Technical Exhibits. Model input parameter values and sources for modeling of Area 1 and Area 2 are summarized in Table 5. Input parameter values and sources for modeling of Area 3 are summarized in Table 6.

Hydraulic conductivity, specific yield, and storativity values were obtained from results of pumping inflow tests performed on wells LR-1, LR-2, LX-17, LX-18, and LX-19 by past consultants for USACE. Testing results from LR-1 and LR-2 were used in modeling of Area 1 and Area 2. Testing results from LX-17, LX-18, and LX-19 were used in modeling of Area 3.

Effective porosity values were obtained from physical testing results included as Technical Exhibit 6d. An effective porosity of 0.29 was calculated by averaging results from soil samples collected near Area 1 and Area 2.

The groundwater flow direction and gradient were determined from groundwater elevations recorded in wells LC-26 (located east of Area 1) and LC-27 (located west of Area 2) from December 1999 to November 2000 and summarized in the RI and Technical Exhibit 2. Groundwater flow appeared to be westerly in direction in April and November of 2001 (Figures 5-17 and 5-18 in the RI) with an average gradient of 0.0033 horizontal foot per vertical foot (ft/ft).

Table 5: Area 1 and Area 2 Hydraulic Control Model Input Parameter Values and Source Information

Parameter	Value	Unit	Source
Model Grid			
easting origin	1,496,439	ft	World Coordinate System
northing origin	651,590	ft	World Coordinate System
easting length	1400	ft	Figure 5-5 (RI)
northing length	800	ft	Figure 5-5 (RI)
ground surface	280	ft amsl	Averaged from Table 3-2 (RI)
aquifer thickness	100	ft bgs	Sonic boring logs (Technical Exhibit 4)
columns	115		
rows	75		
layers	4		
Hydrogeologic			
K_H	201.5	ft/d	Table 5-2 (RI) and Technical Exhibit 1
K_H/K_V	111.5		Table 5-2 (RI) and Technical Exhibit 1
S_y	0.145		Table 5-2 (RI) and Technical Exhibit 1
S_s	0.000675		Table 5-2 (RI) and Technical Exhibit 1
n_e	0.2947		Table 3-4 (RI)
horizontal gradient	0.0033	ft/ft	Well LC-26 and LC27 (Table 3-7 of RI)

Table 6: Area 3 Hydraulic Control Model Input Parameter Values and Source Information

Parameter	Value	Unit	Source
Model Grid			
easting origin	1,496,439	ft	World Coordinate System
northing origin	651,590	ft	World Coordinate System
easting length	1400	ft	Figure 5-5 (RI)
northing length	800	ft	Figure 5-5 (RI)
average g.s. elevation		ft amsl	Table 3-2 (RI)
aquifer thickness		ft bgs	Sonic boring logs (Technical Exhibit 4)
columns			
rows			
layers			
Hydrogeologic			
K_H	less	ft/d	Table 5-2 (RI) and Technical Exhibit 1
K_H/K_V			Table 5-2 (RI) and Technical Exhibit 1
S_y			Table 5-2 (RI) and Technical Exhibit 1
S_s			Table 5-2 (RI) and Technical Exhibit 1
n_e			Table 3-4 (RI)
horizontal gradient	0.0033	ft/ft	Well LC-26 and LC27 (Table 3-7 of RI)

Each NAPL area model had a domain of 2300 feet in the east-west direction and 1500 feet in the north south direction. The aquifer depth was estimated at 100 feet from sonic boring logs provided in the Technical Exhibits. The domain was discretized by 20 feet in the horizontal plane and 25 feet in the vertical plane (total of four layers).

For each simulation, upgradient and downgradient boundaries were assigned constant head values to generate a natural, uniform gradient of 0.0033 feet/feet. No-flow or zero-flux conditions were assigned to boundaries parallel to the natural groundwater flow direction. Similarly, the regional impermeable aquitard (consisting of non-glacial deposits) directly underlying the Vashon aquifer was simulated as a no-flow boundary.

Wells construction details described in Section 6 were used to assign well screen intervals in the model domain. Groundwater pumping wells were screened across the uppermost two layers, while the MPE wells and infiltration galleries were screened only in the uppermost layer.

5.10.4 Modeling Scenarios

Individual groundwater flow models were developed to simulate hydrogeologic conditions near each of the three NAPL treatment areas. A variety of gradients were modeled for each area incorporating a natural hydraulic gradient direction of east to west. The hydraulic gradient for NAPL Area 3, however, is reflected as a northwest groundwater flow direction in the associated Figures 5e and 5f. To account for seasonal changes in the direction of groundwater flow, additional simulations for each NAPL area were performed using natural gradient directions of northeast to southwest and southeast to northwest.

Hydraulic gradient control systems were designed for each NAPL area by assigning groundwater extraction and injection rates to the pumping wells, MPE wells, and infiltration galleries. The number and locations of pumping wells and MPE wells were fixed for each NAPL area model. The magnitudes of the flow rates were varied until locally low groundwater head elevations were established within each NAPL area. The design parameters for each NAPL area were the combination of flow rates that created this area of low groundwater head elevations with the minimum total extraction rate. The hydraulic gradient control system designed under westerly flow conditions was compared with designs obtained from the southwest and northwest flow models.

Each design was evaluated to insure that the contract specifications were satisfied. Particles representing contaminant mass were released within each NAPL area and tracked. The contract specifications were assumed to be satisfied if each particle released within each NAPL area were either contained in the NAPL boundaries or captured by MPE wells.

5.10.5 Results

The results of the groundwater flow simulations for each NAPL area are presented in this section. Modeling results are presented in two plan views and four cross-sectional views of groundwater head elevations and particle paths for each simulation.

The design parameters of the hydraulic gradient control systems include the number and pumping rate of extraction wells, the number and pumping rate of injection wells, and the groundwater infiltration rate. For each NAPL area, changes in the direction of the natural gradient resulted in different configurations of extraction and injection wells. In general, however, the overall pumping rate that was required to control the hydraulic gradient was independent of the natural gradient direction. The total extraction rates for each set of simulations (i.e. NAPL Area 1 simulations, NAPL Area 2 simulations, etc.) did not vary significantly with changes in the direction of the natural gradient.

The system designs presented in this section also control vertical hydraulic gradients within the NAPL treatment areas. Figures containing cross-sectional views of the NAPL treatment areas demonstrate that groundwater extracted from NAPL areas is replaced by groundwater flowing upward into the treatment zone.

Area 1 Modeling Results

NAPL Area 1 modeling results using a westerly groundwater flow direction are shown on Figures 5a and 5b. Under westerly groundwater flow, the modeling results indicate that a total extraction rate of approximately 120 gallons per minute (gpm) will establish hydraulic gradient control. Groundwater was extracted from wells HCW01, HCW02, and HCW03 with pumping rates of 30, 30, and 40 gpm, respectively. The NAPL Area 1 MPE wells had a combined total extraction rate of 20 gpm. Recovered water was injected into wells HCW04, HCW05, and HCW06 at rates of 25, 25, and 15 gpm, respectively. The balance of the extracted groundwater was discharged at 55 gpm into both legs (northwest and southwest) of the infiltration gallery.

Model results with natural groundwater flow to the southwest and to the northwest yielded similar total extraction rates of 110 gpm and 115 gpm, respectively. For the southwesterly flow simulation, groundwater was extracted from wells HCW01, HCW02, and HCW04 at 30 gpm each, and injected into wells HCW03, HCW05, and

HCW06 at 30 gpm each. Water recovered from the MPE wells (pumping a combined total of 20 gm) was injected into the southwest leg of the infiltration gallery.

Under northwesterly groundwater flow conditions, groundwater was extracted from pumping wells HCW02, HCW03, and HCW06 at 30, 35, and 30 gpm, respectively, and from the MPE wells at 20 gpm. Wells HCW01, HCW04, and HCW05 were injection wells operating at 15, 5, and 30 gpm, respectively. The balance of the extracted groundwater was discharged into both legs of the infiltration gallery at 65 gpm.

Area 2 Modeling Results

NAPL Area 2 modeling results using a westerly groundwater flow direction are shown on Figures 5c and 5d. Under westerly groundwater flow, the modeling results indicate that a total extraction rate of approximately 142.5 gallons per minute (gpm) will establish hydraulic gradient control. Groundwater was extracted from wells HCW01, HCW02, and HCW03 with pumping rates of 30, 30 and 40 gpm, respectively. The NAPL Area 2 MPE wells had a total extraction rate of 42.5 gpm. Recovered groundwater was discharged into both legs of the infiltration gallery at 142.5 gpm.

Model results with natural groundwater flow to the southwest and to the northwest yielded similar total extraction rates of 132.5 gpm and 142.5 gpm, respectively. For the southwest simulation, groundwater was extracted from wells HCW01, HCW04, and a contingency well labeled as HCW08 at 30 gpm each, and injected into wells HCW06 and a contingency well labeled as HCW07 at 10 gpm and 30 gpm. The balance of the extracted groundwater was discharged into the southwest leg of the infiltration gallery at 92.5 gpm.

With northwesterly groundwater flow, groundwater was extracted from pumping wells HCW03, HCW06, and a contingency well labeled as HCW07 at 40, 30, and 30 gpm, respectively, and from the MPE wells at 42.5 gpm. Wells HCW01, HCW02, HCW04, and a contingency well labeled as HCW08 were injection wells operating at 25 gpm each. The balance of the extracted groundwater was discharged into both legs of the infiltration gallery at 42.5 gpm.

Area 3 Modeling Results

NAPL Area 3 modeling results using a northwesterly groundwater flow direction are shown on Figures 5e and 5f. Preliminary modeling of NAPL Area 3 was performed using the same hydrogeologic parameter values used in the NAPL Areas 1 and 2 models. Initial results suggest that hydraulic gradient control could be established with a total extraction rate of 95 gpm. Three HCWs were simulated as extraction wells with a rate of 25 gpm each. MPE wells extracted an additional 20 gpm from within NAPL Area 3. Recovered groundwater was gravity drained into the infiltration gallery at a rate of 95 gpm.

5.10.6 Additional Considerations

As stated above, the magnitude of the total extraction rate needed to satisfy the USACE contract specifications for each NAPL area appears to be independent of the direction of groundwater flow. Changes in the groundwater flow direction resulted in different combinations of extraction and injection well locations and pumping rates. Factors that are more prone to influence the performance of the hydraulic gradient control systems include regional and localized variations in hydraulic conductivity (e.g. degree of heterogeneity) and seasonal changes in the magnitude of the natural gradient.

Potential effects of local heterogeneities in the study area must be considered when locating the monitoring wells to document hydraulic control. Monitoring wells located in local dense silt deposits would be influenced less by pumping in the gravel and sand lithologies that make up the Vashon outwash and till deposits.

If natural gradients higher than values presented in the RI and TE exist in the EGDY at the time of ERH remediation, the proposed hydraulic gradient control systems would be under-designed. To achieve control under these conditions, higher extraction rates would be required.

AMEC has not evaluated the effects of relocating the existing USACE infiltration gallery on direction and magnitude of the observed natural gradient. The existing infiltration gallery most likely influenced the natural gradient data reviewed by AMEC in constructing the groundwater flow models.

5.10.7 Water Conveyance Piping

Groundwater will be pumped from each of the HCWs directly to the treatment compound using separate piping for each well. Three-inch diameter PVC pipe will be used for transmission of groundwater from each extraction well head to the valve manifold at the treatment compound. This oversized piping provides ample spare capacity if the flow rate from an individual well must be increased later due to changes in groundwater flow. Treated water shall be drained to the appropriate infiltration gallery or injection well in order to maintain the desired groundwater depression in the target NAPL area. Piping connecting the treatment compound to the infiltration gallery will be 6-inch diameter PVC and to the injection wells shall be 3-inch diameter PVC.

A portion of the discharge water from the treatment system air scrubber will be routed to the Ft Lewis Public Works sanitary sewer. The distance from the air scrubber to the proposed tie-in on the sanitary sewer manhole is approximately 5000 feet. The route will be along Lincoln Avenue and the discharge line will be 1 ½-inch Schedule 40 PVC installed approximately 12-inches below surface grade with an invert variance of +/- 5 inches. Native material will be used for backfill. A trench will be cut and covered to accommodate the discharge line as it crosses Lincoln Street. The asphalt patching to accommodate the line on Lincoln Street will be completed in conjunction with the other site asphalt work.

5.10.8 Hydraulic Control System Operations and Maintenance

In general, operations and maintenance of the hydraulic gradient control system will involve monitoring pressures, flow rates, flow totals, temperatures, treatment efficiencies, and groundwater elevations in and around the subject NAPL area. Maintenance issues such as pump motor replacement or cleaning fouled infiltration piping from clean-outs would be carried out on an as needed basis. Due to the relatively short anticipated duration of operation, minimal maintenance is expected to be required for the hydraulic gradient control system. Detailed operations and maintenance issues related to the operation of the hydraulic gradient control systems are covered in the PMOM of this RAMP.

5.11 Liquid Waste Management System (LWMS)

The LWMS will be designed to accomplish the remediation of all three NAPL Treatment Areas without being modified or moved after NAPL Treatment Area 1 system installation activities are complete.

5.11.1 Liquids From The MPE System

NAPL Treatment Area 2 will determine the hydraulic design of the LWMS since it will result in generation of the greatest quantity of wastewater. During remediation of NAPL Treatment Area 2, the MPE system is anticipated to produce 40 gpm of groundwater. In addition, the LWMS will need to treat 10.7 gpm of condensate, and 0.5 gpm of cooling tower blow-down, for a total of 51.2 gpm. A 25% contingency was used to obtain a design flow of 65 gpm.

It is estimated that water from the MPE system will contain at most 24 mg/L TCE (NAPL Treatment Area 3) and 14 milligrams per liter (mg/L) cDCE (NAPL Treatment Area 1). The temperature of water from the MPE system is expected to be about 60°C (140°F) and maximally 66°C (150°F) after conveyance to the LWMS surge tank.

Based on information provided in the Final Investigation Report (FIR), estimated volumes of NAPL requiring separation in the oil-water separator are 21,000 gallons in NAPL Treatment Area 1, 45,000 gallons in NAPL Treatment Area 2, and 5,900 gallons in NAPL Treatment Area 3. These values are based on volumes presented in the FIR and the assumptions that 100% of the NAPL will be recovered and that 90% of the VOC and 10% of the TPH components of the NAPL will be volatilized prior to being conveyed to the equalization tank. The estimated compositions of extracted NAPL were calculated to be 2.1, 0.75, and 21% chlorinated VOCs for NAPL Treatment Areas 1, 2, and 3, respectively. The balance would be petroleum hydrocarbons.

Maximum NAPL production rates were conservatively estimated based on total NAPL recovery over a 60-day period and a safety factor of 100%. Maximum estimated NAPL recovery rates were 360, 750, and 100 gallons per day for NAPL Treatment Areas 1, 2, and 3, respectively. NAPL densities were calculated as a function of temperature and composition to determine the density difference between water and NAPL for oil-water separator sizing. The density differences for NAPL Treatment Areas 1 and 2 are expected to be 0.73 pounds/gallon (lb/gal) at 50°F and 0.86 lb/gal at 140°F. The density differences for NAPL Treatment Area 3 are expected to be 0.08 lb/gal at 50°F and 0.20 lb/gal at 140°F.

5.11.2 Groundwater From Gradient Control

The maximum groundwater extraction rate for hydraulic control is 100 gpm for NAPL Treatment Areas 1 and 2. The maximum groundwater extraction rate for hydraulic control in NAPL Treatment Area 3 is 60 gpm. The selected design flow is 125 gpm incorporating a 25% contingency in addition to the maximum expected flow for NAPL Treatment Areas 1 and 2. Maximum VOC concentrations in groundwater extracted for hydraulic containment will be observed in NAPL Treatment Area 3 and are anticipated to be 1,300 micrograms per liter (µg/L) of TCE and 670 µg/L of cDCE. The groundwater temperature is about 50°F.

5.11.3 Treatment Requirements

Concentrations of chlorinated VOCs in water are to be reduced to less than MCLs prior to injection (refer to Table 2, Section 2.7 for MCL list). The VOCs discharging from the main air sparge tanks do not require treatment according to the Puget Sound Clean Air Agency (PSCAA). VOCs discharging from the NAPL stream sparge tank will be conveyed to the condenser for treatment by the thermal oxidizer.

5.11.4 LWMS Process Flow

Figure 6, Figure 7, and Figure 8 present the layout, piping and instrumentation diagram (P&ID), and control logic of the LWMS. Various streams will be conveyed to a surge tank (T-001) to allow for flow equalization and initial separation of NAPL from water. The surge tank will overflow by gravity into a coalescing plate OWS. A hydraulic profile of the LWMS is show on Figure 9. An optional heat exchanger may be added during LWMS operation depending on temperatures observed in the surge tank effluent and thermal tolerance of downstream equipment.

Once separated by the OWS, LNAPL, DNAPL, and sludge will be sent to the NAPL storage tank (T-002) by pumps (P-002 and P-003). Pumps P-002 and P-003 will be operated under level control. Water will flow by gravity from the OWS to the NAPL stream sparge tank (AS-001), where about 50% of VOCs present in the water stream will be removed by air stripping. Sparge air will be blown through the NAPL stream sparge tank by blower B-001. Air flow through the NAPL stream sparge tank will be controlled by valve (V-107) and will be measured manually using a hot wire anemometer at flow measurement point FP-101. Water will flow by gravity from the NAPL stream sparge tank to the three main sparge tanks (AS-002 through AS-004).

Water extracted for hydraulic control will be combined with effluent from the NAPL stream sparge tank prior to introduction to main sparge tanks. Water will flow through main sparge tanks in series and air will be blown through these sparge tanks in parallel to strip VOCs to concentrations less than maximum concentration limits (MCLs). Air will be blown through the three main sparge tanks by blower B-002.

Air flow through the main sparge tanks will be measured manually using a hot wire anemometer at flow measurement points FP-201, FP-202, and FP-203 and controlled by butterfly valves (V-219 through V-221). Water will flow by gravity from one main sparge tank to another and the main sparge tanks will be mounted on stands at different heights for this purpose. From the last main sparge tank, water will gravity drain to the reinjection wells or to the reinfiltration gallery. After exiting the main sparge tanks the manifolded air stream will be discharged to the atmosphere through a 16-foot tall by 8-inch diameter polyvinyl chloride (PVC) stack. Air flow rate will be measured using a hot wire anemometer at flow measurement point FP-205.

Sampling of liquids and vapors is possible via several ball valves as shown on the P&ID. Sampling locations include:

- Surge tank (T-001) intake (V-101)

- OWS intake (V-103)
- NAPL stream sparge tank (AS-001) intake (V-105)
- NAPL stream sparge tank (AS-001) discharge (V-109)
- NAPL storage tank (T-002) (V-122)
- Main sparge tank No. 1 (AS-002) inlet (V-121)
- Main sparge tank No. 4 (AS-005) discharge (V-212)
- NAPL stream sparge tank air discharge (V-120)
- Discharge stack (V-224)

5.11.5 LWMS Unit Operations

5.11.5.1 Surge Tank

The surge tank (T-001) is designed to contain 20,000 gallons. The tank will be fitted with an internal discharge pipe with the inlet positioned to maintain liquid level at 80% capacity or 16,000 gallons. Based on a maximum flow of 65 gpm, the minimum hydraulic residence time is 4.1 hours. This residence time will be sufficient to equalize variable flows being received from the MPE system and to allow initial separation of NAPL from water. If necessary, reagents to adjust the pH or to aid in phase separation can be added into this tank.

5.11.5.2 Oil-Water Separator

The oil-water separator is a gravity-based settling device with a coalescing plate media. The OWS will be capable of reducing dispersed and non-emulsified oil droplets 30 µm or greater to less than 10 mg/L in the effluent. Required coalescing plate surface area was calculated using the following equation in American Petroleum Institute (API) Publication 421:

$$QM/AH = 0.00386[(SW - SO)/\mu]$$

Where QM is the design flow rate (ft^3/min),

AH is the separation surface area (ft^2),

SW is the specific gravity of water,

SO is the specific gravity of oil, and µ is the viscosity of water (poise).

AH was calculated to be 2,300 and 770 ft^2 for NAPL Treatment Areas 1 and 2 at 50°F and 140°F, respectively. AH was calculated to be 21,000 and 3,300 ft^2 for NAPL

Treatment Area 3 at 50°F and 140°F, respectively. The high value of 21,000 ft^2 is not considered to be realistic considering that it is based on conservative NAPL composition calculations for NAPL Treatment Area 3 where the estimated chlorinated VOC concentration in the NAPL was calculated to be 21%. It is likely that the NAPL will contain significantly lower concentrations of chlorinated VOCs. Additionally, if necessary the NAPL stream sparge tank AS-001 can be moved upstream of the oil water separator if necessary to reduce the VOC concentration and increase the water-NAPL density difference. Based on these considerations, an OWS coalescing plate surface of 2,000 sq. ft. was selected. Stainless steel construction is necessary based on the expected concentrations of chlorinated VOCs in the water. The coalescing plate materials of construction will initially be CPVC and later changed to stainless steel if TCE concentrations in the NAPL are too high for CPVC. The required hydraulic capacity of the OWS is 65 gpm.

5.11.5.3 NAPL Storage Tank

The NAPL storage tank (T-002) will receive up to 750 gallons per day of NAPL during treatment of NAPL Area 2. Double-wall containment for the tank will be necessary and tank materials of construction will need to withstand petroleum hydrocarbons containing TCE and cDCE. While up to 21% chlorinated VOCs are expected in extracted NAPL from NAPL Treatment Area 3, a more conservative basis has been selected for the NAPL storage tank. This basis is the *in-situ* chlorinated VOC concentration in NAPL, which is estimated to be 66%. In addition, the tank will need to withstand temperatures potentially as high as 150°F. Sludge and non-separable water will also be pumped to the NAPL storage tank from the OWS.

5.11.5.4 NAPL Stream Sparge Tank

A sparge tank has been selected for air stripping rather than a packed tower or shallow tray air stripper. The reasons for this selection included superior ability to operate under potentially fouling conditions, minimum required air flow, highest level of flexibility, and cost. The NAPL stream sparge tank (AS-001) is designed for treatment of 65 gpm of water containing 16 mg/L TCE and 14 mg/L cDCE at temperatures up to 150°F. Modeling conducted by the sparge tank manufacturer, Aeromix, indicated the percent removal of TCE and cDCE from 50°F water in the NAPL stream sparge tank is estimated to be about 50% based on use of a three-chamber sparge tank, fine bubble diffusers, and an air flow rate of 50 scfm. These air and water flow rates translate to an air-water ratio of 7.5 to 1. Greater removals can be expected with higher temperatures or higher air flow rates.

5.11.5.5 LWMS Pumps

Pump P-001 is an equipment pad sump pump that transfers rain water from the pad to the surge tank.

Pumps P-002 and P-003 are required to pump LNAPL and DNAPL/sludge, respectively, and will be provided with the oil water separator package. These pumps will be progressive cavity pumps.

The bulk of water transfer within the LWMS is through gravity flow for maximum reliability.

5.11.5.6 Main Sparge Tanks

The three main sparge tanks (AS-002 through AS-004) must treat the effluent from the NAPL stream sparge tank (AS-001) and groundwater extracted for hydraulic control to MCLs. The combined inlet stream is estimated to contain maximal concentrations shown in the table below:

Table 7: NAPL Concentrations Per Area and System Streams

NAPL Area	Hydraulic Control			Multi-Phase Extraction					Combined Streams		
					AS-001 Influent		AS-001 Effluent		AS-002 Influent		
	Flow gpm	TCE µg/L	CDCE µg/L	Flow gpm	TCE µg/L	CDCE µg/L	TCE µg/L	CDCE µg/L	Flow gpm	TCE µg/L	CDCE µg/L
1	125	32	16	34	14000	16000	5000	5000	159	1094	1082
2	125	32	16	65	6000	300	3000	175	190	1047	70
3	75	1343	672	34	24000	3000	12000	1200	109	4667	837

In addition, the effluent from the NAPL Stream Sparge Tank (AS-001) may contain up to 10 mg/L TPH. The maximum influent temperature is estimated to be 65°F and the maximum total flow rate is 190 gpm for this NAPL Treatment Area 2. Operating at an air flow rate of 1,400 scfm and an air to water ratio of 55 to 1, the three main sparge tanks are designed to remove 99.9% TCE and 98.4% cDCE. Based upon influent concentration assumptions, this will allow for effluent concentrations of less than 5 µg/L TCE and less than 70 µg/L cDCE. The design air flow rate is 1,500 scfm and the discharge air flow rate is 1,700 cfm based on 100% relative humidity.

5.11.5.7 Blowers

Blower B-001 must convey 50 to 100 cfm of air to NAPL stream sparge tank AS-001 at a minimum of 29 inches of water column (in. w.c.) discharge pressure.

Blower B-002 must convey a total of 1,500 cfm of air to main sparge tanks AS-002 through AS-004 at a minimum of 50 in. w.c. discharge pressure. The calculated discharge pressure takes into account frictional pressure losses and a sparge tank inlet pressure requirement of 30 in w.c.

5.12 System Controls

System diagnostics, controls, and alarms are accessed and set through the computer in the PCU and the control panels of the condenser, MPE blowers, LWMS, and thermal oxidizer. Emergency shut downs and automatic notification alarms are routed through these same system components.

On-site and remote operators can turn the PCU on or off, change the voltages applied to the electrical phases, reset some PCU alarms, and record temperatures throughout the ERH system. Voltage changes can be made immediately or by ramping up or down over set time intervals. Alarms are provided for transformer over-temperature, current trips and faults, and excessive voltage and current levels. Closing the main contactor on the PCU is the only way to energize the electrode field. Only authorized operations personnel using the PCU control computer can close the main contactor.

Remote and on-site operators can determine if system faults or unwanted operating conditions exist inside the PCU or the electrode field. Most faults and undesired operating conditions can be corrected locally or remotely by altering operating parameters or can be tolerated until field staff can make adjustment to the PCU or the electrode field. More severe system faults may require portions of the electrode field, or the entire PCU, to be shut down for repairs or adjustments. Transformer alarms instigate immediate shut down of the PCU and must be cleared on-site before the PCU can be reenergized.

Because steam collection and vapor treatment are vital operations functions, system alarms that do not originate in the PCU are routed through the control panels of the ERH condenser, MPE blowers, LWMS controllers, and thermal oxidizer. If the MPE system completely stops for any reason, the PCU is automatically shut down and an auto-dialer contacts operations personnel. On-site action is then required to correct the alarm condition and restart the MPE blowers before the PCU can be reenergized. Shutdown of the MPE system will cause a shutdown of the thermal oxidizer due to a low inlet pressure alarm. If there are no operating faults with the condenser and LWMS, they will continue to operate under this scenario until shut down manually.

If the vapor-liquid separator is unable to process groundwater or NAPL, the condenser will automatically assume the function of the VLS. If the ERH condenser is unable to process steam or condensate, it will alarm. This condenser alarm immediately stops the MPE blowers and halt NAPL, groundwater, and steam collection. Stopping steam collection also halts condensate production. Stopping the MPE blowers triggers a shut down of the PCU and initiates the automatic notification auto-dialer. Shutdown of the MPE blowers causes shut down of the thermal oxidizer. If there are no operating faults with the LWMS it will continue to operate under this scenario until shut down manually.

If the thermal oxidizer is unable to process vapors for any reason, it will alarm and shutdown. This alarm immediately initiates a shutdown of the MPE blowers, causing a shutdown of the PCU and triggering the automatic notification auto-dialer. On-site personnel will have to clear the alarm condition in the thermal oxidizer and restart the system. If there are no operating faults with the condenser and LWMS, they will continue to operate under this scenario until shut down manually.

