ILLINOIS EPA RCRA CORRECTIVE ACTION CERTIFICATION

This certification must accompany any document submitted to Illinois EPA in accordance with the corrective action requirements set forth in a facility's RCRA permit. The original and two copies of all documents submitted must be provided.

1.0 FACILITY IDENTIFICATION

Name: WRB Refining LLC - Wood River Refinery

County: Madison

Street Address: 900 South Central Ave.

Site No. (IEPA): 1191150002

City: Roxana, IL 62084

Site No. (USEPA): ILD 080 012 305

2.0 OWNER INFORMATION

Name: Not Applicable

Mailing Address:

3.0 OPERATOR INFORMATION

Equilon Enterprises LLC d/b/a Shell Oil Products US

17 Junction Drive, PMB #399

Glen Carbon, IL 62034

Contact Name:

Kevin Dyer

Contact Title:

Principal Program Manager

Phone No.:

618-288-7237

4.0 TYPE OF SUBMISSION (check applicable item and provide requested information, as applicable)

☐ RFI Phase I Workplan/Report
☐ RFI Phase II Workplan/Report
☐ CMP Report; Phase
☒ Other (describe):
Conceptual/Final Design Report
Date of Submittal June 10, 2011

IEPA Permit Log No. B-43-R
Date of Last IEPA Letter on Project 4/6/11
Log No. of Last IEPA Letter on Project B-43R-CA-9
Does this submittal include groundwater information: ☐ Yes ☒ No

5.0 DESCRIPTION OF SUBMITTAL: (briefly describe what is being submitted and its purpose)

Design for full scale Soil Vapor Extraction (SVE) system..

6.0 DOCUMENTS SUBMITTED (identify all documents in submittal, including cover letter; give dates of all documents)

RCRA Corrective Action Certification, cover letter and Conceptual/Final Design Report dated June 10, 2011.

7.0 CERTIFICATION STATEMENT - ***(This statement is part of the overall certification being provided by the owner/operator, professional and laboratory in Items 7.1, 7.2 and 7.3 below).*** The activities described in the subject submittals have been carried out in accordance with procedures approved by Illinois EPA. I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

7.1 **OWNER/OPERATOR CERTIFICATION** (Must be completed for all submittals. Certification and signature requirements are set forth in 35 IAC 702.126.) All submittals pertaining to the corrective action requirements set forth in a RCRA Permit must be signed by the person designated below (or by a duly authorized representative of that person):

1. For a Corporation, by a principal executive officer of at least the level of vice-president.
2. For a Partnership or Sole Proprietorship, by a general partner or the proprietor, respectively.
3. For a Governmental Entity, by either a principal executive officer or a ranking elected official.

A person is a duly authorized representative only if:

1. the authorization is made in writing by a person described above; and
2. the written authorization is provided with this submittal (a copy of a previously submitted authorization can be used).

Owner Signature: _____ _____ (Date)

Title: _____

Operator Signature: _____ 6/10/11 (Date)

Title: Principal Program Manager

7.2 **PROFESSIONAL CERTIFICATION** *(if necessary)* - Work carried out in this submittal or the regulations may also be subject to other laws governing professional services, such as the Illinois Professional Land Surveyor Act of 1989, the Professional Engineering Practice Act of 1989, the Professional Geologist Licensing Act, and the Structural Engineering Licensing Act of 1989. No one is relieved from compliance with these laws and the regulations adopted pursuant to these laws. All work that falls within the scope and definitions of these laws must be performed in compliance with them. The Illinois EPA may refer any discovered violation of these laws to the appropriate regulating authority.

Professional's Signature: _____ _____ Date:

Professional's Name: _____ Professional's Seal:

Professional's Address: _____

_____

_____

Professional's Phone No.: _____

7.3 **LABORATORY CERTIFICATION** *(if necessary)* - The sample collection, handling, preservation, preparation and analysis efforts for which this laboratory was responsible were carried out in accordance with procedures approved by Illinois EPA.

Name of Laboratory _____

_____
Signature of Laboratory Responsible Officer Date

Mailing Address of Laboratory

_____
Name and Title of Laboratory Responsible Officer

_____

_____

_____

JM:bjh\RCRA-CORRECTIVE-ACTION-CERTIFICATION-FORM.DOC

URS

June 10, 2011

Mr. Steven F. Nightingale, P.E.
Manager, Permit Section
Illinois Environmental Protection Agency
Bureau of Land
1021 North Grand Avenue East
Springfield, Illinois 62794

Subject: **Conceptual/Final Design Report**
Roxana, Illinois
119115002 – Madison County
Equilon Enterprises LLC d/b/a Shell Oil Products US
Log No. B-43-CA-16 and 18

Dear Mr. Nightingale:

On behalf of Shell Oil Products US, URS Corporation is submitting the enclosed Conceptual/Final Design Report for the soil vapor extraction (SVE) system at the WRB Refining LP Wood River Refinery and the Village of Roxana public works facility.

If you have any questions during your review, please contact Kevin Dyer, SOPUS project manager, at kevin.dyer@shell.com (618/288-7237), or me at bob_billman@urscorp.com (314/743-4108).

Sincerely,

Robert B. Billman
Senior Project Manager

Enclosures: RCRA Corrective Action Certification and Report (original plus 2 copies)

Cc: Jim Moore, IEPA
Kevin Dyer, SOPUS
Eric Petersen, ConocoPhillips

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St. Louis, MO 63110
Phone: 314.429.0100
Fax: 314.429.0462

REPORT

CONCEPTUAL/FINAL DESIGN REPORT

ROXANA, ILLINOIS

Prepared for

Shell Oil Products US
17 Junction Drive
PMB #399
Glen Carbon, IL 62034

June 2011

URS Corporation
1001 Highlands Plaza Drive West, Suite 300
St. Louis, MO 63110
314.429.0100
Project #21562593

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SECTION ONE Introduction

Shell Oil Products US (SOPUS) has been conducting subsurface investigations in the Village of Roxana in the area generally bounded by Illinois Route 111 and the west property boundary (a/k/a West Fenceline) of the WRB Refining LP Wood River Refinery (WRR) (**Figure 1**). Together these two areas are will be considered the Site for the purposes of this document. The purpose of this work is to develop an understanding of the extent of hydrocarbon impact in order to develop a mitigation plan.

In September 2010, SOPUS submitted a Vapor Intrusion Investigation Work Plan to the Illinois Environmental Protection Agency (IEPA), in which the installation of soil vapor extraction (SVE) system was originally proposed (SOPUS, 2010). In December 2010, SOPUS submitted a Pilot Test Work Plan to IEPA. The pilot test work plan was approved by IEPA on March 16, 2011 (IEPA, 2011) and in that letter, IEPA required the submittal of a conceptual/final design report within 90 days. This report was developed to meet that requirement and presents background information, remedial objectives, conceptual approach to meet the remedial objectives and the final design of the proposed SVE system. The format and content of the report follows the IEPA Guidance Regarding the Contents of a Basis for Design Report and the Final Design Report which were both provided in Attachment C of the IEPA Guidance for Preparing RCRA Closure Plans.

There are two primary investigation areas that are addressed by this plan, the first is associated with a benzene release which occurred on January 30, 1986 from an underground pipeline on the northwest corner of the intersection of Rand Avenue and Highway 111. The benzene release is situated in the extreme southwestern portion of the Village of Roxana ("Village") and across Highway 111 from Village of Roxana Public Works Yard (Public Works). The second investigation area is inside the WRR and along the West