If the LWMS is unable to process liquids from the vapor-liquid separator and ERH condenser due to high level alarms in the surge tank or oil-water separator, or due to high level or low air flow (as indicated by low air pressure) alarms in the NAPL stream sparge tank, the NAPL stream treatment part of the LWMS (i.e., the OWS and NAPL stream sparge tank) will alarm, shut down, and send a signal to the ERH condenser to shut down. Stopping the ERH condenser causes the MPE blowers to stop, triggers a shut down of the PCU, and initiates the automatic notification auto-dialer. Shutdown of the MPE blowers causes a shutdown of the thermal oxidizer. The remainder of the LWMS (i.e., main sparge tanks and reintroduction pump) will continue to operate normally. If there are no operating faults with the LWMS surge tank, OWS, or NAPL stream sparge tank, the LWMS will continue to operate under this scenario until shut down manually. Figure 7 includes detailed specifications on LWMS control logic. Figure 10 includes a listing of instrumentation that will be used in the LWMS.

If the LWMS is unable to process water from the vapor-liquid separator, ERH condenser, or hydraulic control extraction wells due to high level or low air flow (as indicated by low air pressure) alarms in the main sparge tanks, the entire LWMS will alarm, shut down, and send a signal to the MPE system to shut down. Stopping the MPE system, triggers a shutdown of the PCU, and initiates the automatic notification auto-dialer. Shutdown of the MPE blowers causes a shutdown of the thermal oxidizer. Additionally, the LWMS alarm will shut down the hydraulic control extraction wells.

The hydraulic control extraction wells will only shut down upon the failure of the LWMS – failure of the LWMS initiates an entire system shutdown.

The alarms associated with ERH remediation system components, along with the actions caused by each alarm are identified in the PMOM of this RAMP.

5.13 Power And Mechanical Failures

In case of a site-wide power failure, all system equipment will shut down and the auto-dialer will contact operations staff using an emergency battery pack for power. When power is restored, the thermal oxidizer will have to be restarted manually, and the PCU, ERH condenser, MPE blowers, and Blower B-001 in the LWMS cannot be restarted until the oxidizer is running. Blower B-001 will restart automatically provided that no alarms exist and an enable signal is received from the MPE system. The hydraulic control extraction well pumps will restart automatically as will Blowers B-002.

When the PCU is shut down, the creation of steam in the subsurface stops instantly. Residual steam, however, remains in the subsurface and that steam continues to rise toward the surface. If the MPE system is operating, residual steam is collected at the bottom of the vadose zone. If the MPE system is not operating, a small flux of residual steam will enter the non-heated portion of the vadose zone and condense. The condensate will be remediated by the system once operations are restarted.

6.0 MOBILIZATION AND INSTALLATION

6.1 General Information

Prior to the mobilization of equipment to the site, there will be preconstruction kick-off meeting to discuss the general plan and schedule for construction, installation, and operations. In addition, the project-wide health and safety issues will be presented and discussed (regular, daily health and safety tailgate meeting will occur throughout the duration of the project).

The mobilization to the site will occur in several phases. Reporting of activities for all phases will be posted on the project website.

<u>Phase I</u>

The initial phase will concern the following:

- Surveying
- Abandonment of the existing infiltration gallery and specified monitoring wells at NAPL Area 1
- Site grading (including transport of existing stockpiled soils into NAPL Area 1 prior to cap construction)
- Construction and installation of the site cap
- Installation of the hydraulic control wells
- Installation of the Area 1 and Area 2 infiltration gallery
- Installation of the scrubber discharge line to the sanitary sewer.
- Trenching activities for the hydraulic control system and discharge pipes

The schedule for mobilization activities for NAPL Areas 2 and 3 will be determined at a later date.

Phase II

- Electrode Installation
- Monitoring well and temperature monitoring point installation
- Well development
- Vapor recovery piping installation
- Cabling of electrodes
- Vapor recovery piping installation
- Construction of the LWMS
- Installation of the ERH and MPE Systems

Phase III

- Startup/Shakedown of the hydraulic control system, LWMS and ERH system

Phase IV

- Operations
- Sample collection and process monitoring
- Reporting (project website)

The schedule for the construction and operation of the ERH system is presented as Figure 15 of this RAMP WP.

6.1.1 Construction and Installation Hours of Operation

All drilling activities will be performed during daylight hours (approximately 7:00 a.m. to 5:00 p.m.). All work activities will be conducted in accordance with approval from USACE and any rules and regulations according to Ft. Lewis.

6.2 Underground Utilities

All NAPL areas will be surveyed for the presence of underground utilities (however, the EGDY is an open field and the likelihood of any utility lines of concern within the treatment area is minimal). Utility locations will be determined using existing utility maps and communication with Ft. Lewis Public Works and USACE. The utility survey will be completed prior to construction activities associated with the site cap installation. Before commencing drilling, digging permits will be obtained by TRS.

6.3 Equipment Decontamination

The WMP and the SAP detail all decontamination activities associated with site work.

6.4 Electrical Utility Infrastructure

In order to support the remediation effort, a 200 amp electrical service at 13.8kV will be routed to the site. Only 100 amps are required to remediate Area 1; however, the full capacity will be required for Area 2. The electrical meter will be located near the site gate off Lincoln Avenue.

The TRS team will extend the electrical service to the equipment compound near Area 2. The equipment will be located near Area 2 for both the Area 1 and Area 2 remediation. The PCU and the MPE system equipment will be relocated near Area 3 during its remediation and the equipment will be connected to the utility service there.

The electrical one-line diagrams for the ERH and LWM systems are provided on Figures 12a and 12b, respectively.

6.5 Asphalt Cover Design and Installation

The TRS subcontractor, Garry Struthers Associates, Inc. (GSA) will provide the necessary labor, materials, and personnel to prepare the surface grade and construct an asphalt surface cover (cap) within the prescribed boundaries of the three treatment areas, Area 1, Area 2, and Area 3. The location of the treatment areas within the East Gate Disposal Yard project site is presented on Figures 2a and 2b.

The asphalt surface at each treatment area will consist of 4-inches of base rock, overlaid by a 10-gauge wire mesh screen, covered by a 4-inch layer of class B asphalt mix. The asphalt will be rolled and the surface provided with a slope adequate to provide drainage and surface runoff to the asphalt cap perimeter.

A profile of the asphalt cap design for NAPL Area 1 is presented as Figure 11a. Prior to initiating any asphalt construction activities, GSA will use a licensed land surveyor to establish the perimeter and topography of the area where the cap will be installed. GSA will utilize a bulldozer and an experienced operator to prepare the existing ground surface. Native material will be excavated along the perimeter of the treatment area and used to establish a gradient or slope at arbitrary "center points" within the treatment area. The crown of each asphalt cap will rise at these center points approximately one foot above the cap perimeter to provide adequate drainage.

Once the site is rough graded, the native material will be compacted using a vibrating roller. Soil within the treatment area, including existing soils stockpiled at the site that have been transported to NAPL Area 1, will be compacted to meet prescribed criteria. Once an acceptable compaction is obtained, a 4-inch layer of crushed surfacing base course rock will be placed atop the graded, compacted, native material. The base course will be evenly distributed and then compacted with the vibrating roller.

After the base course is in place, wire mesh screens will be installed on top of the base rock before a layer of class B asphalt is placed. The wire mesh screens are a 10-gauge (0.135 inch diameter) wire panel provided in 20-foot by 20-foot sections or mats. The panels making up the sections are 6 inch by 6 inch in size. The panels will be overlapped by one grid row and tie wired together.

The final layer of class B asphalt will be four inches thick. The asphalt will be placed atop the base course and wire mesh layers in two lifts, each lift being 2-inches thick. The vibrating roller will be used to smooth, evenly distribute, and compact the asphalt. Compaction testing and Rice Density Mixture tests will not be performed for the asphalt.

6.5.1 Equipment Pad

Hardware and support components associated with the *in-situ* thermal treatment system will be staged and operated within an equipment pad, adjacent to treatment Area 2. The equipment pad will measure 60 feet wide and 120 feet long. The pad will be constructed in the sequence and manner similar to the asphalt treatment area covers. The exception being the equipment pad will have a 1-inch sloped “lip” constructed of asphalt along the outer edge of the pad. The lip will serve as a containment barrier for liquids that may leak or be spills from treatment equipment. A profile and plan view of the equipment pad design for NAPL Area 1 is presented as Figure 11b.

The pad will be finished with a slope running from the equipment pad corners to the center of the pad. A catch basin will be installed at the center of the equipment pad that will allow rainwater or liquids released within the equipment pad material to be pumped from the pad to a secondary container or drums for proper handling or disposal. The catch basin will not be connected to any external piping or drainage systems.

6.5.2 Treatment Area 1

The scope of work to install the asphalt cover at NAPLE Area 1 will require some additional minor tasks. Currently, there is a small pile, less than 5-cubic yards of soil at the northwest corner of the treatment area. Material from the soil pile will be incorporated with the native material to complete the final grade within the treatment area before the base course is installed.

The asphalt cap will cover an area approximately 32,500 square feet, which includes a 10-foot wide strip of asphalt around the perimeter of the treatment area, outside the area where the ERH electrode locations.

Specific work details for tasks required at NAPL Areas 2 and 3 will be provided as an addendum to this section when those areas are scheduled for construction activities.

6.6 Drilling Procedures

6.6.1 Drilling Oversight

The standard operating procedures for drilling are presented in the SAP. The ERH project will employ the use of two drilling technologies: rotosonic and air rotary drilling. These methods were selected for their ability to expedite the installation without the concern for refusal and offset due to the subsurface lithology (glacial till). The use of rotosonic drilling provides an added advantage as the stratigraphic sample cores will greater detail for determining the extent of the NAPL boundaries within each area of concern and to verify the treatment design is appropriate (i.e., USACE and TRS will identify and discuss whether or not any treatment areas should be modified based on field screening data). Rotosonic drilling technology will be used for the installation and construction of the monitoring wells and every other perimeter electrode location (the spacing between electrodes should allow for adequate determination of NAPL boundaries by only selecting every other perimeter electrode location).

Rotosonic Drill Rig

A geologist will oversee and supervise the rotosonic drill rig. Each geologist will supervise the drilling, NAPL screening (see the SAP), and well and designated perimeter electrode installation and construction. The geologist will affix his signature to all drilling logs, as-built well construction diagrams, lithologic logs, sampling records, and similar documents. All site personnel, geologists and others will be supervised by the TRS Site Manager, who will have overall responsibility for the installation and construction of the subsurface materials necessary for the ERH application.

Air Rotary Drill Rig

TRS personnel will oversee and supervise the air rotary drill rig(s) for the construction and installation of the remaining electrodes, and temperature monitoring points (TMPs). As air rotary does not provide stratigraphic sample cores, logging requirements will be kept to a minimum: dimensions of borehole, noticeable changes in subsurface lithology, time started and completed, and electrode and TMP construction details (as-builts).

Wells, electrodes, and temperature monitoring points (TMPs) will be constructed according to the specifications and requirements in the following subsections. All drilling activities will conform with federal, state, and local regulations. TRS will obtain all permits, applications, and other documents, including START cards, required by state and local authorities for drilling and ERH construction activities, as well as Washington State's Underground Injection Control (UIC) Program. TRS will work with the USACE Seattle office to provide the necessary information for completion of UIC registration.

TRS will provide chemical analyses of any lubricants proposed for downhole use. Chemical detection limits will be equivalent to those used in analyzing project groundwater samples. Lubricants with constituents that are toxic or that increase, decrease, or mask the target chemical species of the investigation will not be permitted. Any lubricant analysis results will be provided to USACE prior to drilling mobilization.

6.6.2 Drilling Log

A log of drilling activities will be kept in a bound field notebook. Information in the log book will include, at a minimum, location, time on site, personnel and equipment present, down time, materials used, and activities conducted. Details regarding logbook entries are provided in the accompanying FSP and the CQCP. The subcontracted drilling firm will complete a Daily Drilling Log at the end of each day of drilling for approval and signature by the rig supervisor.

6.6.3 Field Screening

Continuous sampling will only occur during rotosonic drilling activities that include the monitoring wells and selected perimeter locations. Ultraviolet (UV) field screening and sheen and dye tests will be conducted to determine the presence of NAPL (see the SAP for further details). A photo-ionization detector (PID) will be used during all drilling operations for air monitoring and to record volatile organic compound (VOC) concentrations in the soil cores. Details regarding sampling and air monitoring are provided in the accompanying SAP and the SSHP of this RAMP.

6.6.4 Drilling Derived Waste

Soil cuttings, including the soil core, will be transported to NAPL Area 2 for stockpiling. Please refer to the WMP of this RAMP for further details.

6.7 Sampling and Logging

The lithology in all boreholes will be documented on the Boring Log Form provided in SAP. Information on the boring log sheet will include the borehole location; lithology, sampling information such as sample intervals, recovery, and any other pertinent drilling information.

Samples for lithologic description from will be obtained on a continual basis for all drilling activities, however greater detail is expected from the installation of the monitoring wells and selected perimeter electrode locations due to the drilling method (rotosonic). Lithologic descriptions of unconsolidated materials encountered in the boreholes will generally be described in accordance with American Society for Testing and Materials (ASTM) D-2488-90 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) (ASTM, 1990).

6.7.1 Borehole, Casing, Grout, Filter Pack, and Seal Requirements

The table below provides the construction details for the subsurface components of the ERH system.

Table 8: ERH Subsurface Components and Surface Completion Details

Location and Type	Specifications
Electrodes	
Number of Electrodes	106
Borehole	Minimum 10-inch diameter; 38 ft bgs
Casing	4-inch diameter steel pipe
Screen Interval	2.5 to 22.5 ft bgs
Well Boxes	None. Complete at grade
Grout Seal	Class G Grout
Filter Pack	Graphite and steel shot
Temperature Monitoring Points (TMPs)	
Number of TMPs	20
Borehole Dimensions	6-inch diameter; 33 ft. bgs
Casing	3/4-inch diameter CPVC casing
Screen Interval	Not Applicable
Well Boxes:	None. Complete at grade
Grout Seal	Class G Grout
Filter Pack	Not Applicable
Hydraulic Control Wells	
Number of Wells:	6 planned for NAPL Area 1 and 2
Borehole Dimensions	10-inch diameter; 30 ft bgs
Casing	6-inch diameter stainless steel casing
Screen Interval (NAPL Area 1 and 2)	Extraction wells (3) 10 to 30-ft bgs Injection wells (3) 20 to 30 ft bgs
Well Screen:	6-inch stainless steel (0.02" slot)
Well Boxes	Standard Traffic Rated Boxes
Grout Seal	Class G Grout
Filter Pack	8-10 sieve silica Sand
Groundwater Monitoring Wells	
Number of Wells	20 (NAPL Area 1)
Borehole Dimensions	8-inch diameter; 33-ft bgs (17 wells) and 48-ft bgs (3 wells)
Casing	2-inch diameter stainless steel casing and a 3/4-inch CPVC (TMP) casing
Screen Intervals (NAPL Area 1 and 2)	19-24 ft bgs (17 wells) 43-48 ft. bgs (3 wells)
Well Screen:	2-inch stainless steel (0.02" slot)
Well Boxes	None. Complete at grade
Grout Seal	Class G Grout
Filter Pack	8-10 sieve silica Sand

Casing Requirements

Because casing for monitoring wells installed in the ERH treatment area must be temperature resistant, stainless steel will be used. The MPE wells will be low carbon steel. The TMPs will use 3/4-inch diameter chlorinated PVC (CPVC) encased in Class G grout. CPVC, as opposed to the stainless steel for monitoring wells, will be used for the TMPs because it can withstand high temperatures in conjunction with moderate VOC vapor concentrations. It cannot withstand high temperatures in conjunction with DNAPL-condensing VOC vapor concentrations.

Bentonite Seal Requirements

Due to the heating (and potential drying) effect of the ERH process, bentonite is prone to shrinkage and cracking and is therefore not an effective well sealing material. Pure sodium bentonite is used only in thin layers during well construction to divide electrically conductive zones, to differentiate zones for vapor recovery, or to prevent grout from penetrating a lower, permeable material.

6.8 Electrode Installation

The electrode design is detailed in Section 5.4. The electrode pipes will be constructed in the field by the drill crew. Borehole depths will be sounded and recorded on as-built drawings for each location. An Area 1 and Area 2 plot plan with electrode locations is shown on Figure 3a and an Area 3 plot plan is shown on Figure 3b. Design details for these hybrid wells are shown on Figures 4a, 4b, and 4c for NAPL Areas 1, 2, and 3, respectively. Electrode elements are constructed of 4-inch diameter steel pipe extending to 33-feet bgs. The borehole annulus from 38 to 2-feet bgs is filled with high permeability graphite and steel shot to expand the effective diameter of the electrode. The rig supervisor will record sounding depths that are taken by the drill crew with a weighted tape, as well as document the volume of graphite and steel shot that is used at each location. As indicated in Section 5.4, borehole will be sealed with a 6-inch layer of bentonite and at least three feet of Class G (high temperature) grout.

As shown on the electrode details, the electrode elements will have a surface/subsurface completion that consists of an 8-inch diameter CPVC oversleeve and non-conductive nipples, to prevent personnel exposure to hazardous voltages.

Surface/Subsurface Seal

Class G cement grout is used to seal the CPVC oversleeve and electrode elements to the asphalt vapor cap. A bentonite seal just below the grout keeps it from flowing down into the graphite and steel shot during electrode construction. The use of bentonite is minimized in order to prevent well seal failures at elevated temperatures. The grout seal is important to eliminate steam from leaking to the surface, therefore, great care must be taken to ensure that the oversleeve installation has not created any air pockets.

6.9 Groundwater Monitoring Wells

Groundwater monitoring wells will be used to collect groundwater samples for analysis, monitor groundwater elevations and hydraulic head, collect subsurface temperature data, and measure the pressure in shallow vadose zone soil.

A total of 20 groundwater monitoring wells will be used to monitor the progress of the NAPL Treatment Area 1 remediation. Monitoring well locations are shown on the plot plan (Figure 3a). Twelve of the monitoring wells will be inside the treatment area (with three of these twelve wells screened below the treatment region) and eight monitoring wells will be located just outside of the treatment area. Shallow monitoring wells will be screened in the permeable outwash deposits above the till and below the water table. Deep monitoring wells screened in the first relatively high permeability outwash deposit beneath the uppermost till.

Shallow monitoring well locations were selected based on the size of the treatment area in order to provide adequate representation. The wells are generally placed between three electrodes to provide representative information regarding the ERH treatment process (i.e., wells too close to the treatment boundary – not surrounded by electrodes - may provide skewed information due to potential water mixing and diffusion). Screen intervals of five feet were selected to minimize the influx of steam into the monitoring wells (i.e., longer screens might provide a "chimney" effect that would encourage steam flow up through the MW and make its parameters less representative of bulk soils). The deep monitoring well locations are in areas where there are already significant chlorinated solvent concentrations at depth, and where the highest concentrations of chlorinated solvents have been documented. Deep monitoring well F12 will be located just downgradient of existing well RS0012, MW I07 will be near well RS003, and MW C08 will be located near well RS0032.

Seventeen of the monitoring wells will be constructed to 33-feet bgs and three of the wells will be constructed to 48-feet bgs. Construction details for both shallow and deep groundwater monitoring wells are shown on Figures 13a, 13b, 13c, 13d, and 13e for NAPL Areas 1, 2A, 2B, 2C, and 3, respectively. A silica sand filter pack will surround the screened intervals and Class G high temperature grout will be used to provide well seals. Thin (1-foot) layers of bentonite will be used at filter pack/cement interfaces to prevent the spread of materials during well construction. The geologist will complete as-builts for all of the monitoring well installations and construction. The boreholes will be sounded for depth, water level will be recorded, and construction material intervals will be documented.

The wellhead design for the groundwater monitoring wells is also shown on Figures 13a, 13b, 13c, 13d, and 13e. This design has proven capable in the allowing safe and accurate sampling of groundwater wells that are at temperature due to ERH operations. In addition, the wellhead that allows groundwater sampling to be accomplished without opening the wells. Each well will have transducers installed near the bottom of the wells to monitor hydraulic head. The wellheads will be constructed by the AMEC rig supervisors and field technicians.

In addition, existing multiport wells LC-188, LC-192 and LC-193 will also be included in the groundwater sampling program. Well LC-188 is located within Area 2 and wells LC-192 and LC-193 are located south of Area 2. The project team will evaluate information from these wells and the newly installed monitoring wells to determine in other existing wells at the site warrant sampling during operations.

Temperature Monitoring Point

In addition to the well casings, each groundwater monitoring well borehole will also contain a TMP consisting of a 3/4-inch CPVC pipe extending the length of the borehole. TMPs in the deep groundwater monitoring wells will contain 11 thermocouples spaced at 5-foot depth intervals, while the shallow internal wells will contain 8 thermocouples spaced at 5-foot depth intervals. A thermocouple will be located at the upper and lower boundary of the treatment area and one thermocouple will be located at 1-foot bgs.

Monitoring wells located just outside the treatment region require a lower thermocouple density and will have thermocouples located at 6 ft, 14 ft, 22 ft, and 30 ft bgs.

Vacuum Monitoring Piezometer

The top of each groundwater monitoring well will be constructed to include a vacuum monitoring piezometer placed to measure subsurface vacuums at the depth interval of 4 to 5-feet bgs. The vacuum piezometers are constructed of sintered bronze filters surrounded by a silica sand filter pack and attached to a 1/4-inch Teflon tube, which extends to the surface where pressure readings can be made.

6.10 Well Development

All monitoring wells will be developed by the drilling service provider using a well development rig. Oversight will be provided by either TRS or AMEC personnel. Wells will be developed using surge blocks. At a minimum, well development will either last four hours or until approximately 200 gallons of water has been removed. Water quality parameters (pH, conductivity, temperature) will be monitored during development. In addition, turbidity readings will be collected and must stabilize to plus or minus 10 percent before well development may be considered complete. A groundwater well development log will be maintained for each location.

6.11 Temperature Monitoring Points (TMPs)

The ERH heating process is directly monitored by thermocouple instrumented TMPs. A total of 20 TMPs are co-located with the groundwater monitoring wells and an additional 20 TMPs are located in TMP borings across NAPL Treatment Area 1, as shown in the plot plan (Figure 3a).

Construction details of the TMP borings for all of the NAPL Areas are shown on Figures 13a through 13e. These borings will extend to 33-feet bgs and will contain a 3/4-inch CPVC casing instrumented with 8 thermocouples spaced at 5-foot depth intervals. A thermocouple will be located at the upper and lower boundary of the treatment area and one thermocouple will be located at 1-foot bgs. In addition, the top of each TMP boring will contain a vacuum monitoring piezometer placed to measure subsurface vacuums at the depth interval of 4 to 5-feet bgs. The vacuum piezometers are constructed of sintered bronze filters surrounded by a silica sand filter pack and attached to a 1/4-inch Teflon tube, which extends to the surface where pressure readings can be made.

The EGDY site has very high permeability soils in the vadose zone and only a low wellhead vacuum will be required in order establish vacuum influence over the site. Vacuum levels in the piezometers are likely to be quite low (less than 1” H_2O) also.

6.12 Vadose Zone Vacuum Piezometers

Vacuum in the shallow vadose zone (5-feet bgs) inside and outside the treatment area will be monitored at 40 separate vacuum piezometer points, 20 inside the groundwater monitoring wells and 20 inside the TMP borings, to ensure that no VOC vapors are escaping the treatment area. Measurements will be made during the start-up of the MPE system, to confirm that the MPE system has an adequate radius of influence, and then periodically during the remediation to confirm that the MPE system continues to keep the vadose zone beneath NAPL Treatment Area 1 under vacuum conditions.

6.13 Hydraulic Control System Wells

Six hydraulic control system wells will be installed for the remediation of Areas 1 and 2, at locations shown on Figure 3a. Three of the wells (HCW01, HCW02, and HCW03) will be used for extraction of relatively low VOC water from upgradient of Area 1. The other three wells (HCW04, HCW05, and HCW06) will be used for injection during the remediation of Area 1. In addition, wells HCW04 and HCW06 may be converted to extraction wells during the remediation of Area 2, especially if the direction of groundwater flow changes in the interim. Details of Hydraulic Control Wells are shown in Figure 14.

6.14 Infiltration galleries

Two infiltration galleries will be installed to the west of Area 2. Construction details are provided in Figure 15. Each infiltration gallery is sized to handle the entire discharge of the LWMS - the flow directed to each gallery will be adjusted to provide the optimal hydraulic control near Area 2.

7.0 EQUIPMENT AND MATERIALS

The ERH system will use a wide variety of equipment and materials during construction, installation, and operations. General field equipment will include an assortment of hand and power tools such as circular saws and drills. The information presented below presents the basic equipment to be utilized during site cap construction, ERH, hydraulic control, and LWMS operations.

7.1 Heavy Construction Equipment

This is the list for heavy equipment. Additional items may include a plate compactor and various hand tools, saws, and survey equipment.

- 455G track loader
- JD 650H dozer
- Double drum Vibratory roller
- 580M backhoes for trenching (2)
- Support vehicles (pickup trucks) (2)
- Optional: 2000 gallon water truck in case dust becomes an issue

7.2 Electrical Resistance Heating Equipment

Item	Description	Quantity
HCW Well Pumps	1.5 HP or 2 HP Electric - 65 gpm	3
Vapor Liquid Separator	36" diameter, 8" inlet, 1.5 HP liquid pump	1
Condenser	plate and frame heat exchanger, non-contact water cooled	11
VR Blower 1	40 HP rotary lobe blower with discharge silencer and noise enclosure	1
VR Blower 2	15 HP rotary lobe blower with discharge silencer and noise enclosure	1
Thermal Oxidizer	1000 scfm, two second residence time, 60% heat exchanger, acid gas scrubber	

7.3 Liquid Waste Management System Equipment

Table 9: Liquid Waste Management System Equipment Details

Liquid Waste Management System Equipment Details	
Surge Tank T-001 • Manufacturer - Baker Tanks • Model - Vapor Tight EZ Clean • Volume - 20,000 gal • Materials of construction - A36 low carbon steel • Double containment - None	**Oil-Water Separator OWS** • Manufacturer - Parkson • Model - SRC-100 • Type - Coalescing plate • Rated flow - 100 gpm • Coalescing Plate area - 2,000 sq ft. • Materials of construction - Stainless steel housing, CPVC coalescing pack with ¾ in spacing
LNAPL Pump P-002 • Manufacturer - Part of Parson OWS package • Model - TBD • Type - Progressing cavity • Flow rate - TBD • Discharge TDH TBD • Inlet pressure - TBD • Duty - Cycling • Materials of construction - SS • Electrical - ____ HP, 460 VAC, 3 PH	**DNAPL/Sludge Pump P-003** • Manufacturer - Part of Parkson OWS package • Model - TBD • Type - Progressing cavity • Flow rate - TBD • Discharge TDH - TBD • Inlet pressure - TBD • Duty - Cycling • Materials of construction - TBD • Electrical - ____ HP, 460 VAC, 3 PH

Table 9: Liquid Waste Management System Equipment Details

Liquid Waste Management System Equipment Details	
NAPL Storage Tank T-002 • Manufacturer - To be determined by Ft. Lewis • Model - TBD • Volume - TBD • Materials of construction - TBD	**NAPL Stream Sparge Tank AS-001** • Manufacturer - Aeromix • Model - Breeze Series 3 with fine bubble diffusers • VOC removal efficiency - 50% • Water flow rate - 65 gpm • Air flow rate - 50 to 100 scfm • Maximum allowable temperature - 150^{o}F • Materials of construction - Polypropylene and stainless steel
Main Sparge Tanks AS-002, AS-003, AS-004 • Manufacturer - Aeromix • Model - 4 Breeze Series 8 with fine bubble diffusers operated in series for water and in parallel for air. • VOC removal efficiency - 99.9% TCE and 98.4% cDCE • Water flow rate - 190 gpm • Air flow rate - 1,500 scfm total, 375 scfm per sparge tank. • Maximum allowable temperature - 150^{o}F • Materials of construction - Polypropylene and stainless steel	**Blower B-001** • Manufacturer - New York Blower • Model - 2406A • Type - Pressure blower • Duty - 100% • Flow Rate - 100 cfm at 43 in w.c. discharge • Contaminant concentrations - None • Inlet pressure - ambient • Materials of construction - steel housing and aluminum wheel • Electrical - 7.5 HP, 460 VAC, 3 PH, TEFC motor • Noise - 80.2 dBA at 5 ft
Blower B-002 • Manufacturer - New York Blower • Model - 2608A • Type - Pressure blower • Duty - 100% • Flow Rate -2000 cfm at 53 in w.c. discharge • Contaminant concentrations - None • Inlet pressure - ambient • Materials of construction - steel housing and aluminum wheel • Electrical - 25 HP, 460 VAC, 3 PH, TEFC motor • Noise - 80.2 dBA at 5 ft	

7.4 Hydraulic Control Equipment

Groundwater Extraction Equipment	Manufacturer	Type	Qty
Submersible well pump (4-inch, 1½-Hp, 3-ph, 460V) for HCW01 and 02	Goulds	40GS154534	2
Submersible well pump (4-inch, 2-Hp, 3-ph, 460V) for HCW03	Goulds	55GS204534	1

8.0 SAMPLING AND ANALYSIS PLAN

This RAMP contains a detailed SAP, which is divided into an FSP and a QAPP. The SAP is presented as a separate document.

Details regarding the DQOs, sampling strategies, analytical requirements and sampling schedules are presented in the SAP. The schedule, location and rationale for all sampling and monitoring activities are provided in Tables 1 and 2 of the SAP.

9.0 DATA MANAGEMENT PLAN

This RAMP contains a detailed DMP that is presented as a separate, tabbed section within this document.

Details regarding the presentation and frequency of reporting, the project website, and data management communication strategy are outlined in the DMP. In addition, the DMP contains example outputs of all daily, weekly and monthly reporting including graphs and charts used to monitor the progress of the ERH system.

The DMP, the PMOM, and the SAP provide information regarding the sources of all data generated during the ERH remediation.

10.0 SITE SAFETY AND HEALTH PLAN

Due to size and complexity of the ERH remediation system at Ft. Lewis, the SSHP is presented as a separate document for this RAMP. All site personnel will be required to read and sign an acknowledgment form located within the SSHP. Copies of the SSHP will be available to all site personnel including subcontracting vendors such as drilling service providers.

A kick-off health and safety meeting will be held prior to the commencement of field activities. In addition, daily tailgate meetings will also include health safety briefings.

A daily sign-off sheet, incorporated into the Daily Quality Control Report, will be kept on file at the site and presented with the daily report.

All personnel working on the ERH project at Ft. Lewis will have completed a 40-hour OSHA HAZWOPER course, and will also have a current medical testing report. Copies of the certifications will be maintained in the site files.

11.0 WASTE MANAGEMENT PLAN

This RAMP contains a detailed WMP that is presented as a separate, tabbed section within this document.

Details regarding the handling of all construction and remediation operations waste are detailed within the DMP. Contact and emergency numbers are also presented within the DMP.

12.0 CONTRACTOR QUALITY CONTROL PLAN

This RAMP contains a detailed CQCP that is presented as a separate, tabbed section within this document.

Details regarding the quality control, approvals, and oversight for all phases of the construction, installation, and operation of the ERH remediation system are provided in the CQCP. The plan also provides details regarding the titles and qualifications of all key personnel. Copies of the various DQCRs (i.e., construction, operations and chemical data) are also presented in the CQCP.

13.0 ENVIRONMENTAL PROTECTION PLAN

This RAMP contains a detailed EPP that is presented as a separate, tabbed section within this document.

Details regarding the protocols and measures taken to ensure a safe work environment as well as protection of the surrounding environment are provided in the EPP.

14.0 REPORTING

Per the contract specifications for the ERH remediation project at the EGDY, Ft. Lewis, daily, weekly and monthly reporting will be generated and posted on the project website. Please refer to the DMP for more detail.

An installation completion report and a final report for the ERH remediation of Area 1 are scheduled to be provided.

15.0 PROJECT MANAGEMENT AND SCHEDULE

The enlarged ERH remediation is a joint effort by the TRS project team, which includes AMEC Environmental & Earth, Inc., Camp Dresser & McKee (CDM), and Garry Struthers Associates (GSA), and the USACE-Seattle District. Additionally, the complex nature of this project requires the involvement of numerous other organizations and personnel. Efficient and accurate communication among these organizations is a critical element to the success of this project. The purpose of this section is to outline the management structure and areas of responsibility.

A flow chart within the DMP illustrates the overall relationship among the various organizations involved with this project. The project will require substantial interaction with the TRS project team and USACE. Table 10 provides details on the primary points of contact within each organization. Due to its applicability, this table is repeated within the DMP.

Details regarding the responsibilities of the TRS project team are provided in the CQCP.

A general construction, installation and operations schedule is provided as Figure 16. This schedule is subject to change.

Table 10: Contact Information

Name	Title	Organization	Phone	E-Mail
Rich Wilson	Program Manager	PW-ENDR IRP	253-966-1801	WilsonR@lewis.army.mil
Troy Bussey	Environmental Engineer	PW-ENDR-IRP	253-966-1083	busseyt@lewis.army.mil
Jana Nelson	RCRA Program Manager	PW-ENDR	253-966-6458	Nelsonj2@lewis.army.mil
Richard Singler	Environmental Scientist	PW-ENDR	253-966-6468	singlerr@lewis.army.mil
Tony Huston	Technician	PW-ENDR	253-966-6457	houstont@lewis.army.mil
David Roden	Contracting Officer Representative	USACE Seattle District	206-764-3448	David.E.Roden@nws02.usace.army.mil
Linnea Norby	Project Manager	USACE Seattle District	206-764-6831	Linnea.N.Wolfe@nws02.usace.army.mil
Kira Lynch	Environmental Scientist	USACE Seattle District	206-764-6918	Kira.P.Lynch@NWS02.usace.army.mil
Richard Smith	Hydrogeologist	USACE Seattle District	206-764-3309	Richard.E.Smith@NWS02.usace.army.mil
Marilyn Eleno	Construction Engineer	USACE Seattle District	253-966-4387	Marilyn.R.Eleno@nws02.usace.army.mil
Kim Calhoun	Industrial Hygienist	USACE Seattle District	206-764-3415	Kimberly.Calhoun@nws02.usace.army.mil
Bryce Jones	Environmental Engineer (Construction QAR)	USACE Seattle District	206-764-3324	bryce.r.jones@nws02.usace.army.mil
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Michael Dodson	Program Manager	TRS	360-425-8121	mdodson@thermalrs.com

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Jerry Wolf	Director of Operations	TRS	714-378-5418	jwolf@thermalrs.com
Tom Powell	QC Officer	TRS	360-263-3615	tpowell@thermalrs.com
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Charles Esler, CHMM	Regulatory Specialist	AMEC	503-639-3400	charles.esler@amec.com
James Feild, Ph.D.	Hydrogeologist	AMEC	503-639-3400	james.field@amec.com
Pat Evans	Liquid Waste Management System	CDM	425-453-8383	evanspj@cdm.com
Pete Stringer	LWMS Site Manager	CDM		
Robert Taaffe	GSA Construction Manager	GSA	425-519-0300	
Mike Webb	Environmental Consultant	GSA	425-519-0300 x217	mikew@gsassoc-inc.com
Robin Larson	Site Safety & Health Officer	GSA	425-519-0300	
Eva Davis	In Situ Thermal Expert/Hydrogeologist	EPA	580-436-8548	Davis.eva@epamail.epa.gov
Paul Brown	DRMO Director	DRMO	253-966-3209	paulebrown@dla.mil
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Jim Bush	Technical Group Manager	Batelle PNNL	509-372-1704	Jg.bush@pnl.gov
Ron Smith	Senior Project Manager	Batelle PNNL	509-376-5831	rmsmith@pnl.gov
Dave Becker	Geologist	USACE HTRW CX	402-697-2655	Dave.J.Becker@nwd02.usace.army.mil
Bill Crawford	Process Engineer	USACE HTRW CX	402-697-2579	William.J.Crawford@nwd02.usace.army.mil
Terry Tomasec	Certified Industrial Hygienist	USACE HTRW CX	402-697-2590	Terry.W.Tomasek@nwd02.usace.army.mil

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Johnson, P.C., Stanley, C.C., Kemblowski, M.W., Byers, D.L., and Colthart, J.D. 1990. "A practical approach to the design, operation, and monitoring of *in-situ* soil venting systems," *Ground Water Monitoring Review*. V. 10, no. 2, pp. 159-178.

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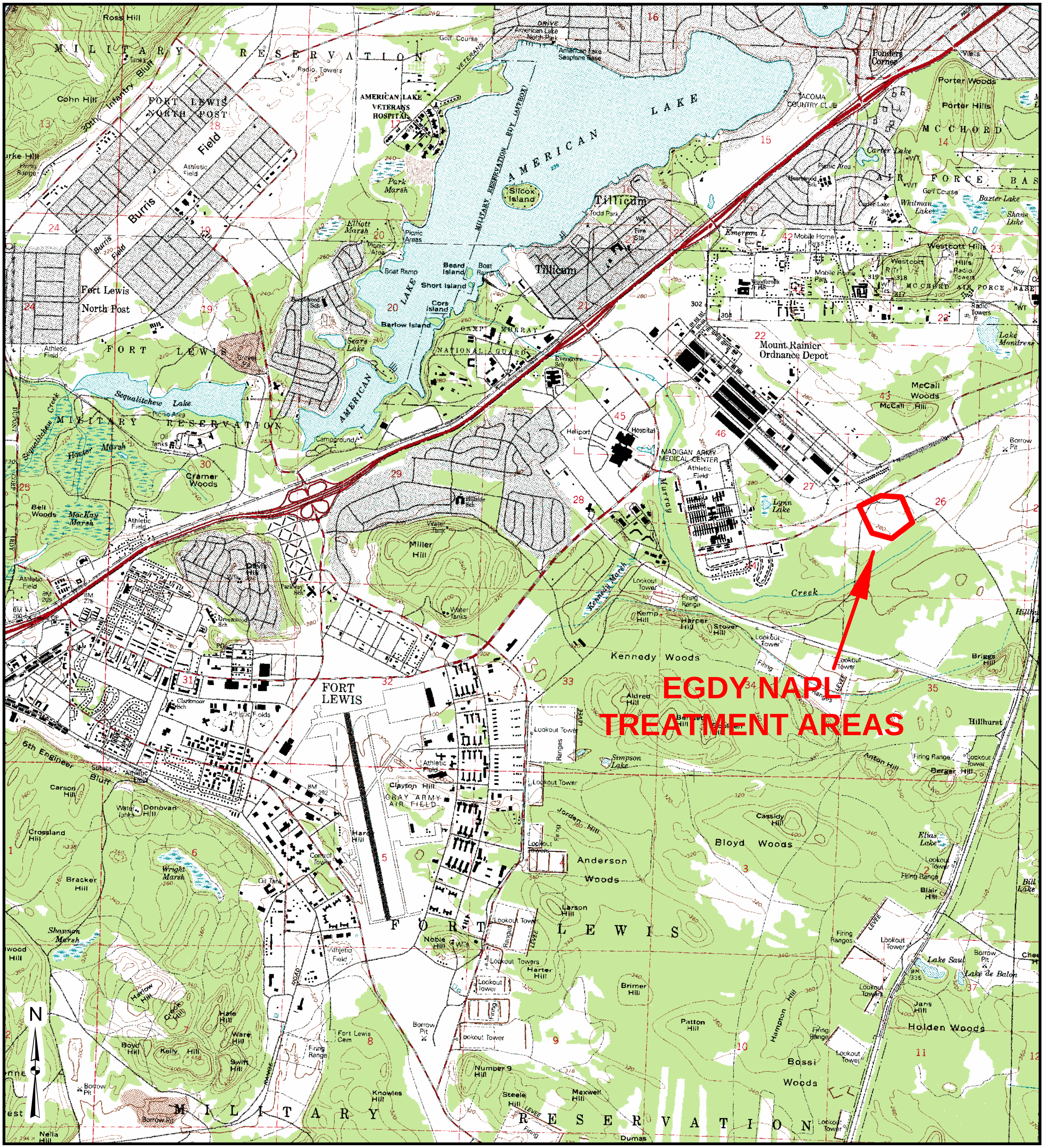

USGS Quads
47122-A5 Ft. Lewis
47122-B5 Steilacoom

0 2,000 4,000 8,000
Feet

1 inch equals 4,000 feet

FIGURE 1

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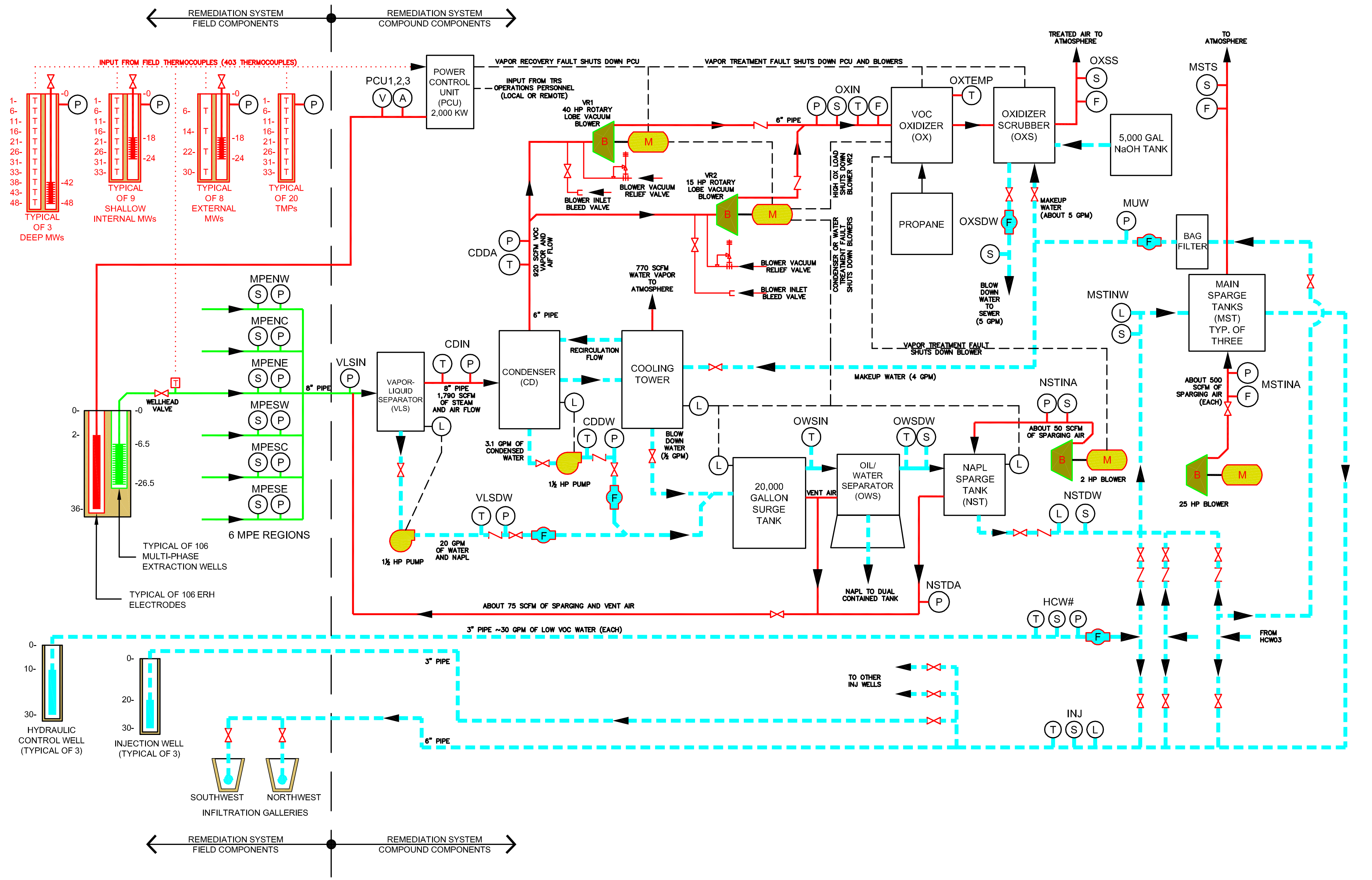
EGDY LOCATION MAP - FORT LEWIS
TACOMA, WASHINGTON

PROJECT SITE

K:\11000\11100\11157\RAMP\FINAL RAMP\DWGs\Figure 1.mxd



LEGEND

- (P) PRESSURE INDICATOR
- (T) TEMPERATURE INDICATOR
- (S) SAMPLE PORT
- (F) FLOW RATE INDICATOR
- (L) LIQUID LEVEL SENSOR
- (F) TOTALIZING FLOW METER
- BALL VALVE
- CHECK VALVE
- T THERMOCOUPLE
- AIR / VAPOR
- WATER
- AIR / VAPORS / STEAM / WATER / NAPLs

TYPICAL VALUES

MPENE	5" Hg
CDIN	65°C (150°F)
CDIN	7" Hg
CDDA	8" Hg
CDDA	AMBIENT + 5°C
OXIN	65°C (150°F)
OXIN	2" H2O VAC
VLSDW	65°C (150°F)
CDDW	30°C (90°F)
OWSIN	60°C (140°F)
NSTDW	55°C (130°F)
NSTDW	5 FEET
HCW#	5 PSIG
INJ	1 FOOT
MUW	40 PSIG

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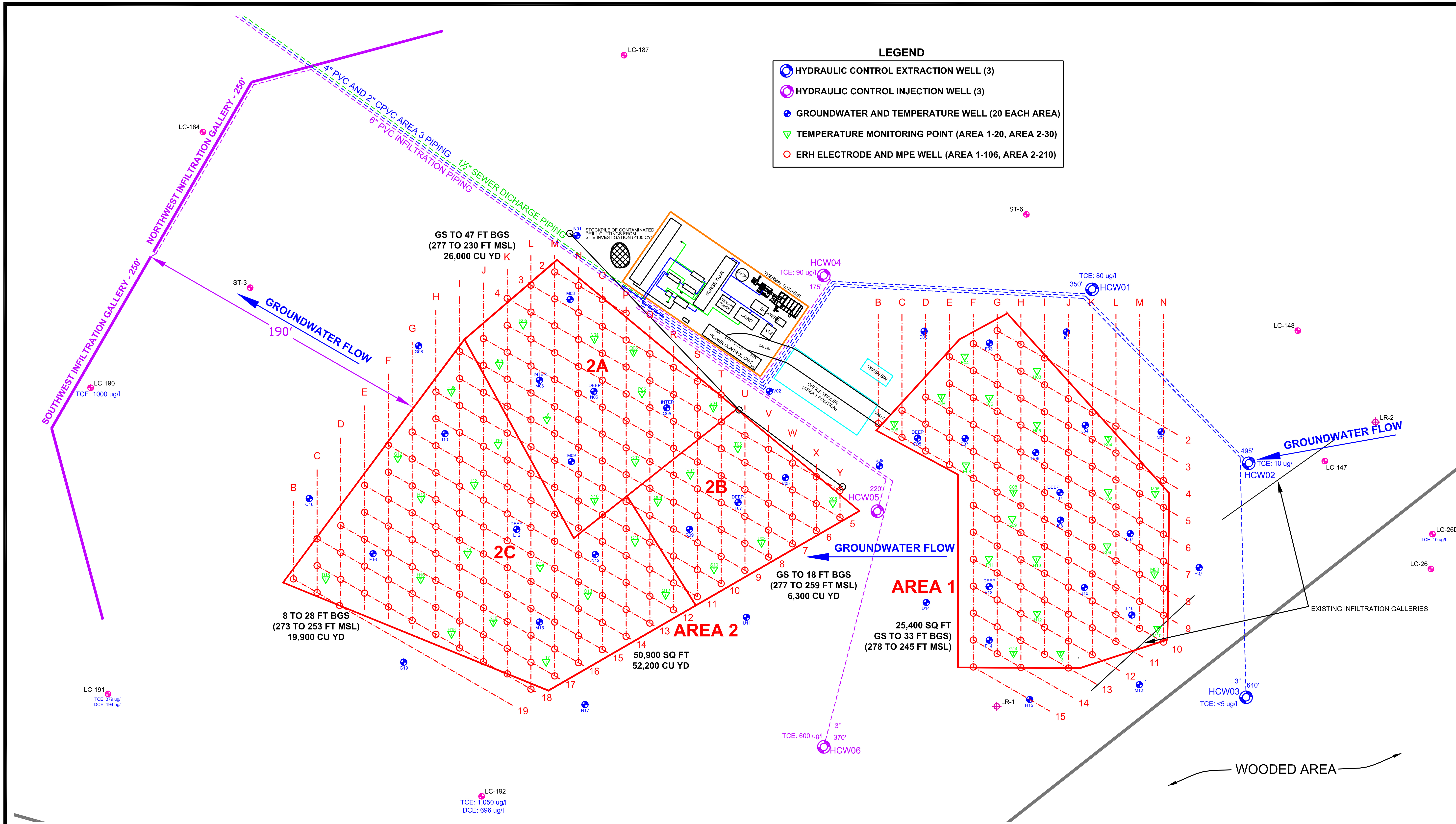
EGDY SITE - FORT LEWIS TACOMA, WASHINGTON

PROCESS FLOW / PIPING AND INSTRUMENTATION DIAGRAM FOR NAPL AREA 1

FIGURE 2



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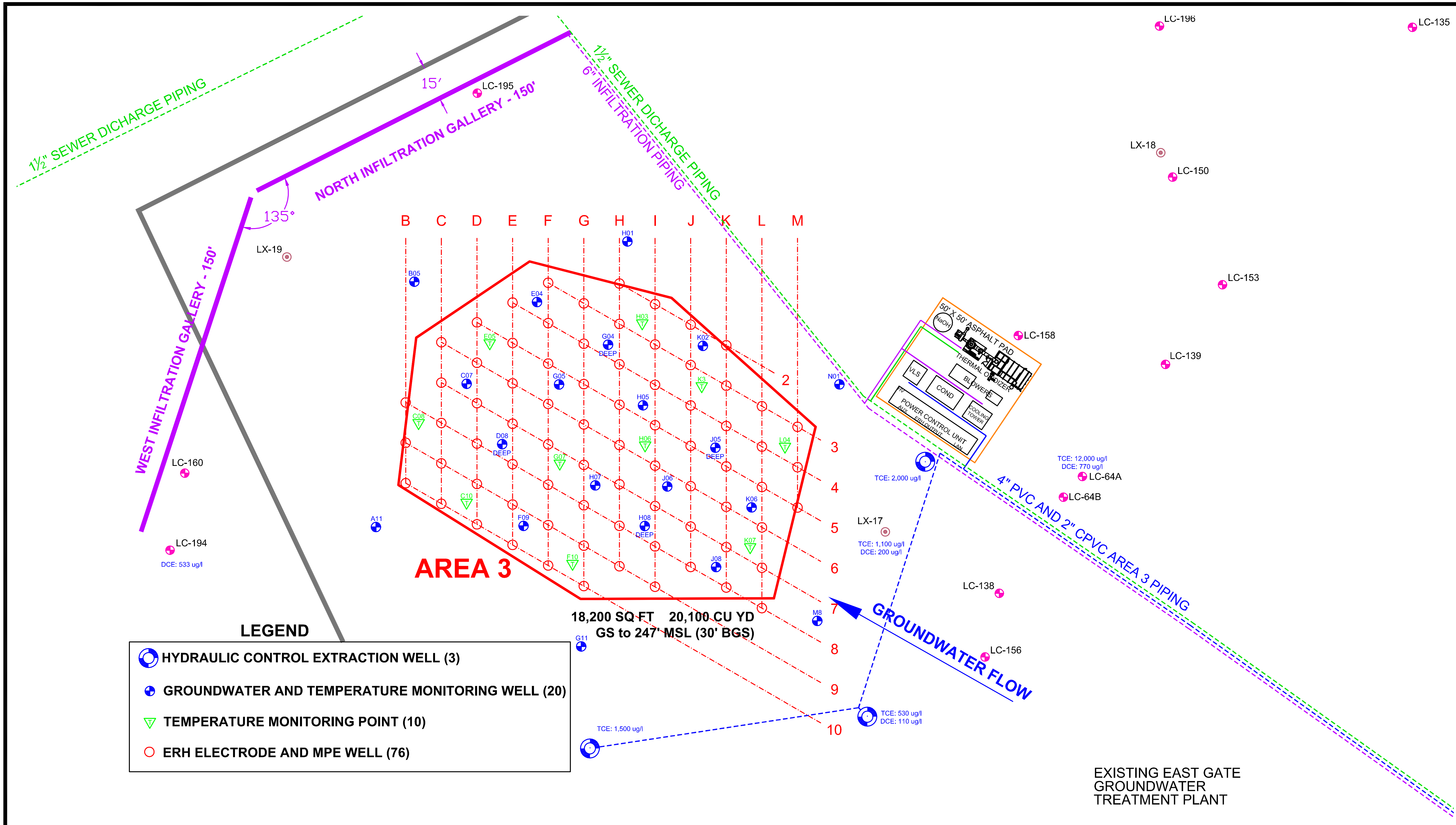
EGDY SITE - FORT LEWIS
TACOMA, WASHINGTON

PLOT PLAN
FOR NAPL AREAS 1 AND 2

FIGURE
3a



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EGDY SITE - FORT LEWIS
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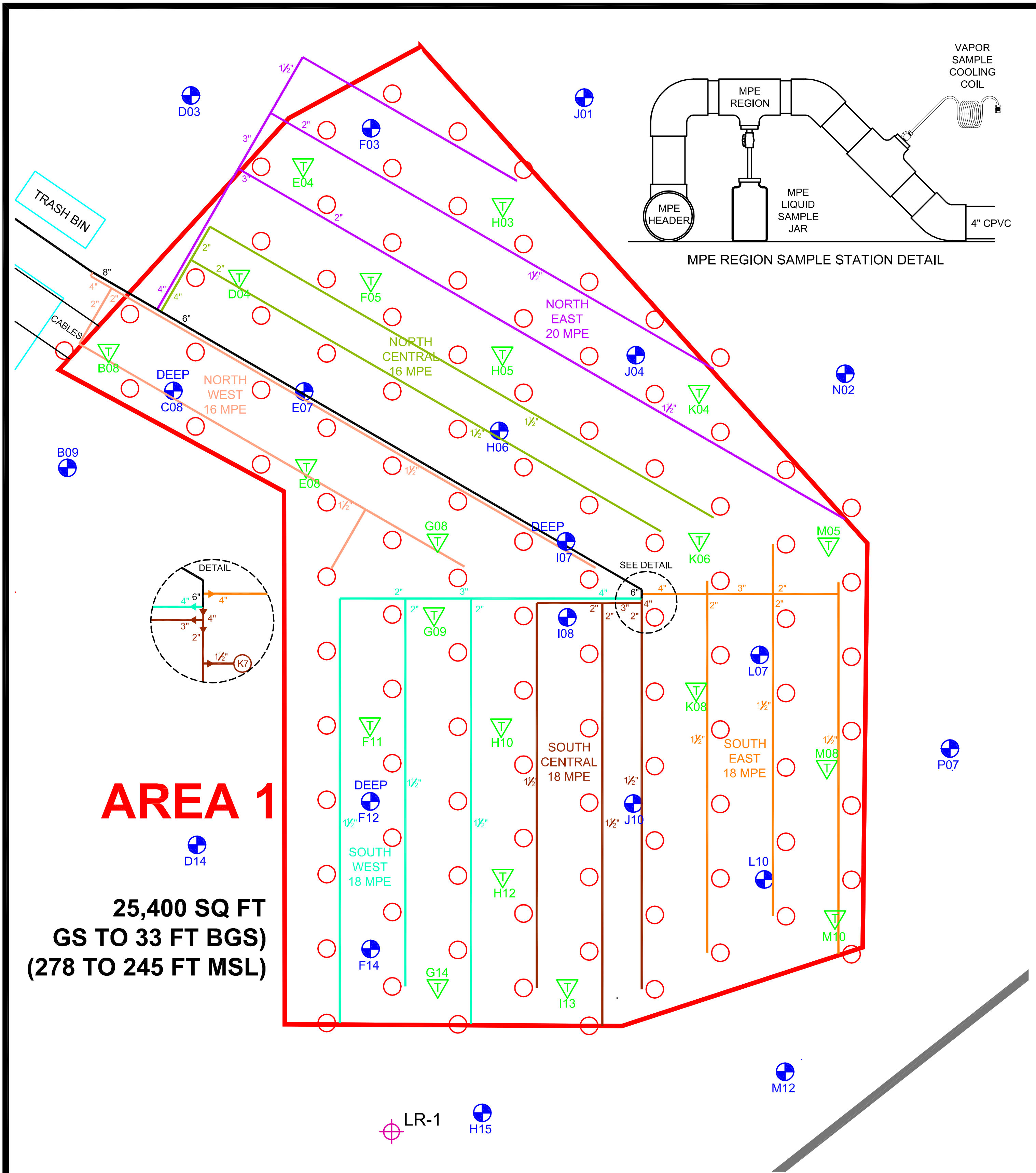
PLOT PLAN
FOR NAPL AREA 3

FIGURE
3b

FINAL RAMP EGDY ERH WORK PLAN Fig 3b

K:\11000\11100\11157\RAMP\FINAL RAMP\DWGs\FIG 3b.dwg



SCALE IN FEET
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FIGURE 3c AREA 1 MPE PIPING DETAIL
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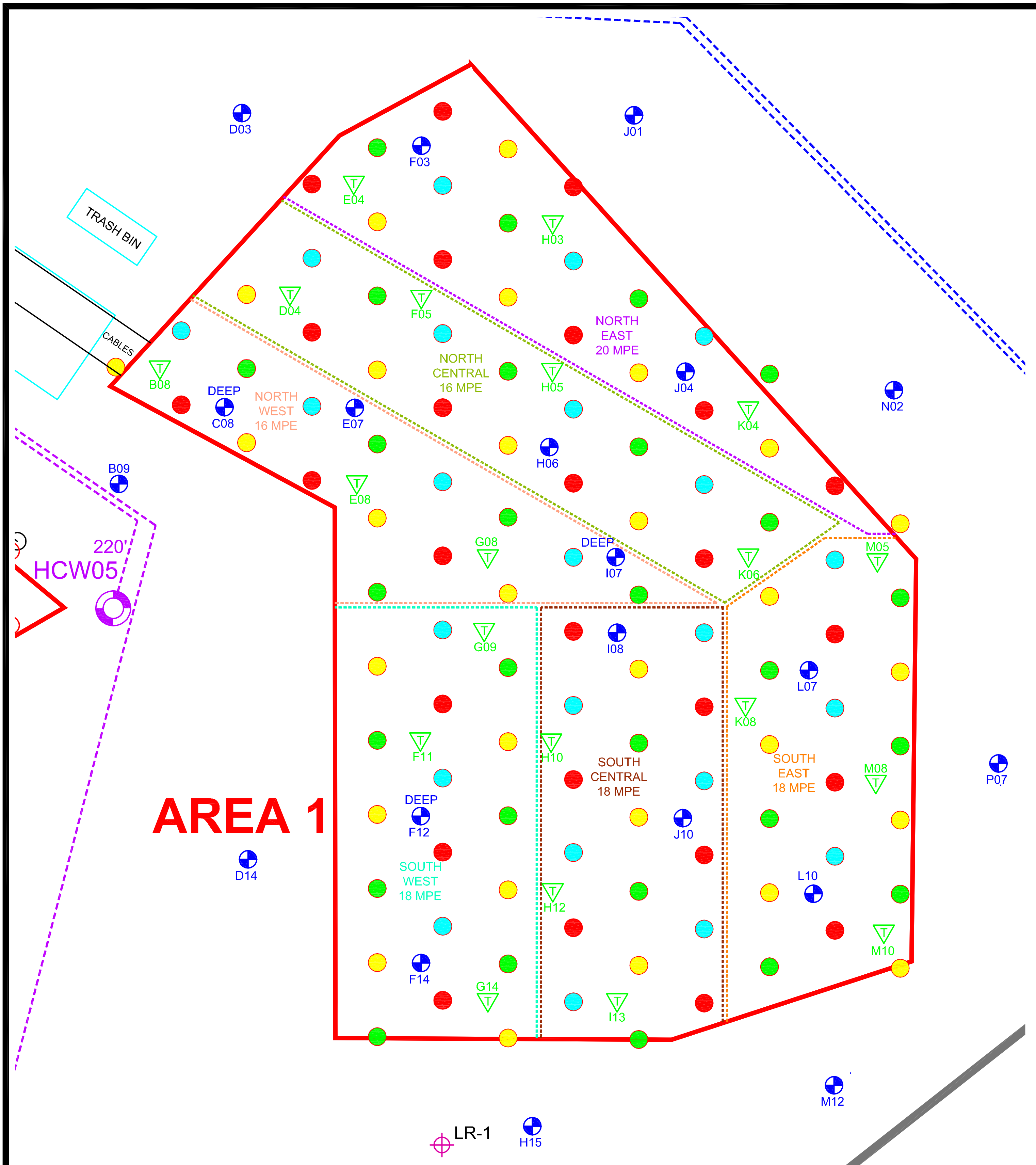

GROUP A MULTIPHASE EXTRACTION (23 MPE)
GROUP B (26 MPE WELLS)
GROUP C (28 MPE WELLS)
GROUP D (29 MPE WELLS)

SCALE IN FEET
0 30

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FIGURE 3d AREA 1 MPE OPERATIONS
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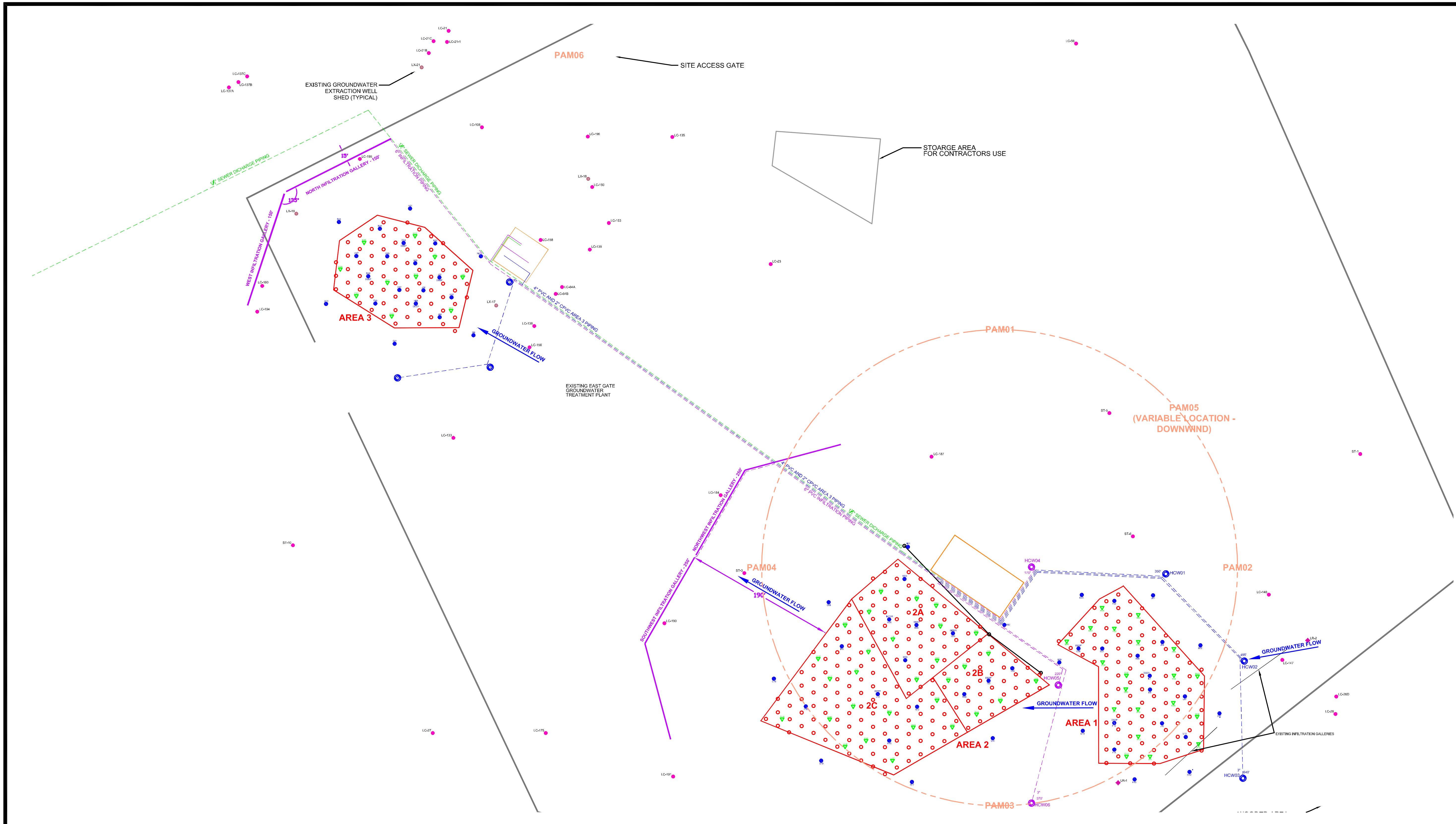
FINAL RAMP EGDY ERH WORK PLAN Fig 3d

K:\11000\11100\11157\RAMP\FINAL RAMP\DWGs\FIG 3d.dwg



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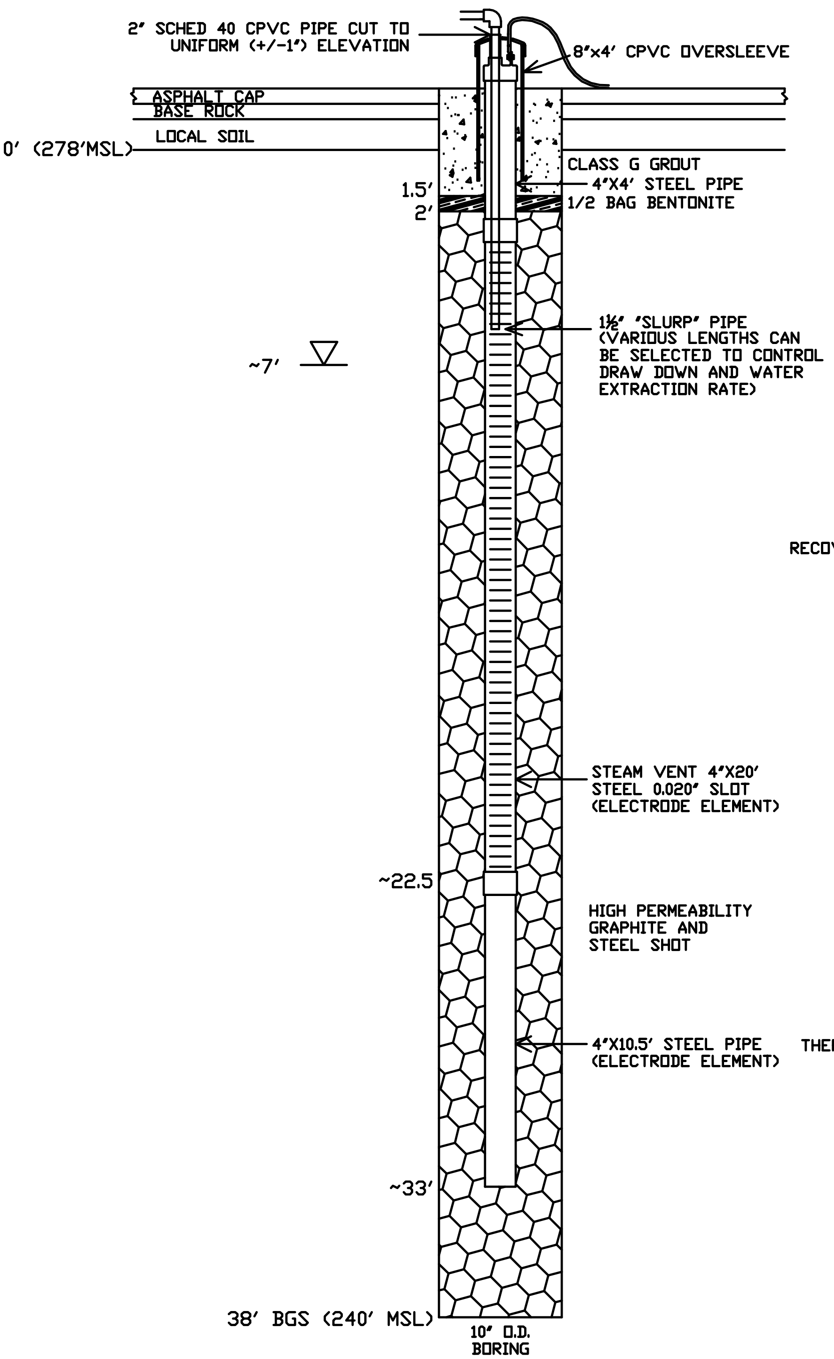
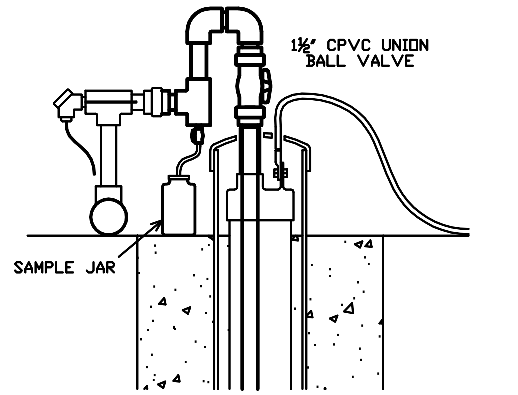
EGDY PLOT PLAN

FIGURE 3e

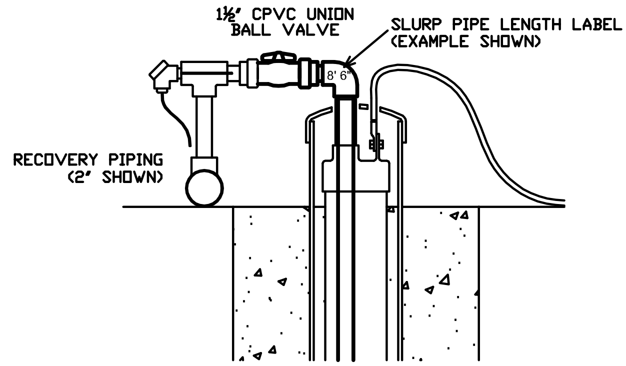
AREA 1 ELECTRODE AND MULTI-PHASE EXTRACTION WELL DETAIL



LIQUID SAMPLE MODE



MULTI-PHASE EXTRACTION MODE



NOTE: BLUE PIPE SECTIONS ARE OF UNIFORM LATERAL LENGTH AND ARE INTERCHANGEABLE FROM WELL TO WELL

VAPOR/STEAM EXTRACTION MODE

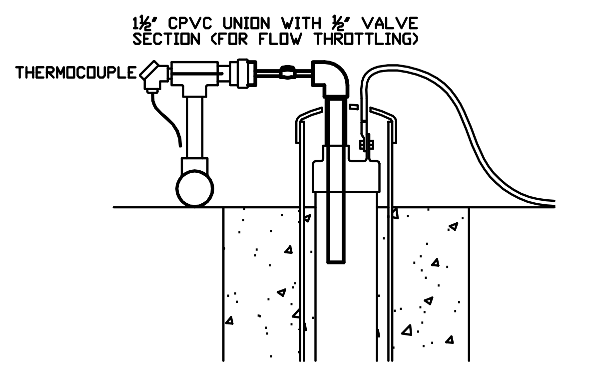


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FIGURE 4a AREA 1 ELECTRODE / MPE WELL DETAIL
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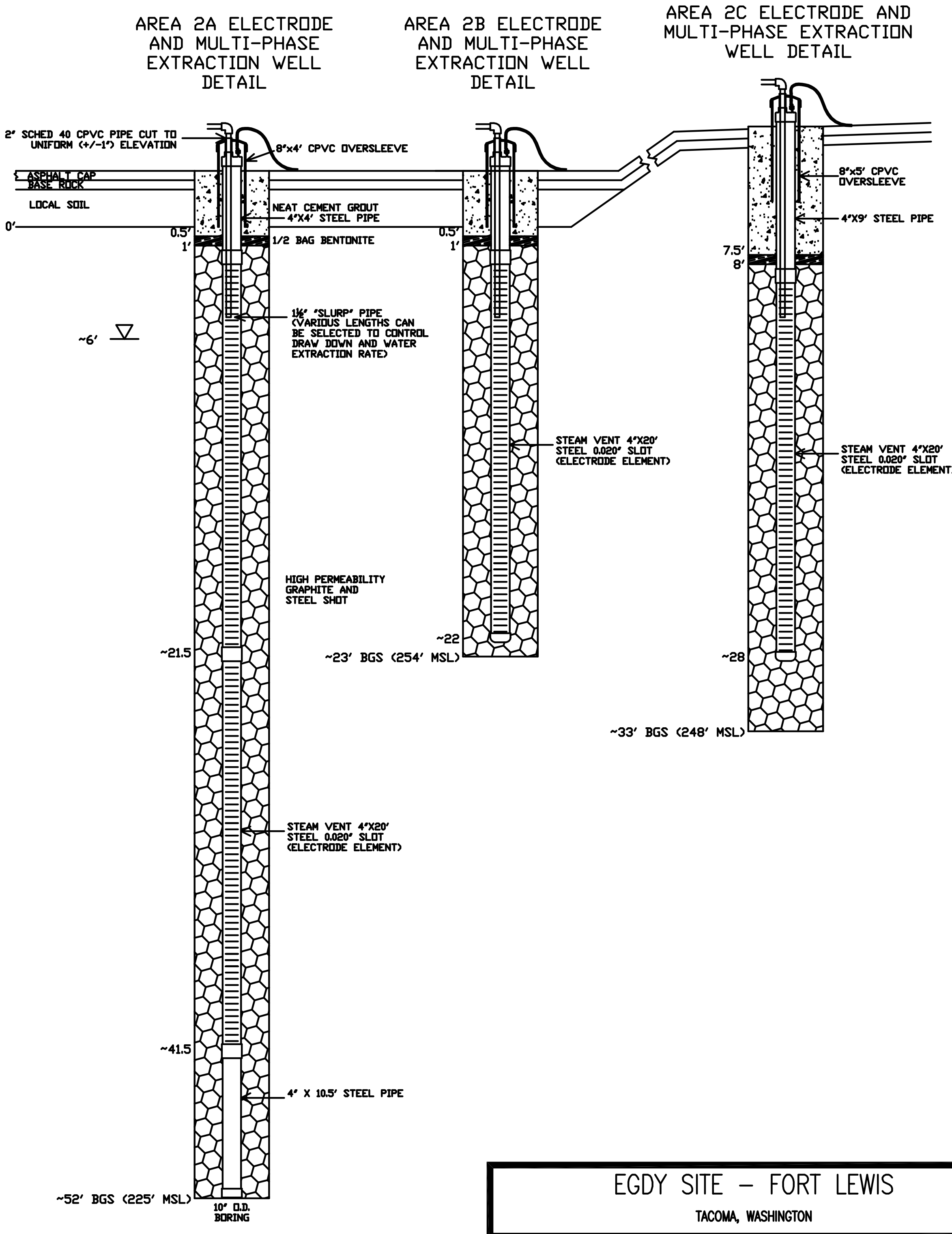

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FIGURE 4b AREA 2 ELECTRODE / MPE WELL DETAILS
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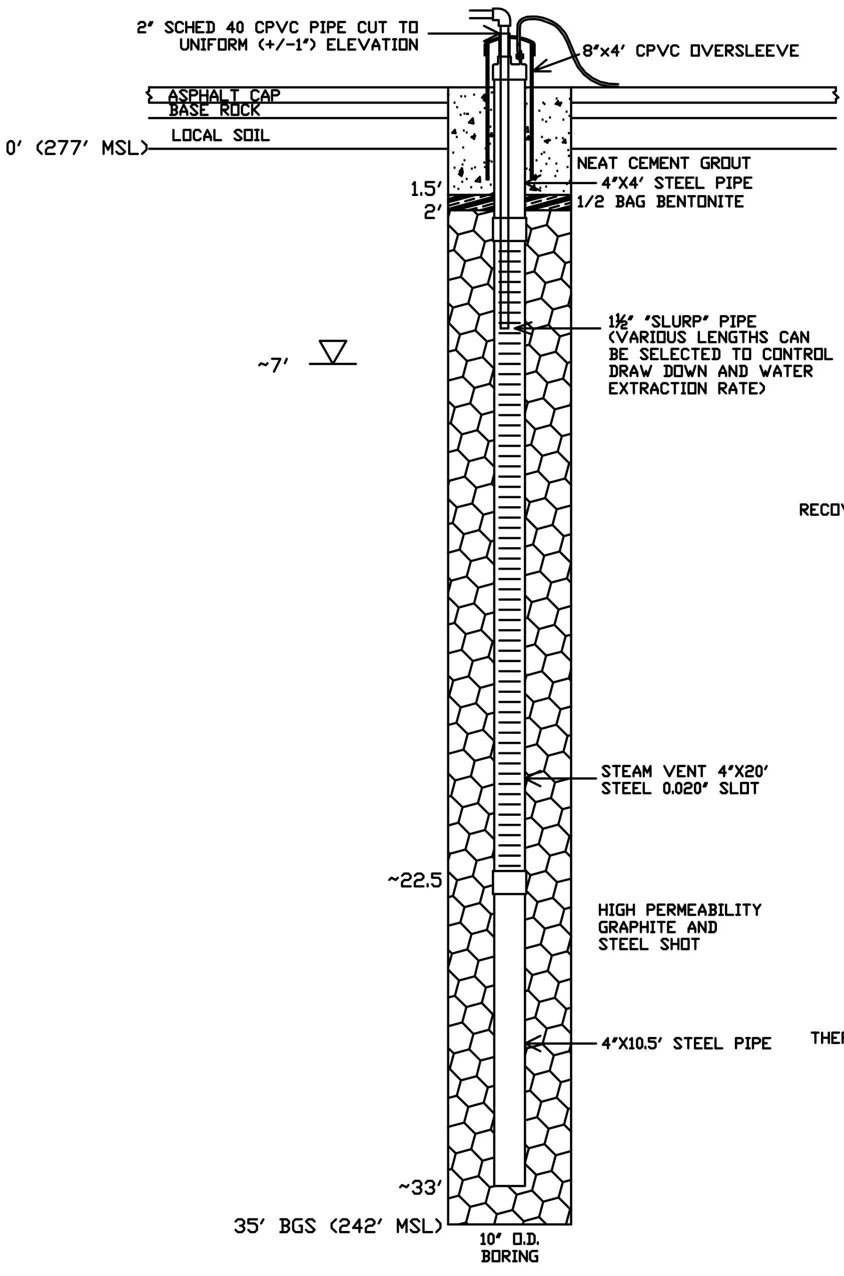
AREA 3 ELECTRODE AND MULTI-PHASE EXTRACTION WELL DETAIL



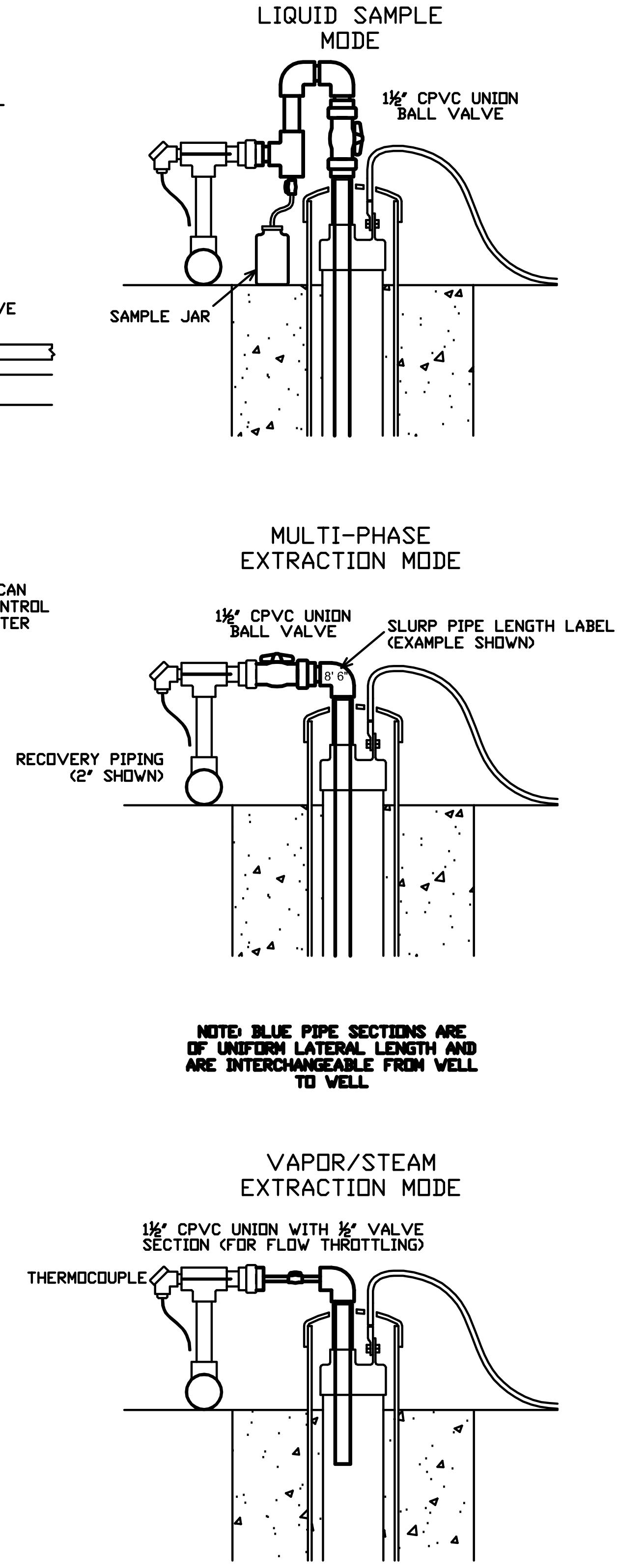


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FIGURE 4c AREA 3 ELECTRODE / MPE WELL DETAIL
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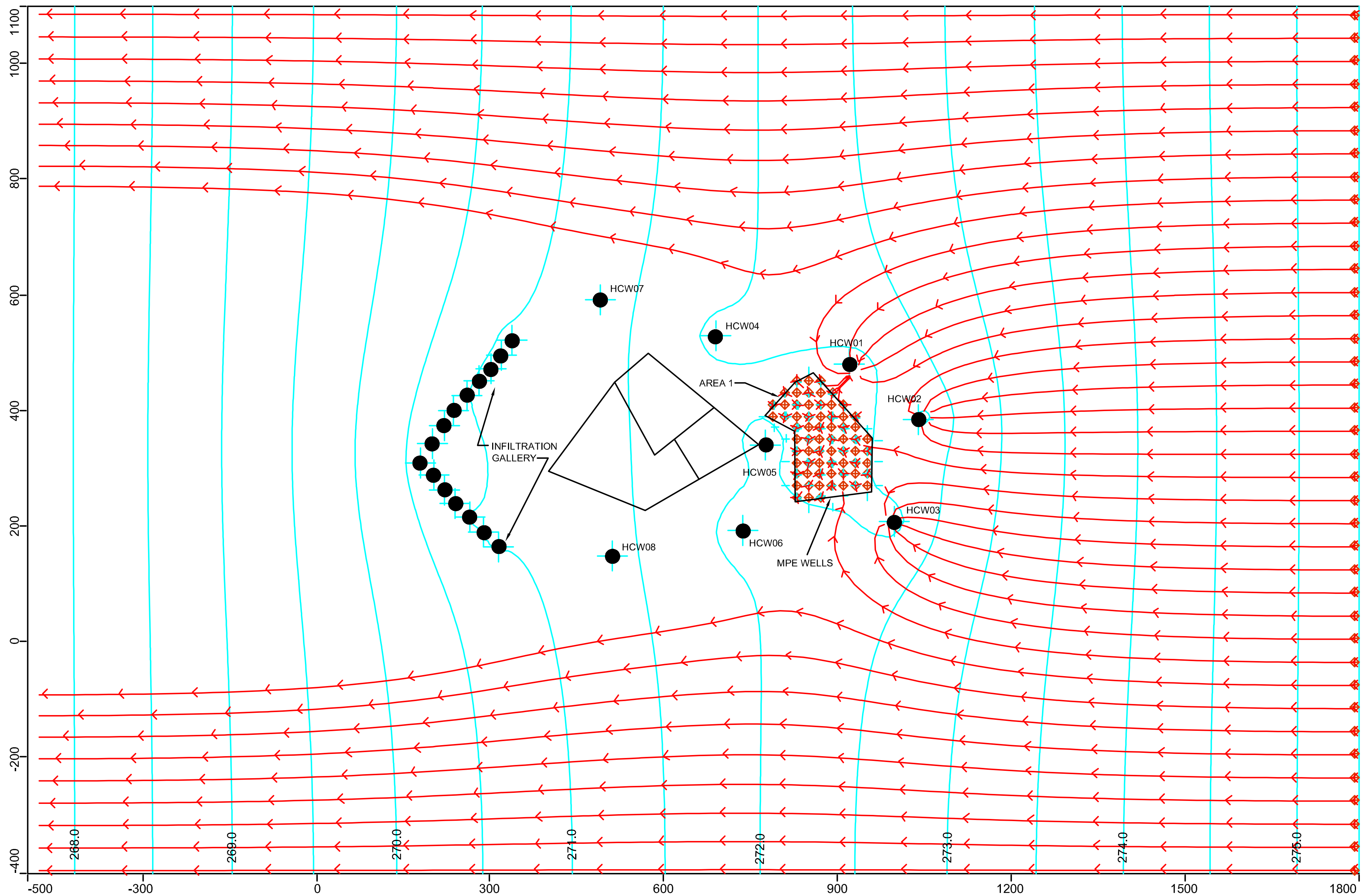

NOTE:
GROUNDWATER ELEVATION CONTOURS ARE IN FEET ABOVE MEAN SEA LEVEL AND SPACED 0.5 FEET.

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EGDY SITE - FORT LEWIS
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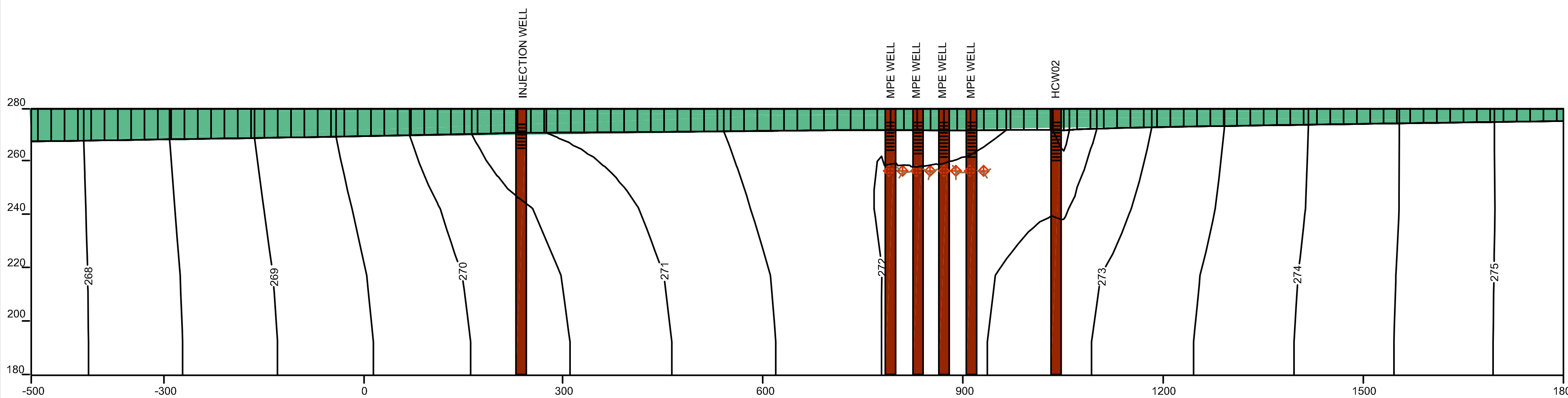
HYDRAULIC CONTROL MODELING FIGURE AREA 1 PLAN VIEW

FIGURE

5a



AREA 1

NOTE:
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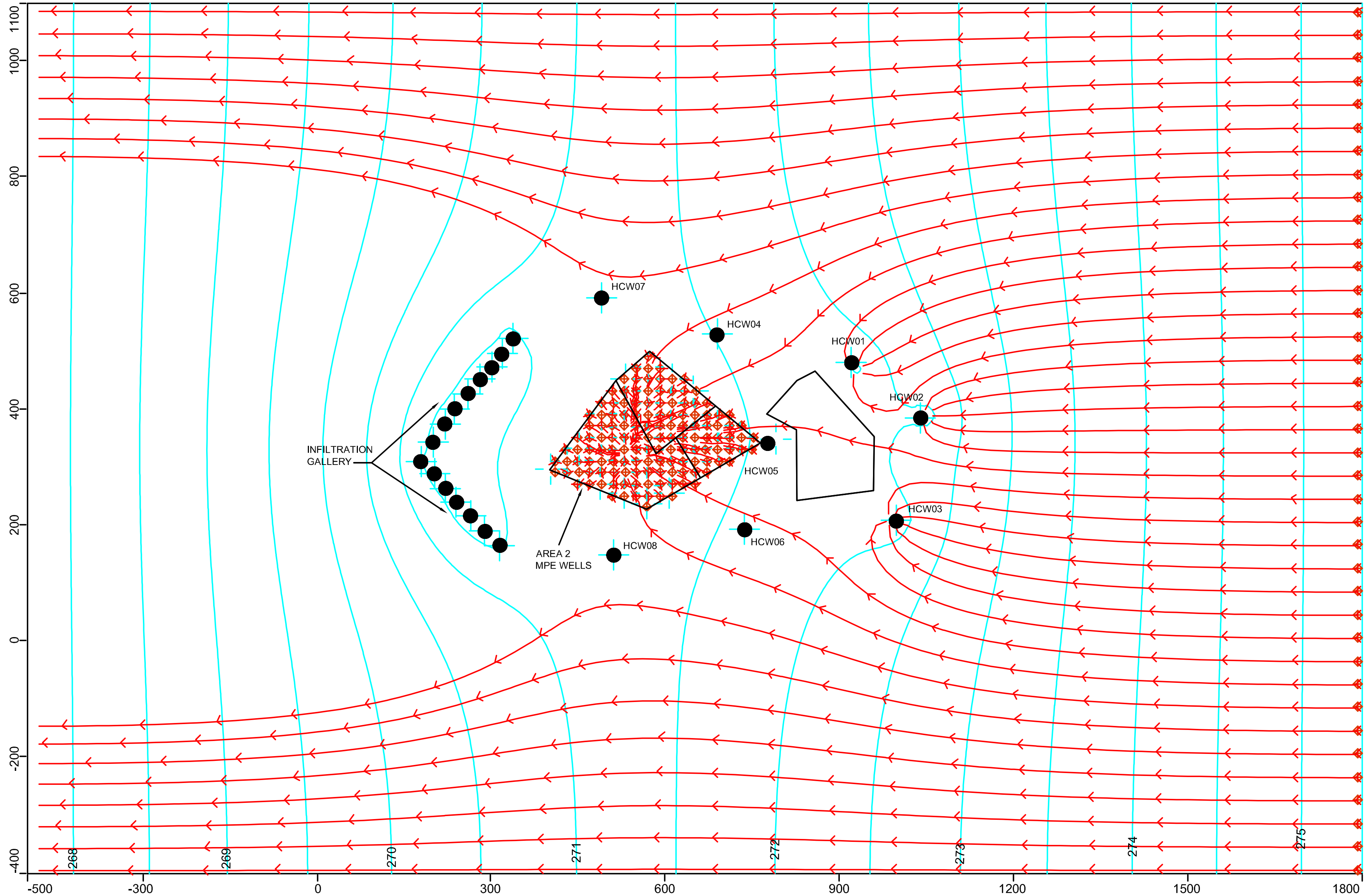
HYDRAULIC CONTROL
MODELING FIGURE
AREA 1 CROSS-SECTIONAL VIEW

FIGURE
5b



NOTE:
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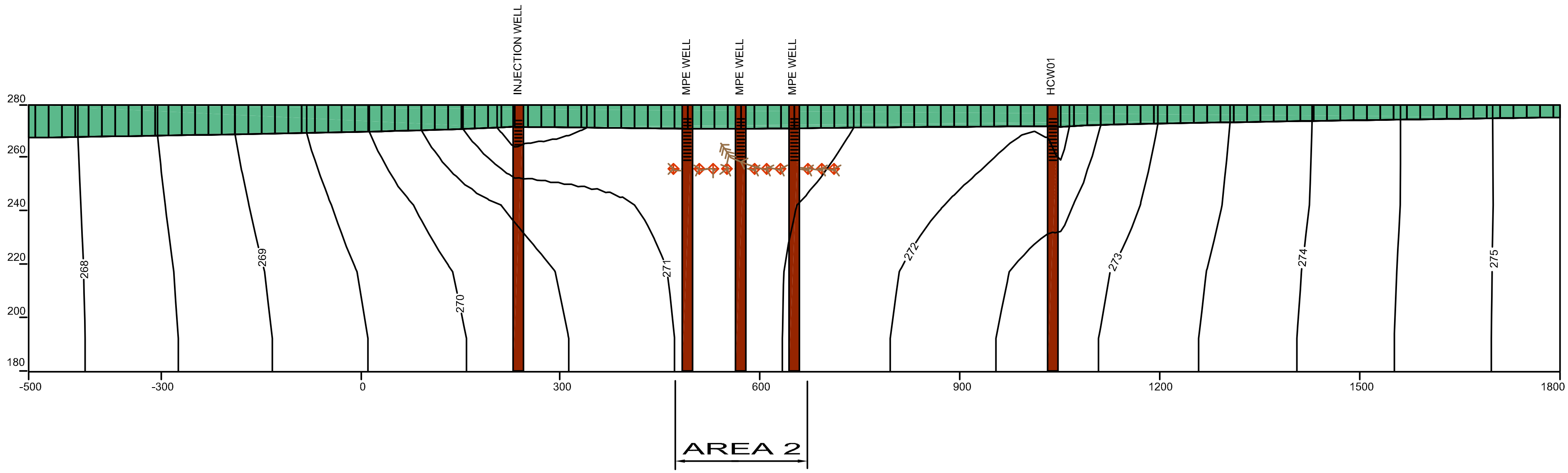
HYDRAULIC CONTROL MODELING FIGURE AREA 2 PLAN VIEW

FIGURE

5c



NOTE:
GROUNDWATER ELEVATION CONTOURS ARE IN FEET ABOVE MEAN SEA LEVEL AND SPACED 0.5 FEET.

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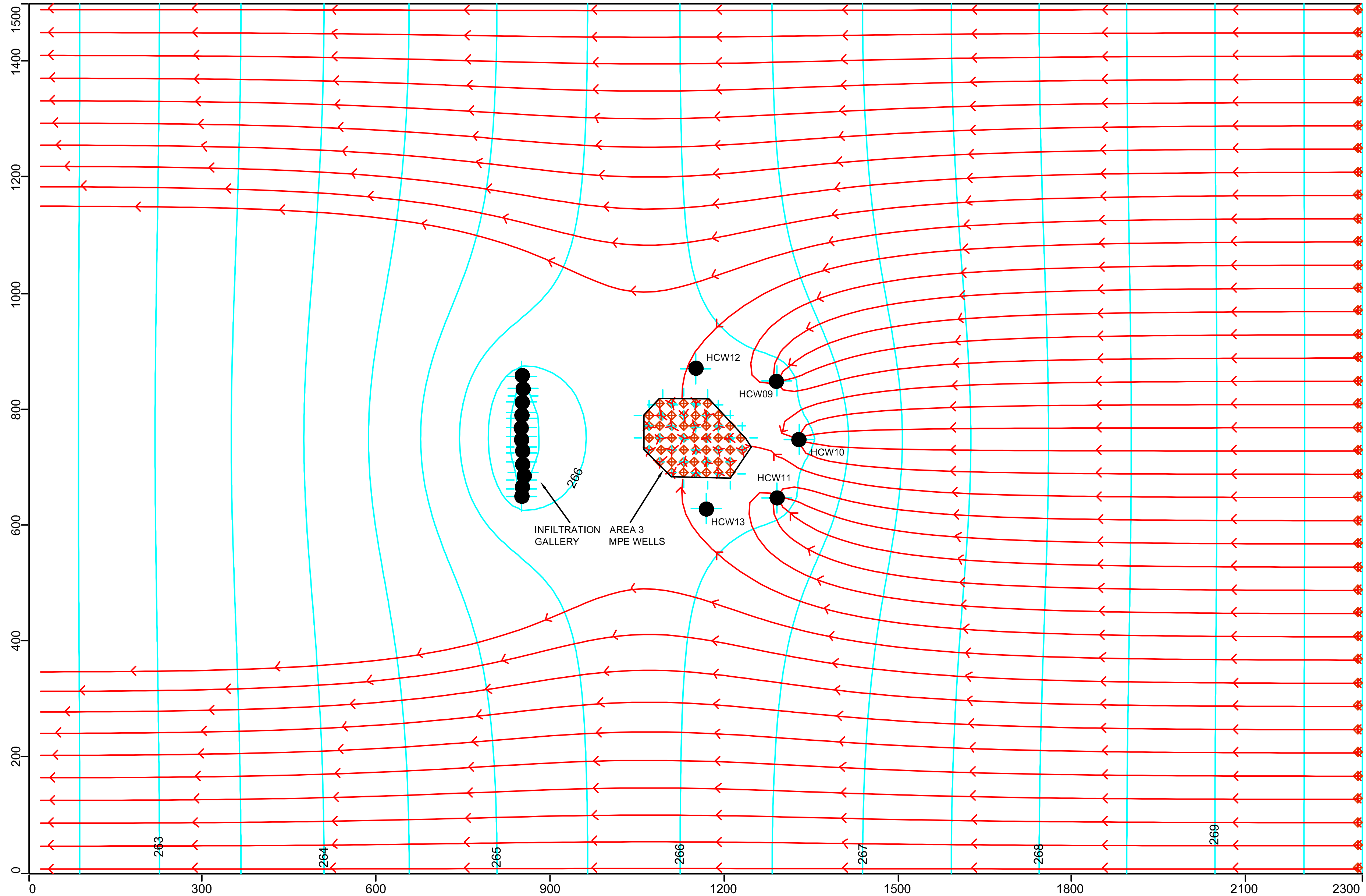
HYDRAULIC CONTROL
MODELING FIGURE
AREA 2 CROSS-SECTIONAL VIEW

FIGURE
5d



NOTE:
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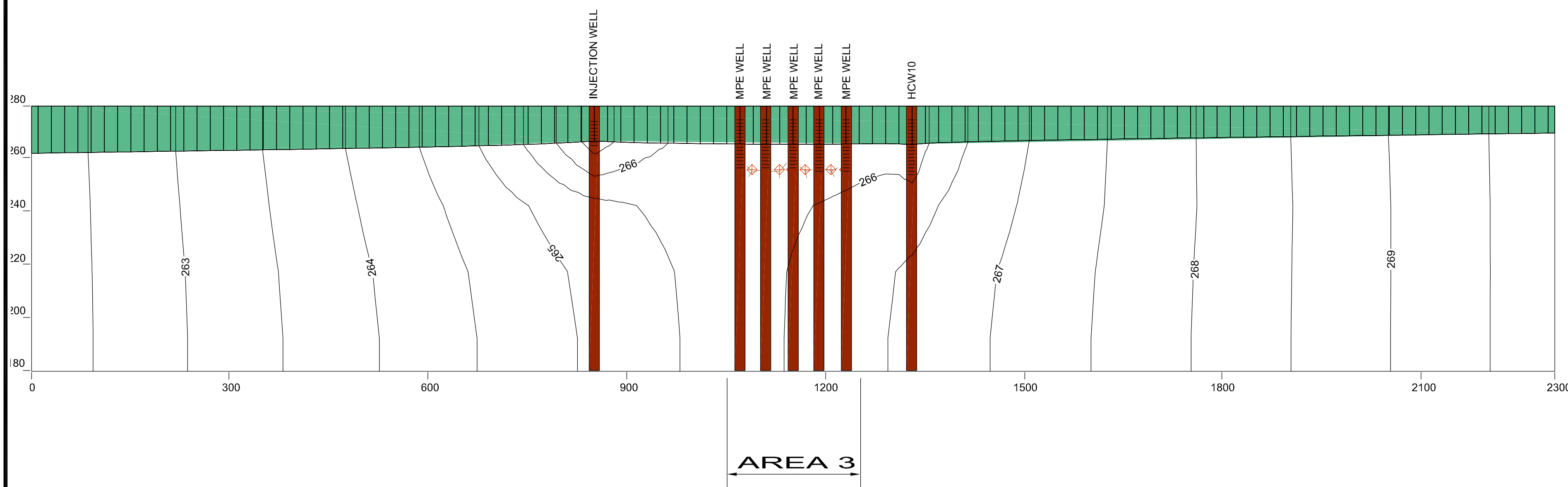
HYDRAULIC CONTROL MODELING FIGURE AREA 3 PLAN VIEW

FIGURE

5e



NOTE:
GROUNDWATER ELEVATION CONTOURS ARE IN FEET ABOVE MEAN SEA LEVEL AND SPACED 0.5 FEET.

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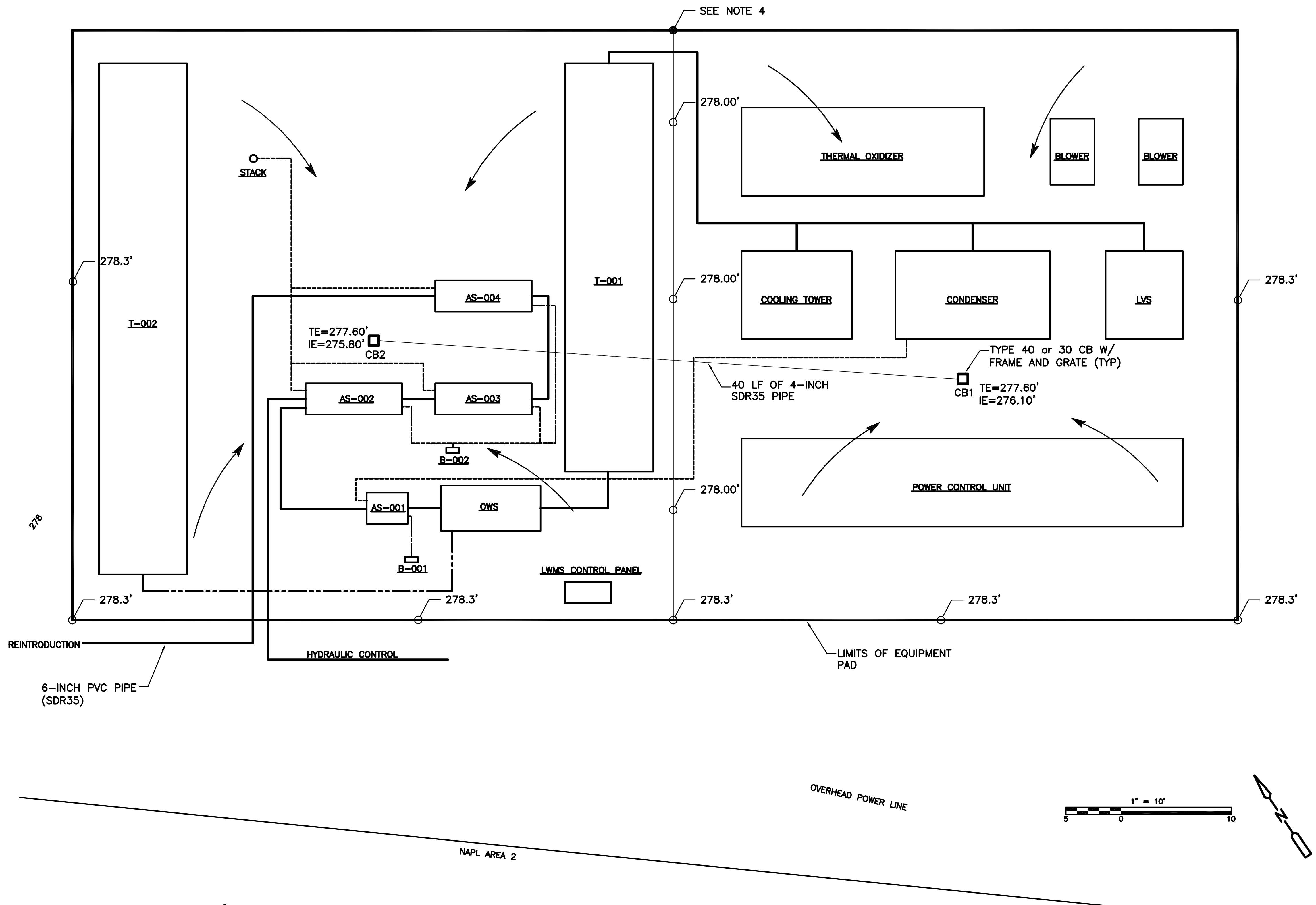
HYDRAULIC CONTROL MODELING FIGURE AREA 3 CROSS-SECTIONAL VIEW

FIGURE 5f

CONSTRUCTION NOTES AND SPECIFICATIONS:

1. GRAVITY PIPE SHALL CONFORM TO THE REQUIREMENTS OF ASTM D3034SDR35.
2. CB2 SHALL BE ABLE TO HOUSE A 1/2 HP SUMP PUMP.
3. GROUT ALL PENETRATION INSIDE AND OUT USING NON SHRINK GROUT.
4. NORTH SIDE ENTRY ASPHALT CONCRETE PAVEMENT SHALL BE SMOOTH TRANSITION FROM ROAD TO PAD TO ALLOW MOBILIZATION/DEMOLITION OF EQUIPMENT, AND DRAINAGE OF STORM WATER AWAY FROM PAD.
5. CLEAR, GRUB, AND CLEAN AREA IDENTIFIED AS LIMITS OF EQUIPMENT PAD. GRUBBING SHALL OCCUR TO 9-INCHES BELOW EXISTING GROUND SURFACES OR UP TO A DEPTH WHERE THE SUBGRADE IS COMPETENT AND UNDISTURBED. THE SUBGRADE SHALL BE FREE OF STANDING WATER PRIOR TO IMPORT OF FILL.
6. CRUSHED IMPORT ROCK (BASE COURSE) MATERIAL SHALL BE 6-INCHES AND SHALL MEET SECTION 9-03.9(3) OF THE LATEST EDITION OF THE STANDARD SPECIFICATIONS FOR ROAD, BRIDGE, AND MUNICIPAL CONSTRUCTION.
7. COMPLETED SURFACING SHALL BE 3-INCHES OF CLASS B ASPHALT CONCRETE PAVEMENT.
8. THE SUBGRADE, BASE COURSE, AND ASPHALT SHALL BE ROLLED USING VIBRATING ROLLERS.
9. FINISHED BERM SURFACE ELEVATION ON WEST, SOUTH AND EAST EDGES OF PAD SHALL BE 4-INCHES ABOVE EXISTING GRADE.
10. REFER TO LWMS P&ID FOR DETAILED PIPING AND APPURTENANCE REQUIREMENTS



PIPING LEGEND:

VAPOR PIPING

NAPL PIPING

WATER PIPING

FINISHED BERM SURFACE ELEVATION 278.3'

SURFACE WATER FLOW

TRANSITION TO ROAD

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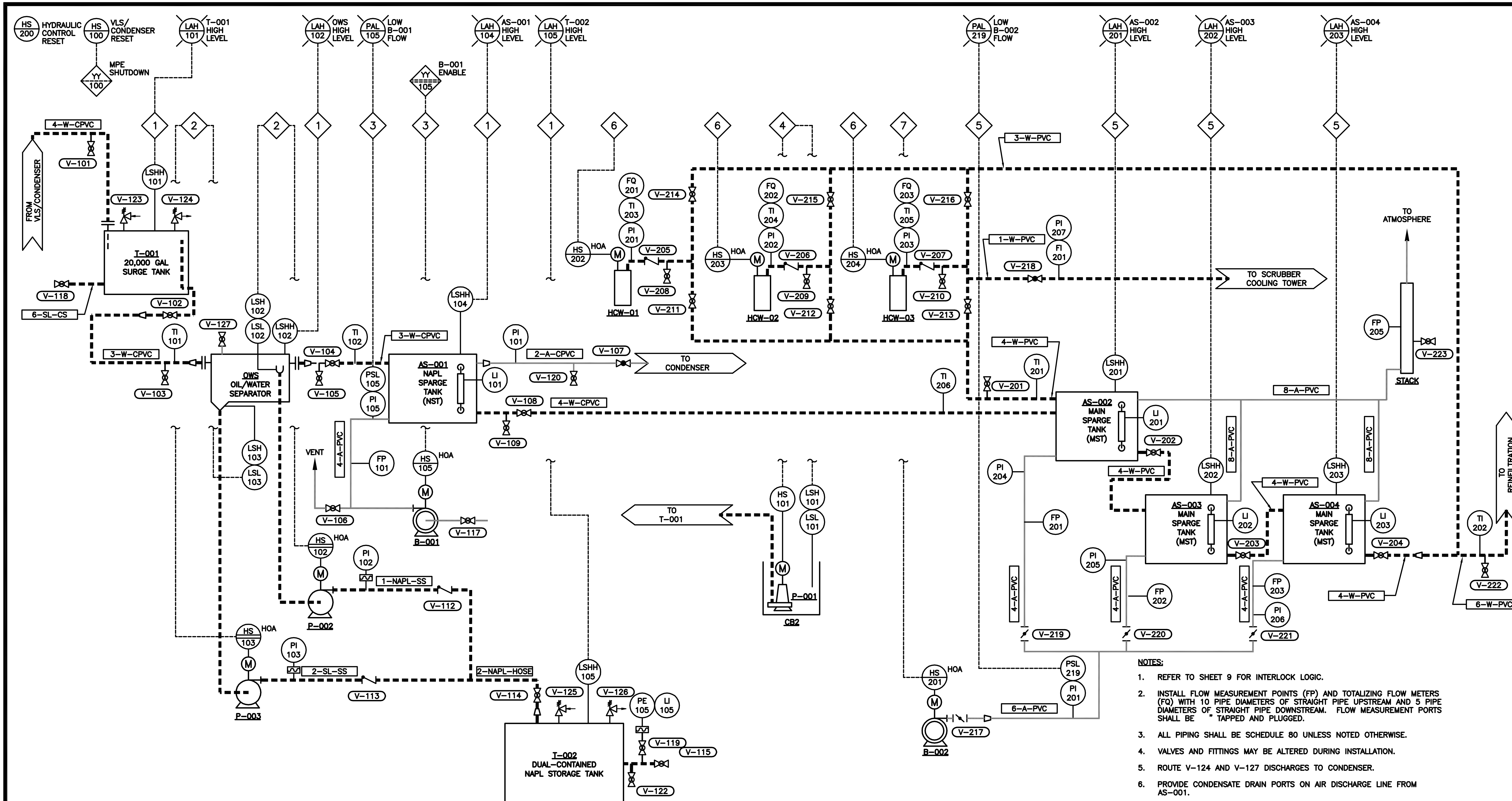
GENERAL ARRANGEMENT

FIGURE 6



NOTES:

1. REFER TO SHEET 9 FOR INTERLOCK LOGIC.
2. INSTALL FLOW MEASUREMENT POINTS (FP) AND TOTALIZING FLOW METERS (FQ) WITH 10 PIPE DIAMETERS OF STRAIGHT PIPE UPSTREAM AND 5 PIPE DIAMETERS OF STRAIGHT PIPE DOWNSTREAM. FLOW MEASUREMENT PORTS SHALL BE " TAPPED AND PLUGGED.
3. ALL PIPING SHALL BE SCHEDULE 80 UNLESS NOTED OTHERWISE.
4. VALVES AND FITTINGS MAY BE ALTERED DURING INSTALLATION.
5. ROUTE V-124 AND V-127 DISCHARGES TO CONDENSER.
6. PROVIDE CONDENSATE DRAIN PORTS ON AIR DISCHARGE LINE FROM AS-001.
7. INSTALL AIR RELIEF VALVES AT HIGH SPOTS ON AS-004 WATER DISCHARGE LINE.
8. T-002 SHALL BE LABELLED AS FOLLOWS: T-002 NAPL STORAGE TANK HAZARDOUS WASTE

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LIQUID WASTE MANAGEMENT SYSTEM PIPING AND INSTRUMENTATION DIAGRAM

FIGURE 7

INTERLOCK LOGIC DESCRIPTIONS

1. HIGH LEVEL IN LIQUID WASTE MANAGEMENT SYSTEM EQUIPMENT ASSOCIATED WITH VLS/CONDENSER (100 SERIES INSTRUMENTATION). CLOSED SERIES 100 OR 200 HIGH LEVEL SWITCH (LIQUID LEVEL ABOVE LSHH SWITCH) SHALL LATCH RED ALARM LIGHT, SHUT DOWN OWS PACKAGE, BLOWER B–001 WHEN IN AUTO, AND ENERGIZE RELAY YY–100 COIL TO CAUSE VLS/CONDENSER SYSTEM AND OWS PACKAGE SHUTDOWN VIA YY–100 DRY CONTACTS TO FIELD. LIGHTS AND RELAYS SHALL REMAIN LATCHED UNTIL RESET HS–100 IS DEPRESSED AND LEVEL SWITCHES ARE OPEN (LIQUID LEVEL BELOW SWITCH).

2. PUMPS P–002 AND P–003 LEVEL CONTROL IN OIL/WATER SEPARATOR PACKAGE. CLOSED HIGH LEVEL SWITCH LSH SHALL ENABLE PUMP. OPEN LOW LEVEL SWITCH LSL SHALL DISABLE PUMP. PUMP STARTER SHALL BE ACTUATED IF PUMP IS ENABLED, YY–100 COIL IS NOT ENERGIZED, AND PUMP HAND SWITCH IS IN AUTO.

3. BLOWER B–001 CONTROL. BLOWER STARTER SHALL BE ACTUATED WHEN NO 100 SERIES ALARMS ARE PRESENT, HAND SWITCH IS IN AUTO, AND REMOTE ENABLE RELAY YY–105 DRY CONTACT IS CLOSED. YY–105 COIL SHALL BE CONTROLLED BY 120 VAC FROM THE PCU IN FIELD. ALARM PAL–105 SHALL BE ACTIVATED 5 SECONDS AFTER B–001 IS STARTED IF PSL–105 INDICATES LOW PRESSURE. ALARM PAL–219 SHALL SHUTDOWN BLOWER B–001 WHEN IN AUTO AND ENERGIZE RELAY YY–100 COIL TO CAUSE VLS/CONSENSER SYSTEM AND OWS PACKAGE TO SHUTDOWN VIA YY–100 DRY CONTACTS TO FIELD. LIGHTS AND RELAYS SHALL BE REMAIN LATCHED UNTIL RESET HS–100 IS DEPRESSED.

4. CB2 SUMP PUMP CONTROL. SUMP PUMP P–001 SHALL BE CONTROLLED BY INTEGRAL LEVEL SWITCHES LSL–101 AND LSH–102. AUTOMATIC PUMP OPERATION SHALL BE DISABLED BY RELAY YY–100 IN THE EVENT OF SERIES 100 OR 200 ALARMS.

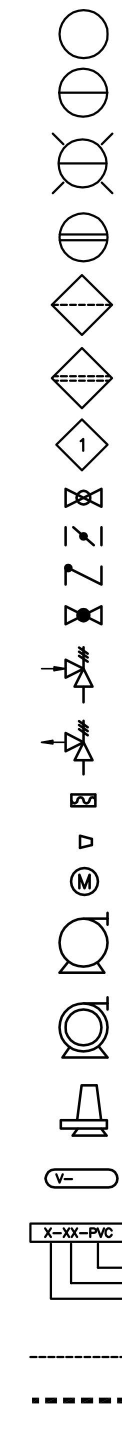
5. HIGH LEVEL LWMS EQUIPMENT ASSOCIATED WITH HYDRAULIC CONTROL PUMP (200 SERIES INSTRUMENTATION). CLOSED 200 SERIES HIGH LEVEL SWITCH AND SHALL LATCH RED ALARM LIGHT, SHUT DOWN ALL HYDRAULIC CONTROL PUMPS AND BLOWERS B–001 AND B–002 WHEN ON AUTO, ENERGIZE RELAY YY–100 COIL TO CAUSE VLS/CONDENSER SYSTEM AND OWS PACKAGE SHUTDOWN VIA YY–100 DRY CONTACTS TO FIELD. LIGHTS AND RELAYS SHALL REMAIN LATCHED UNTIL RESET HS–200 IS DEPRESSED AND LEVEL SWITCHES ARE OPEN.

6. HYDRAULIC CONTROL PUMP CONTROL. A HYDRAULIC CONTROL PUMP SHALL BE ACTUATED IF NO SERIES 200 ALARM EXISTS AND HAND SWITCH IS IN AUTO.

7. BLOWER B–002 CONTROL. BLOWER STARTER SHALL BE ACTUATED IF NO SERIES 200 ALARMS ARE PRESENT AND HAND SWITCH IS IN AUTO. ALARM PAL–219 SHALL BE ACTUATED AND LATCHED 5 SECONDS AFTER THE BLOWER (B–002) IS TURNED TO AUTO IF THE ASSOCIATED PSL INDICATES LOW PRESSURE, ALARM PAL–219 SHALL SHUTDOWN HYDRAULIC SONTROL PUMPS AND BLOWERS B–001 AND B–002 AND ENERGIZE RELAY YY–100 COIL TO CAUSE VLS/CONDENSER SYSTEM AND OWS PACKAGE TO SHUT DOWN VIA YY–100 DRY CONTACTS TO FIELD. LIGHTS AND RELAYS SHALL REMAIN LATCHED UNTIL RESET HS–200 IS DEPRESSED.

P & ID SYMBOLS

SYMBOL / DESCRIPTION

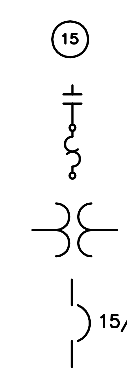


- INSTRUMENT – FIELD MOUNTED
- INSTRUMENT – PANEL MOUNTED (LWMS CONTROL PANEL)
- LIGHT – PANEL MOUNTED (LWMS CONTROL PANEL)
- INSTRUMENT – AUXILLIARY PANEL MOUNTED (OWS PACKAGE)
- RELAY IN LWMS CONTROL PANEL
- RELAY IN POWER CONTROL UNIT (PCU) PANEL
- INTERLOCK LOGIC NUMBER 1
- BALL VALVE
- BUTTERFLY VALVE
- CHECK VALVE
- GLOBE VALVE
- VACUUM RELIEF VALVE
- PRESSURE RELIEF VALVE
- DIAPHRAGM SEAL
- REDUCER
- MOTOR
- PUMP
- BLOWER
- SUMP PUMP
- VALVE TAG
- PIPE TAG
  - MATERIAL
  - FLUID
  - SIZE
- ELECTRICAL SIGNAL
- LIQUID PROCESS LINE
- GAS PROCESS LINE

INSTRUMENTATION IDENTIFICATION LETTERS DEFINITION

	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	CONDUCTIVITY (ELECTRICAL)			CONTROL	
D	DENSITY (MASS) OR SPECIFIC GRAVITY	DIFFERENTIAL			
E	VOLTAGE (EMF)		PRIMARY ELEMENT		
F	FLOW RATE	RATIO (FRACTION)			
G	GAGING (DIMENSIONAL)		GLASS VIEW DEVICE		
H	HAND (MANUALLY INITIATED)				HIGH
I	CURRENT (ELECTRICAL)		INDICATE		
J	POWER	SCAN			
K	TIME OR TIME–SCHEDULE	TIME RATE OF CHANGE		CONTROL STATION	
L	LEVEL		LIGHT (PILOT)		LOW
M	MOISTURE OR HUMIDITY	MOMENTARY			MIDDLE OR INTERMEDIATE
N	USER'S CHOICE		USER'S CHOICE	USER'S CHOICE	USER'S CHOICE
O	USER'S CHOICE		ORIFICE (RESTRICTION)		
P	PRESSURE OR VACUUM		POINT (TEST CONNECTION)		
Q	QUANTITY	INTEGRATE OR TOTALIZE			
R	RADIOACTIVITY		RECORD OR PRINT		
S	SPEED OR FREQUENCY	SAFETY		SWITCH	
T	TEMPERATURE			TRANSMIT	
U	MULTIVARIABLE		MULTIFUNCTION	MULTIFUNCTION	MULTIFUNCTION
V	VIBRATION			VALVE, DAMPER OR LOUVER	
W	WEIGHT OR FORCE		WELL		
X	TROUBLE FAIL		TROUBLE FAIL		
Y	EVENT, STATE OR PRESENCE			RELAY OR COMPUTE	
Z	POSITION			DRIVE, ACTUATE OR UNCLASSIFIED FINAL CONTROL ELEMENT	

ELECTRICAL SYMBOLS



- MOTOR, NUMERAL INDICATES HORSEPOWER
- MOTOR STARTER WITH THERMAL OVERLOAD
- POTENTIAL TRANSFORMER
- LOW VOLTAGE AIR CIRCUIT OR MOLDED CASE BREAKER, X/Y BREAKER RATED FOR X AMPS WITH Y POLES

ABBREVIATIONS

A	AIR
AS	AIR SPARGE TANK
B	BLOWER
CPVC	CHLORINATED POLYVINYL CHLORIDE
CS	CARBON STEEL
FLA	FULL LOAD AMPS
GAC	GRANULATED ACTIVATED CARBON
HOA	HAND – OFF – AUTO
LWMS	LIQUID WASTE MANAGEMENT SYSTEM
MST	MAIN SPARGE TANK
NAPL	NON AQUEOUS PHASE LIQUID
NST	NAPL SPARGE TANK
OWS	OIL/WATER SEPARATOR
P	PUMP
PH	PHASE
PVC	POLYVINYL CHLORIDE
SL	SLUDGE
SS	STAINLESS STEEL
T	TANK
V	VALVE
VAC	VOLTS ALTERNATING CURRENT
VLS	VAPOR LIQUID SEPARATOR
W	WATER

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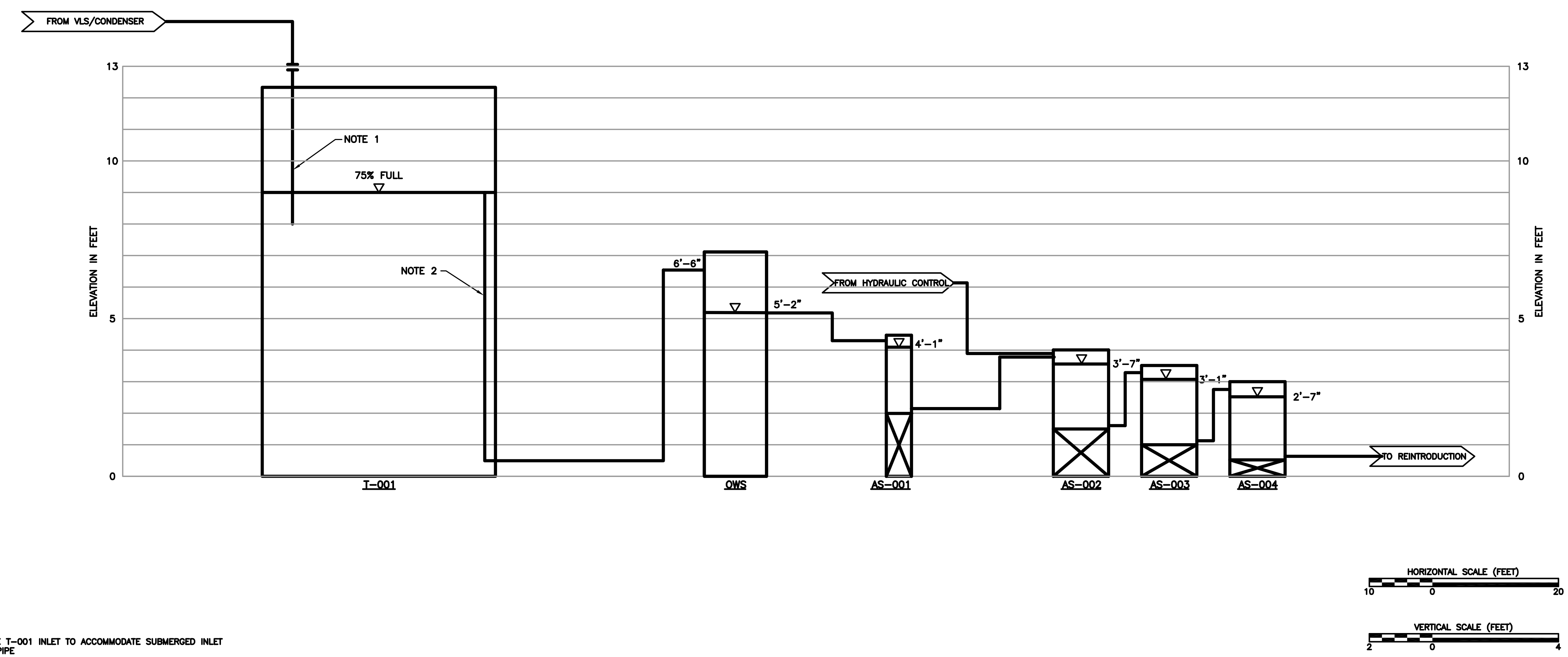
LIQUID WASTE MANAGEMENT SYSTEM P&ID AND ELECTRICAL LEGEND, ABBREVIATIONS AND CONTROL LOGIC

FIGURE 8



NOTES:

1. MODIFY TANK T-001 INLET TO ACCOMMODATE SUBMERGED INLET DISCHARGE PIPE
2. MODIFY TANK T-001 OUTLET TO ACCOMMODATE ELEVATED OUTLET INTAKE PIPE

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HYDRAULIC PROFILE

FIGURE 9

EQUIPMENT SCHEDULE

TAG	DESCRIPTION	MANUFACTURER	MODEL	REQUIRED CAPACITY	MATERIALS OF CONSTRUCTION	ELECTRICAL	MINIMUM RATINGS	
							PRESSURE	TEMPERATURE
AS-001	NAPL SPARGE TANK	AEROMIX	BREEZE SERIES 3 FINE BUBBLE W/ MIST ELIMINATOR	65 GPM, 100 CFM	POLYPROPYLENE	–	±10 IN WC	150 F
AS-002	MAIN SPARGE TANK	AEROMIX	BREEZE SERIES 8 FINE BUBBLE	8 CHAMBERS 190 GPM, 400 CFM	POLYPROPYLENE	–	±10 IN WC	150 F
AS-003	MAIN SPARGE TANK	AEROMIX	BREEZE SERIES 8 FINE BUBBLE	8 CHAMBERS 190 GPM, 400 CFM	POLYPROPYLENE	–	±10 IN WC	150 F
AS-004	MAIN SPARGE TANK	AEROMIX	BREEZE SERIES 8 FINE BUBBLE	8 CHAMBERS 190 GPM, 400 CFM	POLYPROPYLENE	–	±10 IN WC	150 F
B-001	NAPL STREAM SPARGE TANK BLOWER	FPZ	SCL V5-2-3	100 CFM @ 40 IN WC	STEEL/ALUMINUM	2 HP 460V, 3PH	–	70 F
B-002	MAIN SPARGE TANK BLOWER	NEW YORK BLOWER	2608	1500 CFM @ 52 IN WC	STEEL/ALUMINUM	25 HP 460V, 3PH	–	70 F
OWS	COALESCING OIL WATER SEPARATOR	PARKSON	SRC-100	100 GPM, 2000 SQ FT	304 STAINLESS STEEL	2 x 1/2 HP, 120V	–	150 F
P-001	CB2 SUMP PUMP	NA	NA	NA	NA	1/2 HP 120VAC	–	–
P-002	LNAPL PUMP ON OWS	PARKSON PACKAGE-MOYNO	300 SERIES	500 GAL/DAY	316 SS	–	–	150 F
P-003	DNAPL/SLUDGE PUMP ON OWS	PARKSON PACKAGE-MOYNO	300 SERIES	500 GAL/DAY	316 SS	–	–	150 F
STACK	VAPOR DISCHARGE STACK	–	–	8 IN DIAM/16 FT HEIGHT	PVC	–	–	–
T-001	SURGE TANK	BAKER	MODIFIED VAPOR-TIGHT EZ CLEAN	20,000 GAL	CARBON STEEL	–	–	150 F
T-002	DOUBLE-CONTAINED NAPL STORAGE TANK	BAKER	DOUBLE WALL, RODLESS FIXED AXLE TANK	17,640 GAL	EPOXY COATED STEEL	–	–	150 F
HCW-01	HYDRAULIC CONTROL PUMP	GOULDS	40GS15434	65 GPM @ 38 FT. W.C.	STAINLESS STEEL	1.5 HP, 460V, 3PH	–	–
HCW-02	HYDRAULIC CONTROL PUMP	GOULDS	40GS15434	65 GPM @ 38 FT. W.C.	STAINLESS STEEL	1.5 HP, 460V, 3PH	–	–
HCW-03	HYDRAULIC CONTROL PUMP	GOULDS	40GS15434	65 GPM @ 38 FT. W.C.	STAINLESS STEEL	1.5 HP, 460V, 3PH	–	–

NOTES:

1. NA – NOT APPLICABLE OR AVAILABLE
2. PE/LI-105 – INSTRUMENT SHALL BE ADJUSTABLE AND CALIBRATABLE TO ALLOW MEASUREMENT OF LIQUID LEVEL WITH VARYING DENSITY.

VALVE SCHEDULE

TAG	DESCRIPTION	TYPE	SUPPLIER	MODEL SIZE (IN)	MATERIAL OF CONSTRUCTION	CAPACITY	MINIMUM RATINGS	
							PRESSURE	TEMPERATURE
V101	T-001 INLET SAMPLE	BALL		1/4	CPVC	NA	20 PSIG	150 F
V102	T-001 OUTLET	TRUNION BALL	BAKER TANK	4	NA	65 GPM	20 PSIG	150 F
V103	T-001 OUTLET SAMPLE	BALL		1/4	CPVC	NA	20 PSIG	150 F
V104	OWS OUTLET	TRUNION BALL		3	CPVC	65 GPM	20 PSIG	150 F
V105	OWS OUTLET SAMPLE	BALL		1/4	CPVC	NA	20 PSIG	150 F
V106	B-001 VENT	TRUNION BALL		2	PVC	50 CFM	20 PSIG	100 F
V107	AS-001 FLOW CONTROL	GLOBE		2	CPVC	100 CFM @ 5 IN HG	25 IN HG VAC	150 F
V108	AS-001 LIQUID OUTLET	TRUNION BALL		4	CPVC	65 GPM	20 PSIG	150 F
V109	AS-001 OUTLET SAMPLE	BALL		1/4	CPVC	NA	20 PSIG	150 F
V112	P-002 OUTLET CHECK	SWING CHECK		1	304 SS	5 GPM	150 PSIG	150 F
V113	P-003 OUTLET CHECK	SWING CHECK		2	304 SS	5 GPM	150 PSIG	150 F
V114	T-002 INLET	TRUNION BALL		2	304 SS	10 GPM	150 PSIG	150 F
V115	T-002 OUTLET	TRUNION BALL		4	304 SS	100 GPM	150 PSIG	150 F
V117	B-001 AIR FLOW CONTROL	TRUNION BALL		2	PVC	100 CFM	10 PSIG	100 F
V118	T-001 DRAIN	TRUNION BALL	BAKER TANK	6	NA	NA	20 PSIG	150 F
V119	T-002 PE-105 SHUTOFF	BALL		1/2	304 SS	NA	20 PSIG	150 F
V120	AS-001 AIR SAMPLE PORT	BALL		1/4	CPVC	NA	10 PSIG	150 F
V122	NAPL STORAGE TANK SAMPLING PORT	BALL		1/4	304 SS	NA	20 PSIG	150 F
V123	T-001 VACUUM RELIEF	VACUUM RELIEF	BAKER TANK	NA	NA	0.4 OZ	–	150 F
V124	T-001 PRESSURE RELIEF	PRESSURE RELIEF	BAKER TANK	NA	NA	16 OZ	–	150 F
V125	T-002 VACUUM RELIEF	VACUUM RELIEF	BAKER TANK	NA	NA	NA	NA	150 F
V126	T-002 PRESSURE RELIEF	PRESSURE RELIEF	BAKER TANK	NA	NA	NA	NA	150 F
V127	OWS VENT	BALL		1/4	CPVC	1 CFM	10 PSIG	150 F
V201	COMBINED HYDRAULIC CONTROL SAMPLE	BALL		1/4	PVC	NA	10 PSIG	100 F
V202	AS-002 WATER OUTLET	TRUNION BALL		4	PVC	200 GPM	20 PSIG	100 F
V203	AS-003 WATER OUTLET	TRUNION BALL		4	PVC	200 GPM	20 PSIG	100 F
V204	AS-004 WATER OUTLET	TRUNION BALL		4	PVC	200 GPM	20 PSIG	100 F
V205	HCW01 CHECK	SWING CHECK		3	PVC	30 GPM	150 PSIG	100 F
V206	HCW02 CHECK	SWING CHECK		3	PVC	30 GPM	150 PSIG	100 F
V207	HCW03 CHECK	SWING CHECK		3	PVC	30 GPM	150 PSIG	100 F
V208	HCW01 SAMPLE	BALL		1/4	PVC	NA	150 PSIG	100 F
V209	HCW02 SAMPLE	BALL		1/4	PVC	NA	150 PSIG	100 F
V210	HCW03 SAMPLE	BALL		1/4	PVC	NA	150 PSIG	100 F
V211	HCW01 CONTROL	TRUNION BALL		3	PVC	50 GPM	150 PSIG	100 F
V212	HCW02 CONTROL	TRUNION BALL		3	PVC	50 GPM	150 PSIG	100 F
V213	HCW03 CONTROL	TRUNION BALL		3	PVC	50 GPM	150 PSIG	100 F
V214	HCW01 DIVERSION	TRUNION BALL		3	PVC	50 GPM	150 PSIG	100 F
V215	HCW02 DIVERSION	TRUNION BALL		3	PVC	50 GPM	150 PSIG	100 F
V216	HCW02 DIVERSION	TRUNION BALL		3	PVC	50 GPM	150 PSIG	100 F
V217	B-002 FLOW DAMPER	B-FLY	NEW YORK BLOWER	8	ALUMINUM	1500 CFM	10 PSIG	100 F
V218	MAKEUP CONTROL	GLOBE		1	PVC	5 GPM	150 PSIG	100 F
V219	AS-002 AIR INLET FLOW	B-FLY		4	PVC	500 CFM	10 PSIG	100 F
V220	AS-003 AIR INLET FLOW	B-FLY		4	PVC	500 CFM	10 PSIG	100 F
V221	AS-004 AIR INLET FLOW	B-FLY		4	PVC	500 CFM	10 PSIG	100 F
V222	REINTRODUCTION SAMPLE	BALL		1/4	PVC	NA	10 PSIG	100 F
V223	STACK SAMPLE	BALL		1/4	PVC	NA	10 PSIG	100 F

INSTRUMENT AND CONTROL SCHEDULE

TAG	LOOP	FUNCTION	SUPPLIER	RANGE
FQ	201	HCW01 TOTALIZER		0 – 50 GPM
	202	HCW02 TOTALIZER		0 – 50 GPM
	203	HCW03 TOTALIZER		0 – 50 GPM
FI	201	MAKEUP FLOWRATE		0 – 10 GPM
FP	101	AS-001 AIR FLOW MEASURING POINT		2000 – 6000 FPM
	201	AS-002 AIR FLOW MEASURING POINT		1000 – 3000 FPM
	202	AS-003 AIR FLOW MEASURING POINT		1000 – 3000 FPM
	203	AS-004 AIR FLOW MEASURING POINT		1000 – 3000 FPM
	205	STACK AIR FLOW MEASURING POINT		2000 – 6000 FPM
LI	101	AS-001 SIGHT GLASS		0 – 30 IN
	201	AS-002 SIGHT GLASS		0 – 30 IN
	202	AS-003 SIGHT GLASS		0 – 30 IN
	203	AS-004 SIGHT GLASS		0 – 30 IN
LSH	101	CB2 SUMP PUMP CONTROL		NA
	103	P-002 CONTROL	PARKSON	NA
	102	P-003 CONTROL	PARKSON	NA
LSL	101	CB2 SUMP PUMP CONTROL		NA
	102	P-002 CONTROL	PARKSON	NA
	103	P-003 CONTROL	PARKSON	NA
LSHH	101	T-001 HIGH LEVEL		NA
	102	OWS HIGH LEVEL	PARKSON	NA
	104	AS-001 HIGH LEVEL		NA
	105	T-002 HIGH LEVEL		NA
	201	AS-002 HIGH LEVEL		NA
	202	AS-003 HIGH LEVEL		NA
	203	AS-004 HIGH LEVEL		NA
PE/LI	105	T-002 LEVEL	ROSEMOUNT OR EQUAL	0-20 FT OIL, CALIBRATABLE
PI	101	AS-001 AIR DISCHARGE PRESSURE		20 IN WC VAC – 20 IN WC PRESSURE
	102	P-002 DISCHARGE PRESSURE		0 – 50 PSIG
	103	P-003 DISCHARGE PRESSURE		0 – 50 PSIG
	105	AS-001 INLET AIR PRESSURE		0 – 20 IN WC
	201	HCW01 DISCHARGE PRESSURE		0 – 100 PSIG
	202	HCW02 DISCHARGE PRESSURE		0 – 100 PSIG
	203	HCW03 DISCHARGE PRESSURE		0 – 100 PSIG
	204	AS-002 INLET AIR PRESSURE		0 – 20 IN WC
	205	AS-003 INLET AIR PRESSURE		0 – 20 IN WC
	206	AS-004 INLET AIR PRESSURE		0 – 20 IN WC
PSL	105	B-001 LOW PRESSURE SWITCH		1 – 100 IN WC ADJUSTABLE
	219	B-002 LOW PRESSURE SWITCH		1 – 100 IN WC ADJUSTABLE
TI	101	T-001 DISCHARGE TEMPERATURE		200 F
	102	AS-001 INLET WATER TEMPERATURE		200 F
	201	AS-002 INLET HYDRAULIC CONTROL WATER TEMPERATURE		200 F
	202	AS-005 DISCHARGE WATER TEMPERATURE		100 F
	203	HCW01 TEMPERATURE		100 F
	204	HCW02 TEMPERATURE		100 F
	205	HCW03 TEMPERATURE		100 F
	206	AS-002 INLET NST TEMPERATURE		200 F

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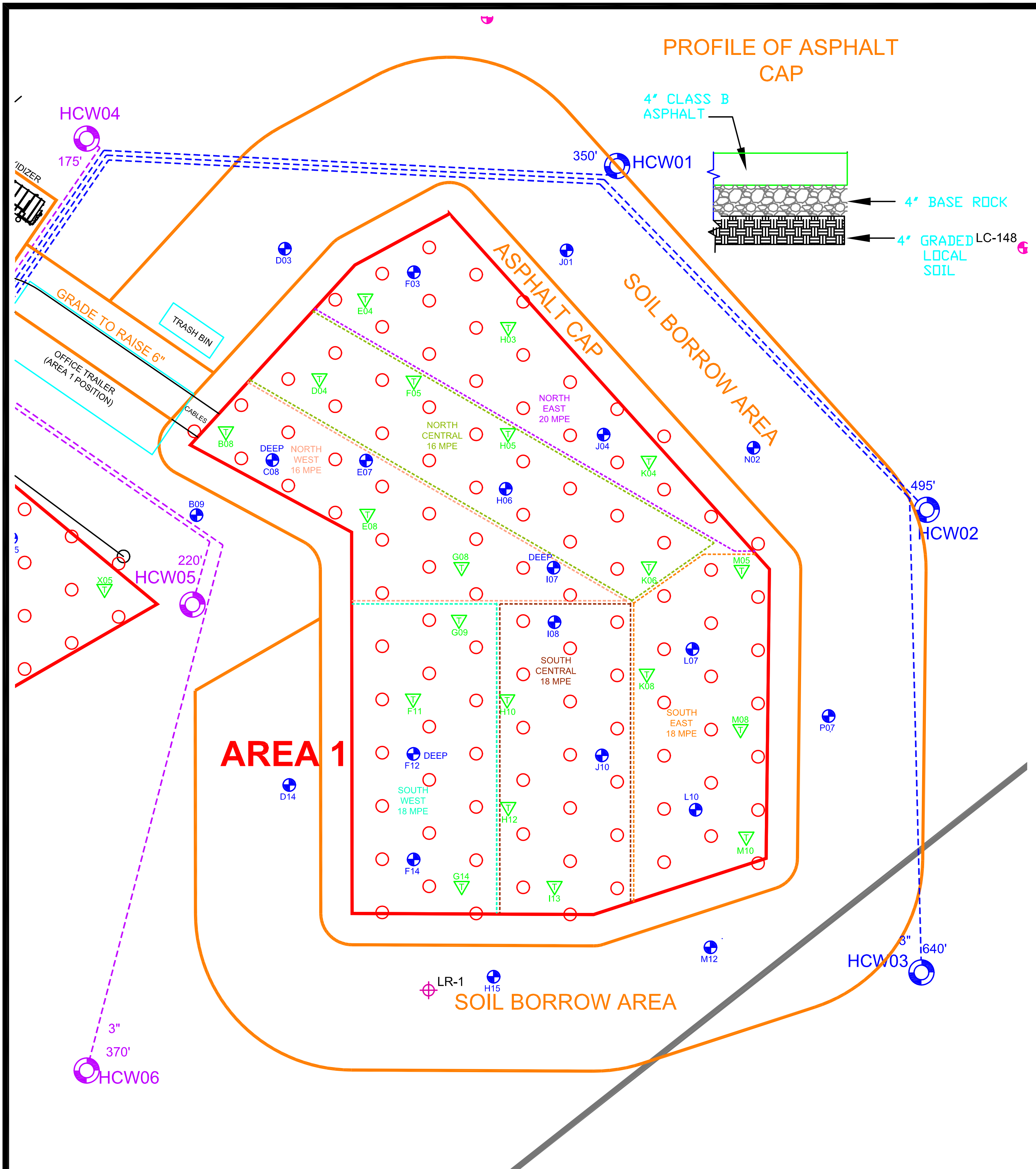
LWMS SCHEDULES

FIGURE 10



GROUP A MULTIPHASE EXTRACTION (23 MPE)
GROUP B (26 MPE WELLS)
GROUP C (28 MPE WELLS)
GROUP D (29 MPE WELLS)

SCALE IN FEET
0 30

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FIGURE 11a AREA 1 ASPHALT CAP DETAILS
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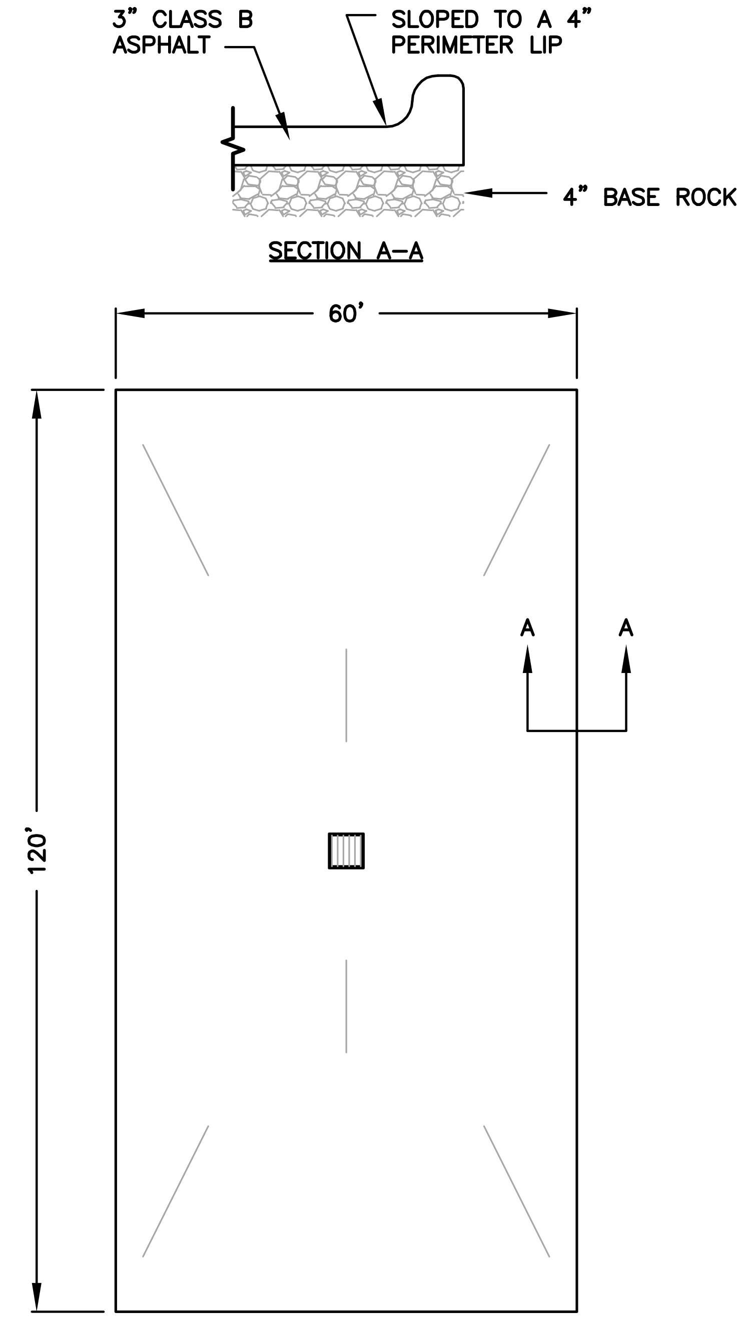

ASPHALT EQUIPMENT CONTAINMENT PAD
NOT TO SCALE

GARRY STRUTHERS ASSOCIATES, INC.
3150 Richards Road, Suite 100 Bellevue, WA 98005-4446
Phone: (425) 519-0300 Fax: (425) 519-0309
E-mail: gsa@gsassoc-inc.com http://www.gsassoc-inc.com

EGDY IN–SITU
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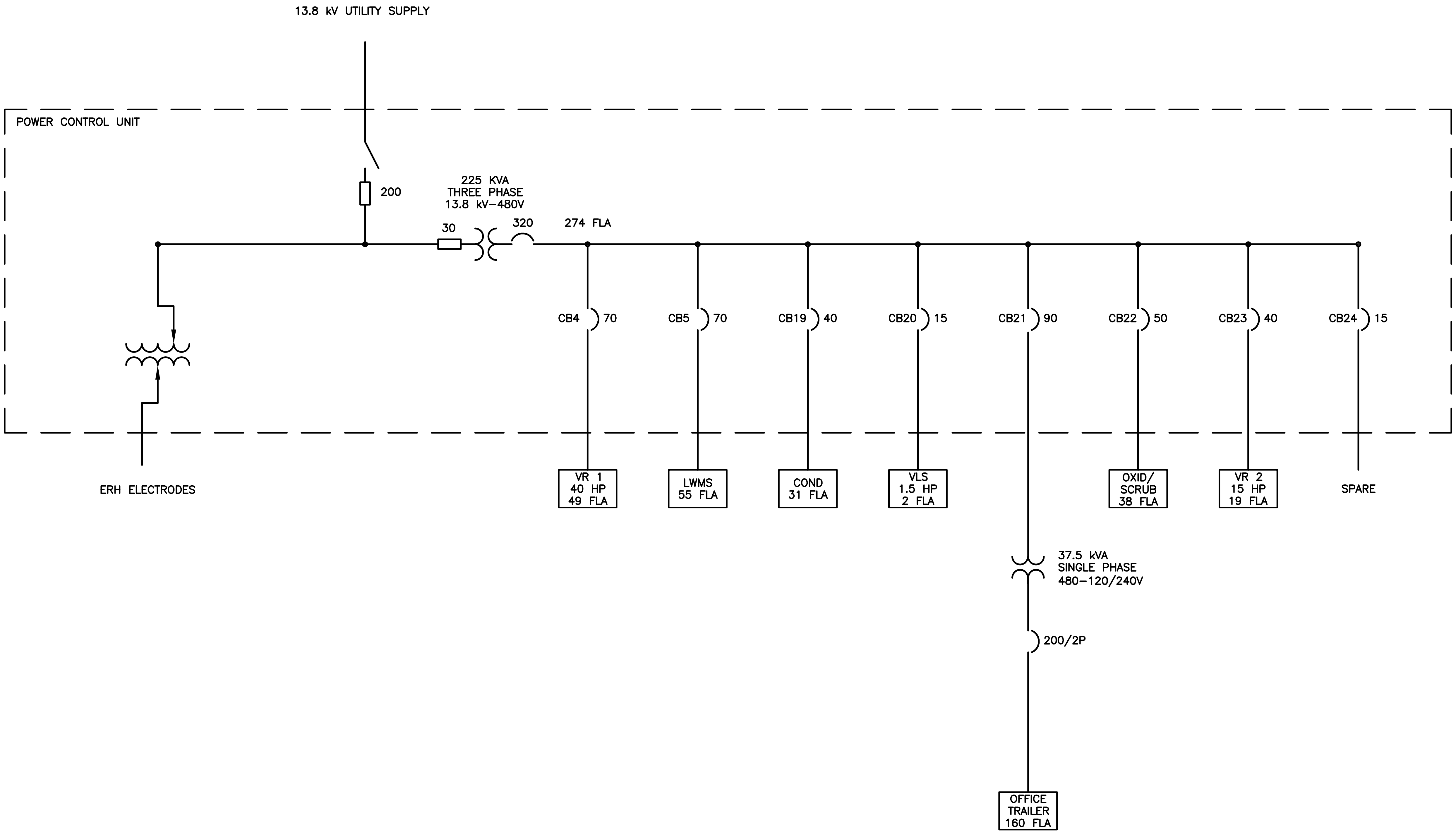
EGDY EQUIPMENT PAD DETAIL
TREATMENT AREA 1

FIGURE
11b



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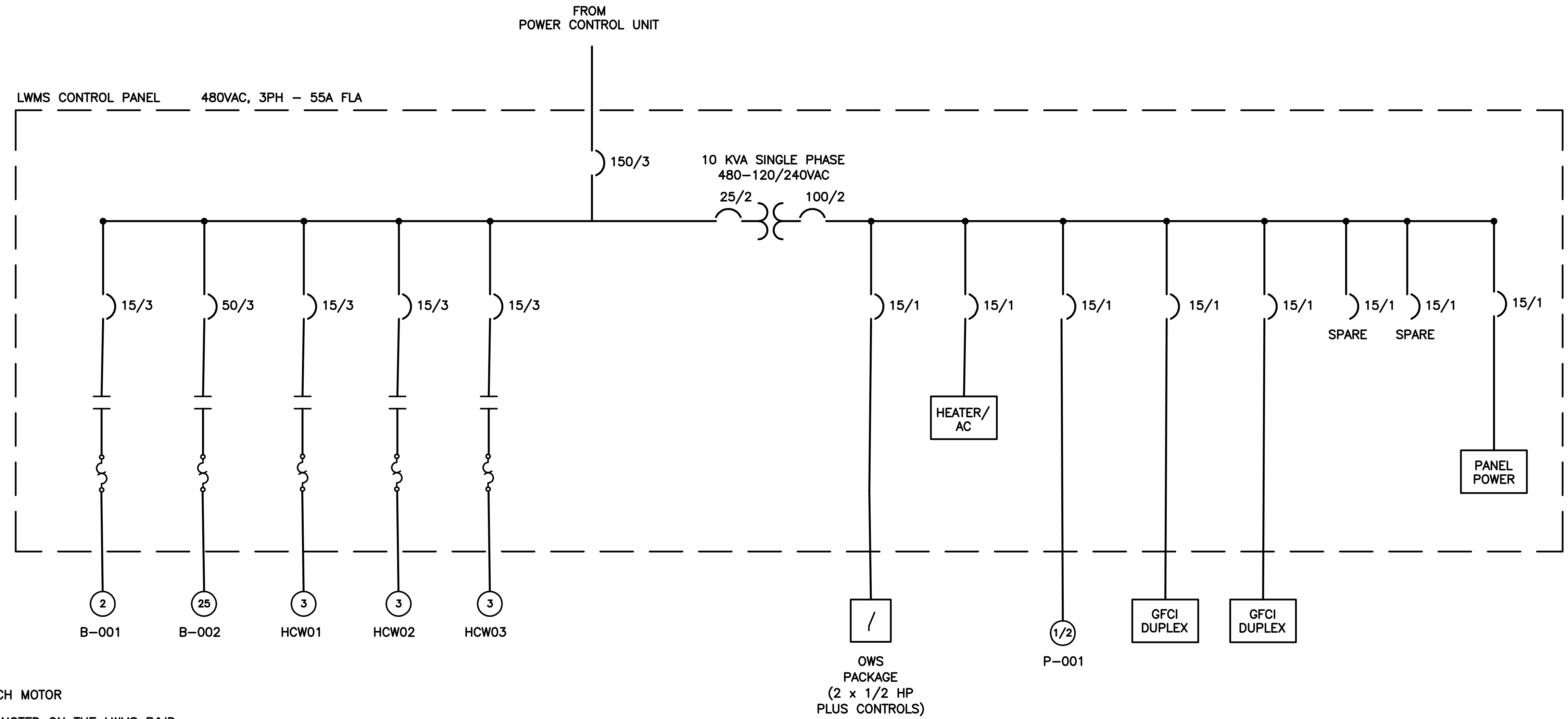
ERH ELECTRICAL ONE-LINE DIAGRAM

FIGURE
12a



NOTES:

1. ENCLOSURE SHALL BE NEMA4
2. CONTROL PANEL SHALL BE LISTED UL508A
3. RED RUN LIGHTS SHALL BE PROVIDE WITH EACH MOTOR
4. RELAYS AND ALARMS SHALL BE PROVIDED AS NOTED ON THE LWMS P&ID
5. HEATER/AC SHALL BE RATED FOR ENCLOSURE, PANEL COMPONENT HEAT GENERATION, AND YEAR–ROUND OUTDOOR USE AT FT. LEWIS
6. GROUNDING AND CONDUCTOR/CONDUIT SIZING SHALL BE PER NEC AND UL508A
7. TWO WEATHER–PROOF DUPLEX GFCI OUTLETS SHALL BE MOUNTED ON THE OUTSIDE OF THE ENCLOSURE
8. SUMP PUMP P–001 SHALL HAVE INTEGRAL MOTOR STARTER AND LEVEL SWITCHES
9. TERMINAL BLOCKS SHALL BE USED FOR ALL FIELD TERMINATIONS
10. 20 PERCENT EXCESS RELAYS SHALL BE PROVIDED
11. 20 PERCENT EXCESS TERMINAL BLOCK CAPACITY SHALL BE PROVIDED
12. MOTOR STARTERS SHALL BE IEC TYPE WITH ADJUSTABLE OVERLOAD SETTING
13. HAND SWITCHES AND LIGHTS SHALL BE LABELED AS DENOTED ON LWMS P&ID
14. PANEL SHALL BE LABELED "LWMS CONTROL PANEL"
15. INTERNAL FLUORESCENT LIGHT SHALL BE PROVIDED

LOAD SCHEDULE

MOTOR	VOLTAGE	PHASE	ESTIMATED LOAD	FULL LOAD AMPS
B–001	460	3	2 HP	4.0
B–002	460	3	18.4 HP	25
HCW–01	460	3	1.5 HP	2.6
HCW–02	460	3	1.5 HP	2.6
HCW–03	460	3	1.5 HP	2.6
OWS PACKAGE	460	3	1.0 HP	1.8
TRANSFORMER	460	1	7 KVA	14.6
TOTAL	–	–	–	53.2

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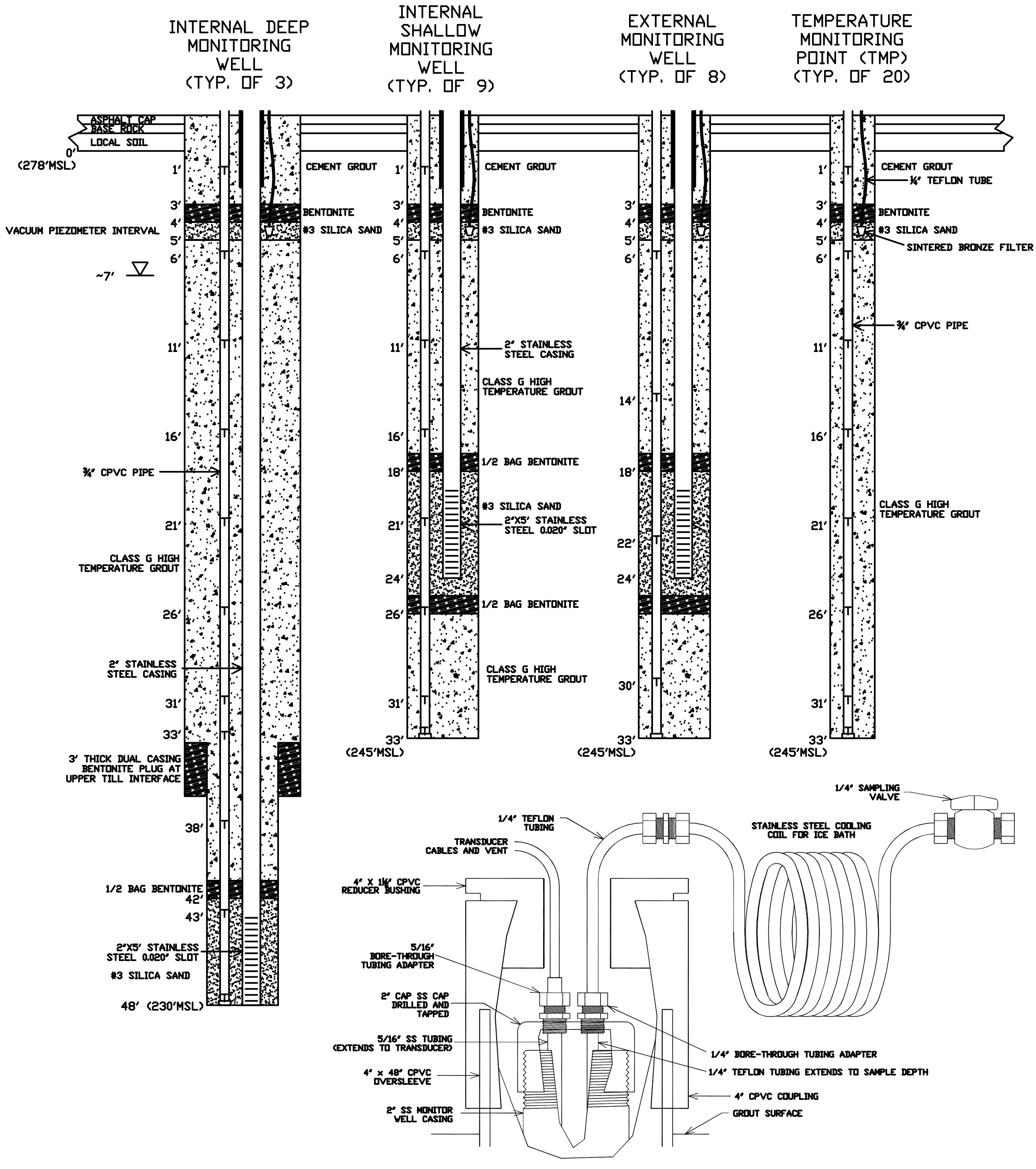
LWMS ELECTRICAL ONE-LINE DIAGRAM

FIGURE 12b



T = TYPE T THERMOCOUPLE
(297 TOTAL FOR AREA 1)
(224 USED FOR TEMPERATURE SPECIFICATION)

EGDY SITE – FORT LEWIS

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FIGURE 13a AREA 1 MONITORING WELL AND TMP DETAIL
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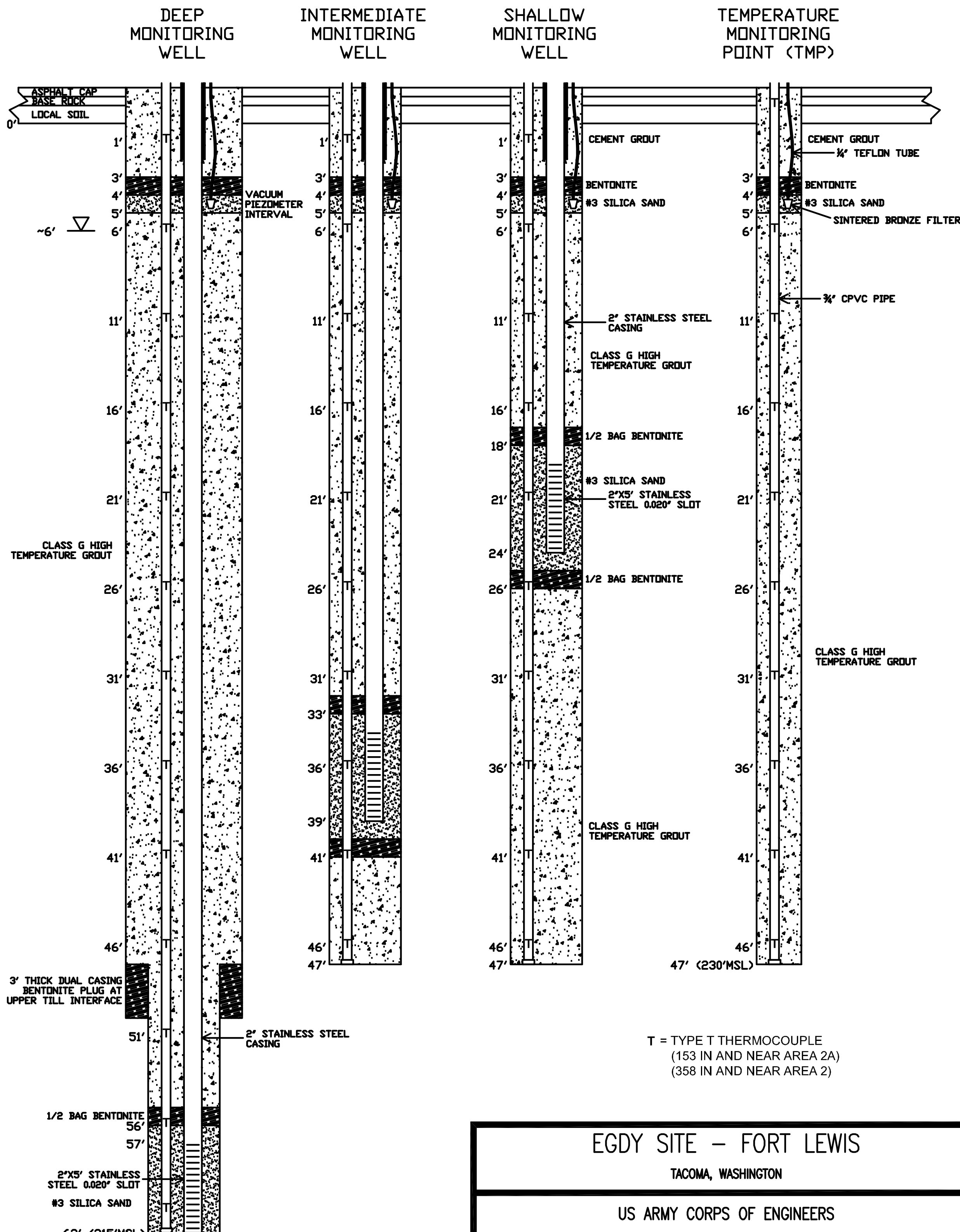

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FIGURE 13b AREA 2A MONITORING WELL AND TMP DETAIL
ERH REMEDIATION – FORT LEWIS, WASHINGTON

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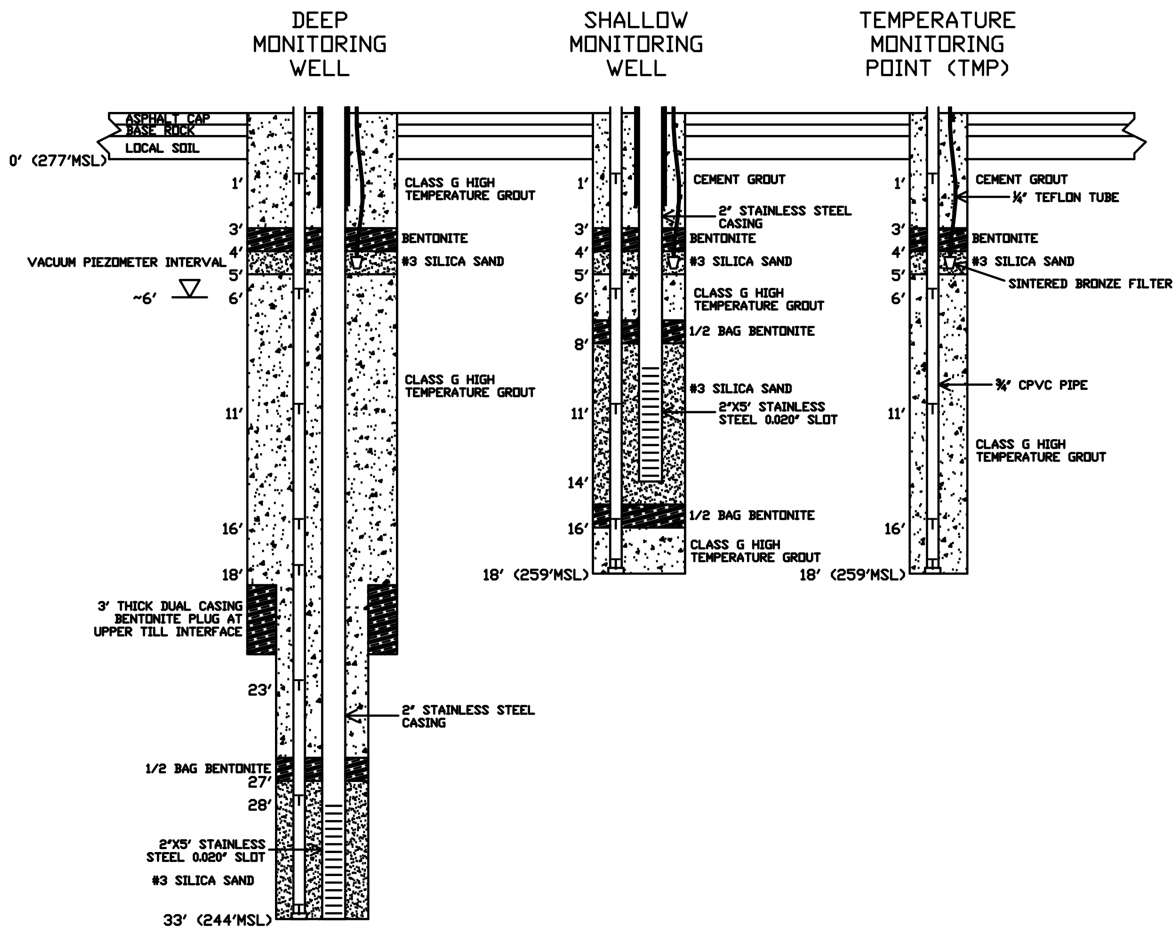

T = TYPE T THERMOCOUPLE
(58 IN AND NEAR AREA 2B)

EGDY SITE – FORT LEWIS

TACOMA, WASHINGTON

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FIGURE 13c AREA 2B MONITORING WELL AND TMP DETAIL
ERH REMEDIATION – FORT LEWIS, WASHINGTON

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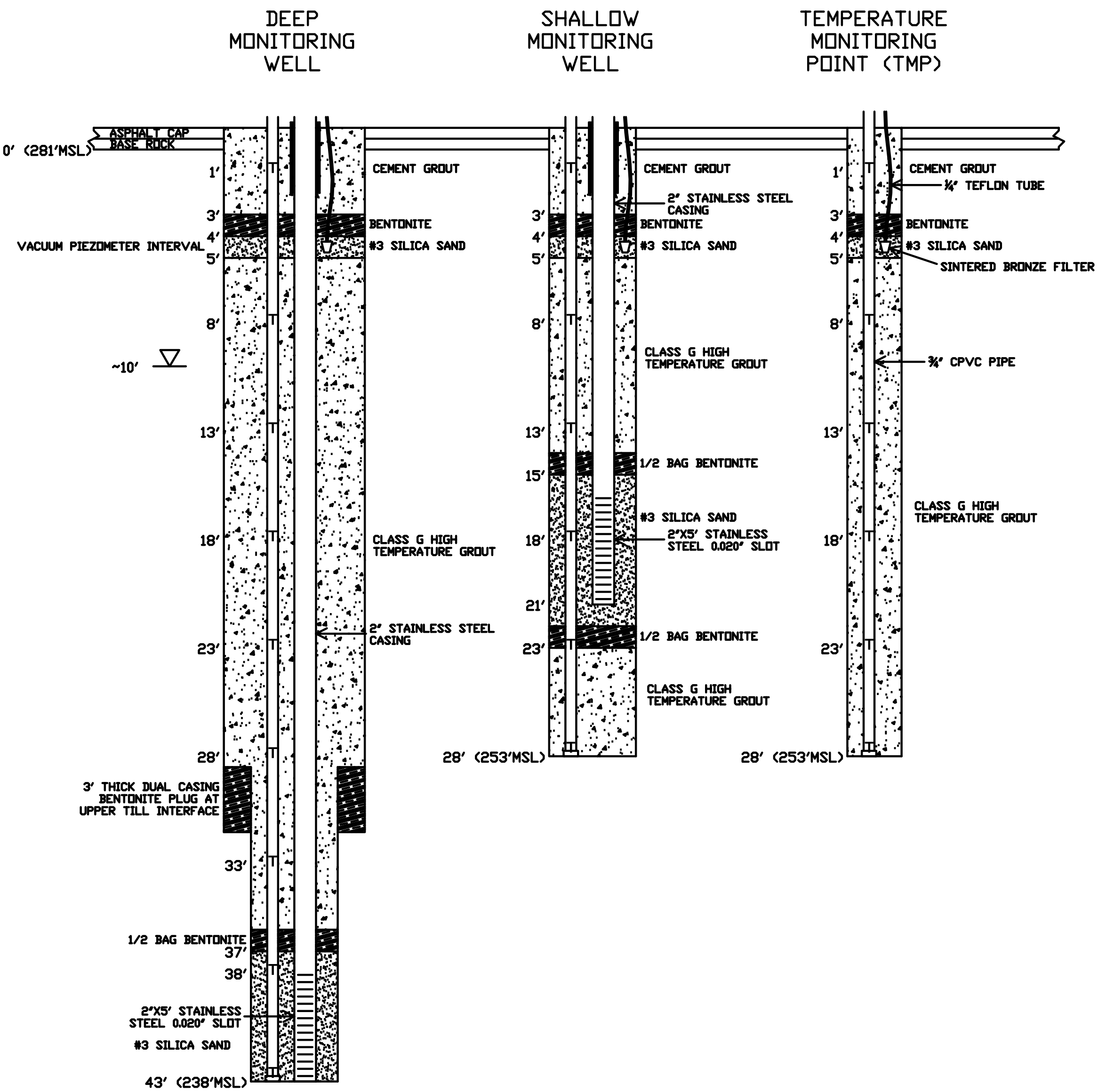


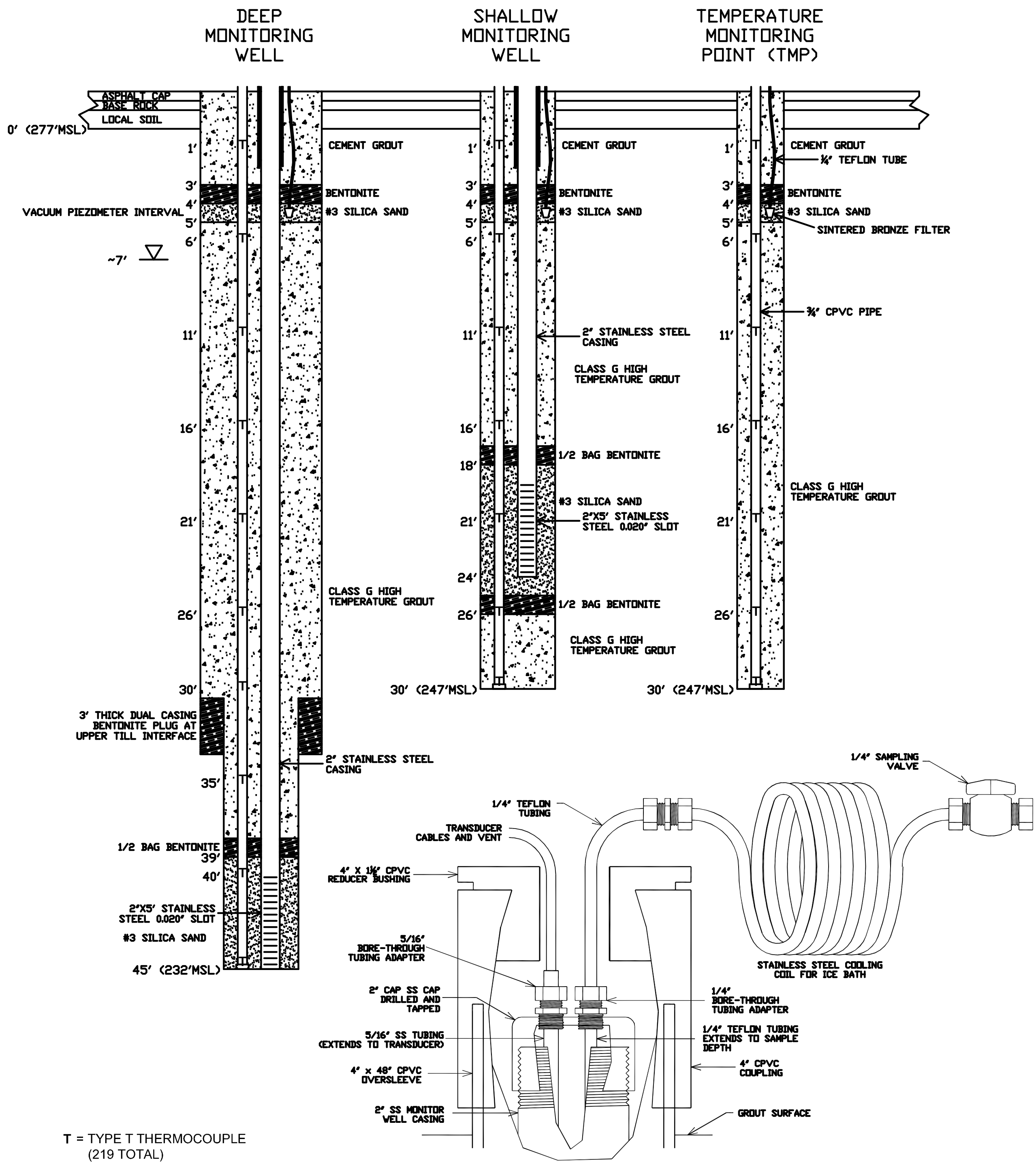
T = TYPE T THERMOCOUPLE
(147 IN AND NEAR AREA 2C)

EGDY SITE – FORT LEWIS
TACOMA, WASHINGTON

US ARMY CORPS OF ENGINEERS

FIGURE 13d AREA 2C MONITORING WELL AND TMP DETAIL
ERH REMEDIATION – FORT LEWIS, WASHINGTON

THERMAL REMEDIATION services inc.
2325 HUDSON STREET
LONGVIEW, WA 98632
(360) 425-8121 FAX: (360) 425-6674



T = TYPE T THERMOCOUPLE
(219 TOTAL)

EGDY SITE – FORT LEWIS

TACOMA, WASHINGTON

US ARMY CORPS OF ENGINEERS

FIGURE 13e AREA 3 MONITORING WELL AND TMP DETAIL
ERH REMEDIATION – FORT LEWIS, WASHINGTON

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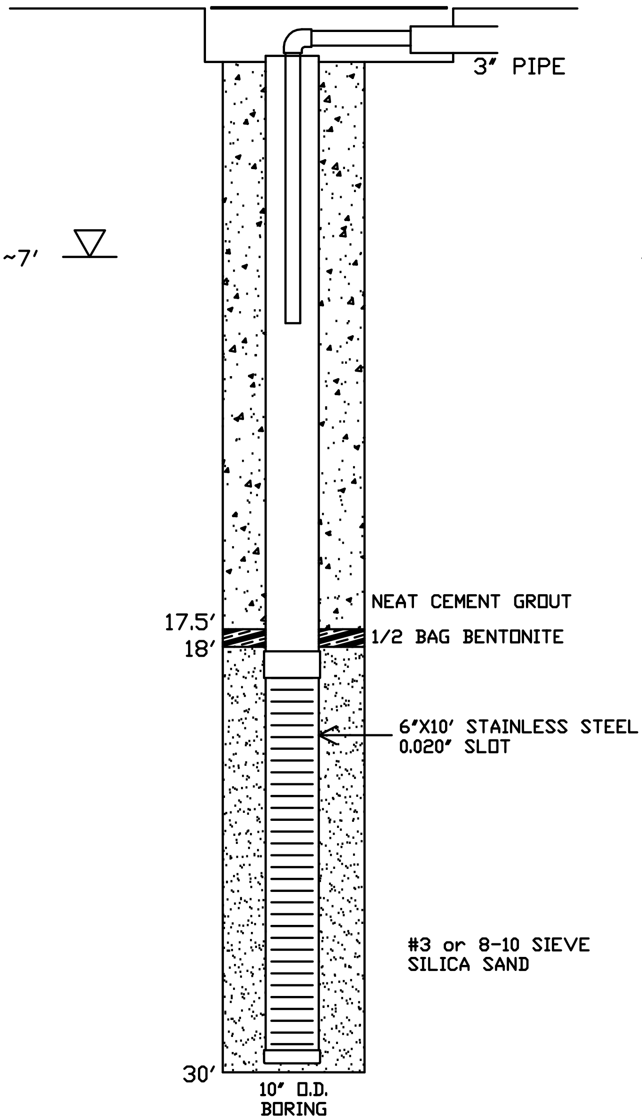
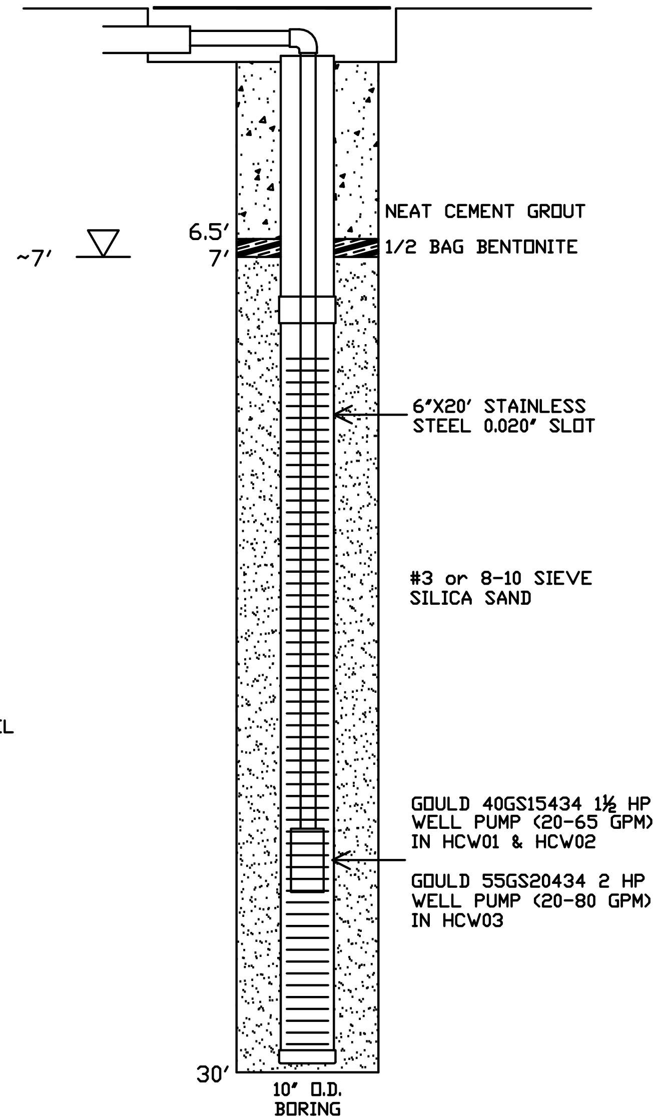
HYDRAULIC CONTROL INJECTION WELL DETAIL (HCW04, 05, 06)



HYDRAULIC CONTROL EXTRACTION WELL DETAIL (HCW01, 02, 03)



EGDY SITE – FORT LEWIS

TACOMA, WASHINGTON

US ARMY CORPS OF ENGINEERS

FIGURE 14 EXTRACTION AND INJECTION WELL DETAILS
ERH REMEDIATION – FORT LEWIS, WASHINGTON

THERMAL REMEDIATION services Inc.
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LONGVIEW, WA 98632
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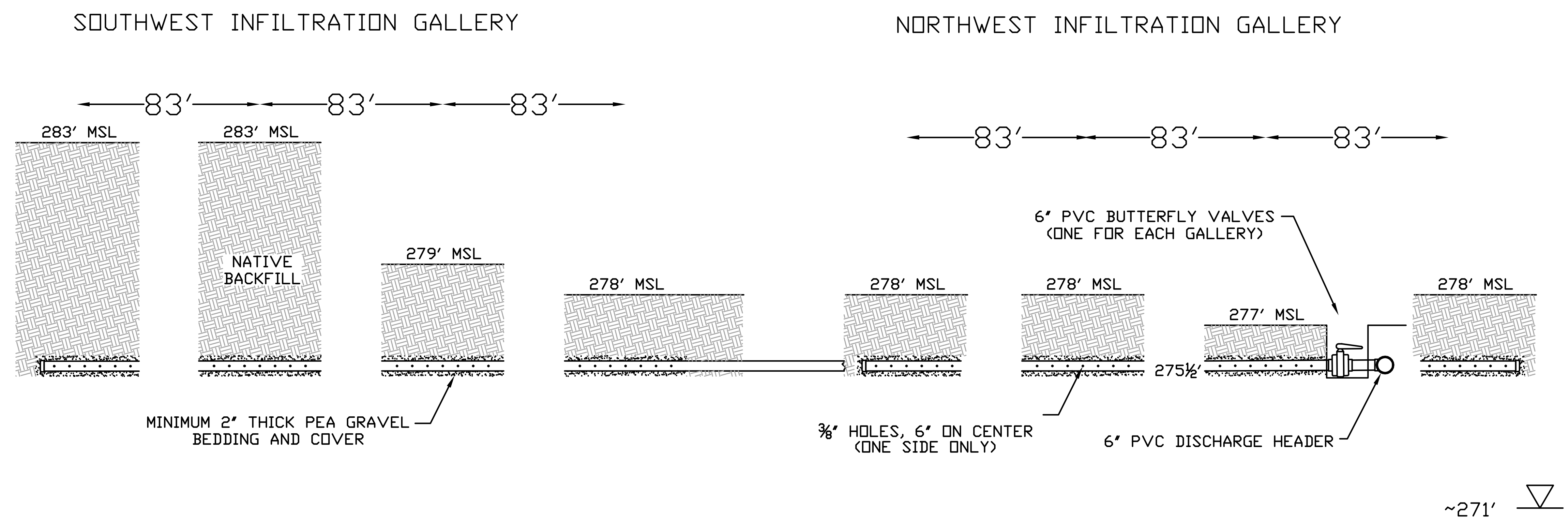
AREAS 1 AND 2 INFILTRATION GALLERIES



6″ INFILTRATION GALLERY PIPING ELEVATION MUST BE LEVEL (+/- 3″)

EGDY SITE – FORT LEWIS

TACOMA, WASHINGTON

US ARMY CORPS OF ENGINEERS

FIGURE 15 AREAS 1 AND 2 INFILTRATION GALLERIES
ERH REMEDIATION – FORT LEWIS, WASHINGTON

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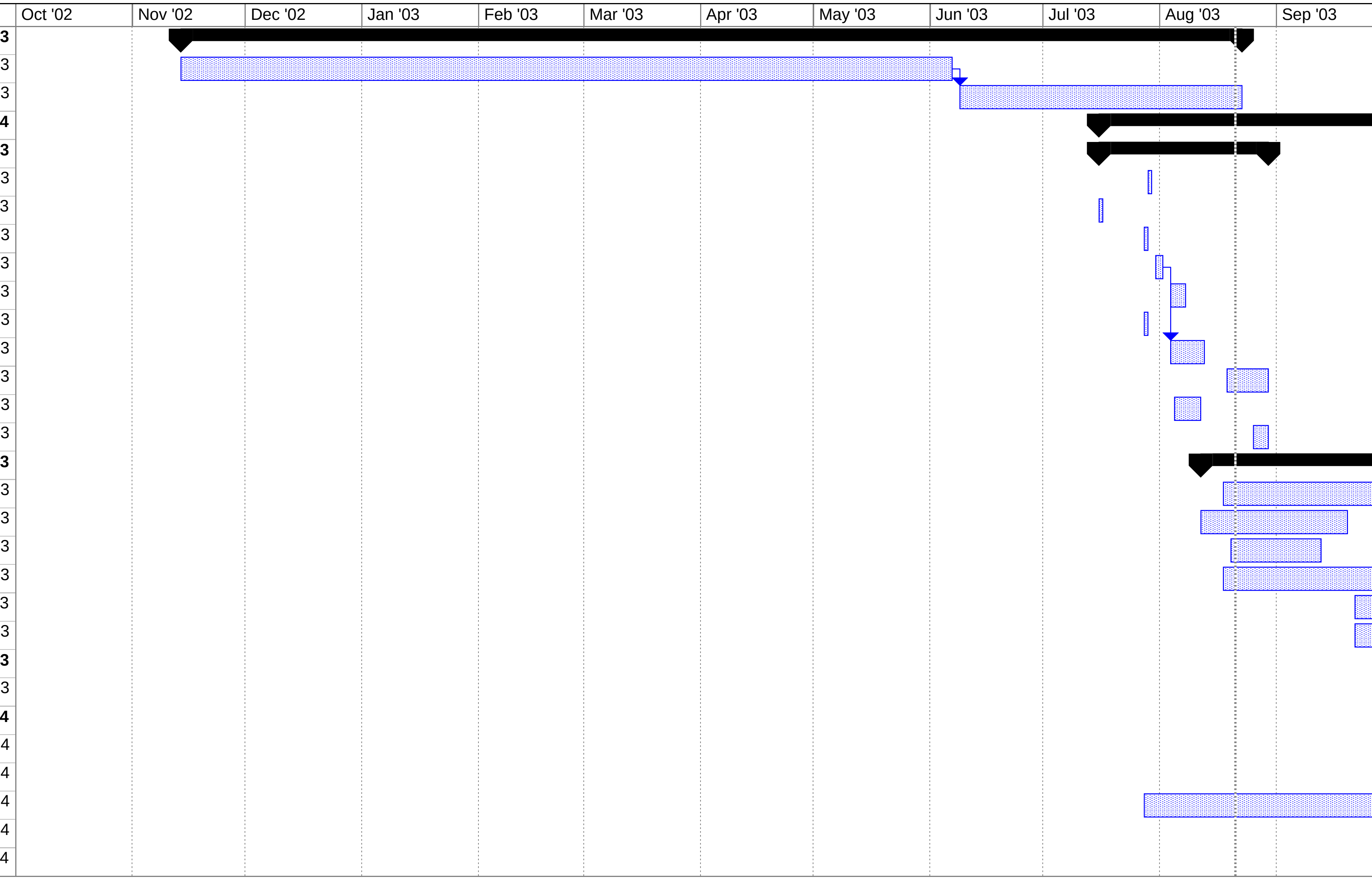
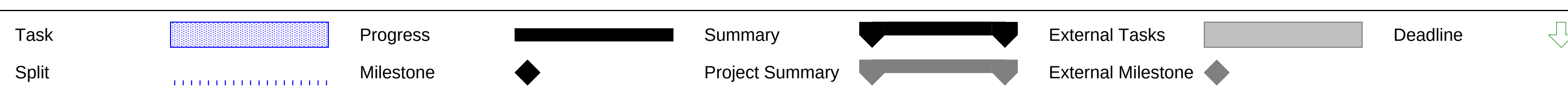
FIGURE 16
PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**RAMP**	**207 days**	**Thu 11/14/02**	**Fri 8/22/03**
2	Draft Ramp	152 days	Thu 11/14/02	Fri 6/6/03
3	Final Ramp (USACE Review and TRS response)	55 days	Mon 6/9/03	Fri 8/22/03
4	**Area One**	**233 days**	**Wed 7/16/03**	**Mon 4/5/04**
5	**Phase I**	**33 days**	**Wed 7/16/03**	**Fri 8/29/03**
6	Locate all utilities	1 day	Tue 7/29/03	Tue 7/29/03
7	Precon mtg w/USACE-TRS	1 day	Wed 7/16/03	Wed 7/16/03
8	Mobilization	1 day	Mon 7/28/03	Mon 7/28/03
9	Surveying	2 days	Thu 7/31/03	Fri 8/1/03
10	Construct Staging Area	4 days	Mon 8/4/03	Thu 8/7/03
11	Abandon existing infiltration gallery/specified MWs	1 day	Mon 7/28/03	Mon 7/28/03
12	CAP Construction/Trenching	7 days	Mon 8/4/03	Tue 8/12/03
13	Infiltration Gallery Install	9 days	Tue 8/19/03	Fri 8/29/03
14	Install Hydraulic Control Wells	5 days	Tue 8/5/03	Mon 8/11/03
15	Scrubber Discharge and HCW Lines	4 days	Tue 8/26/03	Fri 8/29/03
16	**Phase II**	**53 days**	**Tue 8/12/03**	**Fri 10/17/03**
17	Electrode Installation and TMP Installation	30 days	Mon 8/18/03	Fri 9/26/03
18	MW and Perimeter Electrode Installation	29 days	Tue 8/12/03	Fri 9/19/03
19	Well Development	18 days	Wed 8/20/03	Fri 9/12/03
20	LWMS Construction	32 days	Mon 8/18/03	Tue 9/30/03
21	ERH System Installation (process equipment)	15 days	Mon 9/22/03	Wed 10/8/03
22	VR Piping and electrical connections	24 days	Mon 9/22/03	Fri 10/17/03
23	**Phase III**	**19 days**	**Mon 10/20/03**	**Fri 11/7/03**
24	Shakedown Hydraulic Control/MPE/ERH	19 days	Mon 10/20/03	Fri 11/7/03
25	**Phase IV**	**140 days**	**Sat 11/8/03**	**Mon 4/5/04**
26	Operations (heat up/sample collection/monitoring)	80 days	Sat 11/8/03	Mon 1/26/04
27	Heat Up plus 60 days (sample collection/monitoring)	60 days	Tue 1/27/04	Mon 4/5/04
28	Project Website (reporting)	265 days	Mon 7/28/03	Mon 5/31/04
29	Demobe/Site Restoration	30 days	Mon 4/5/04	Fri 5/14/04
30	Draft and Final Report	120 days	Mon 5/10/04	Wed 9/22/04



Schedule subject to change



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6	Locate all utilities	1 day	Tue 7/29/03	Tue 7/29/03
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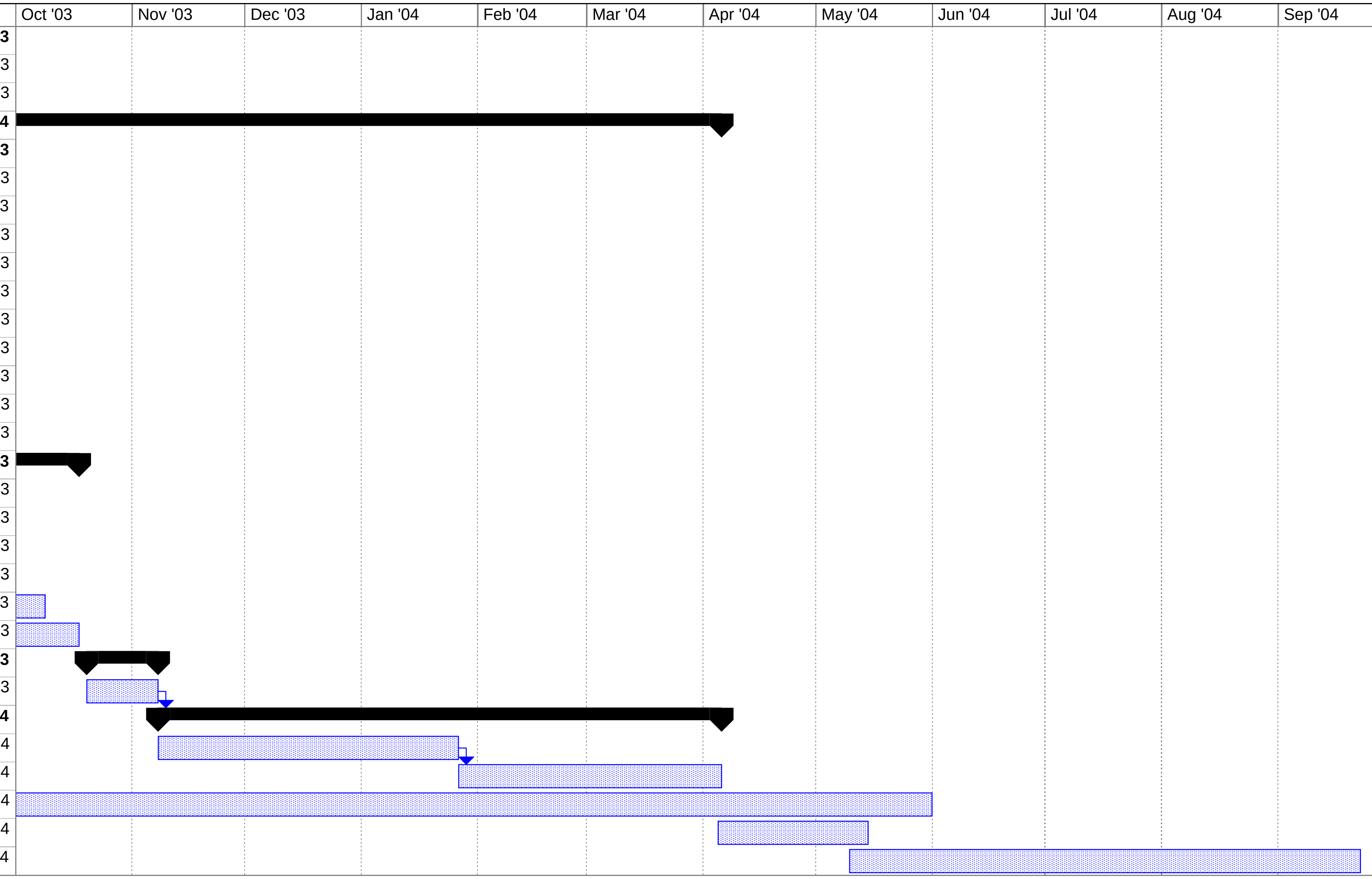

Schedule subject to change

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline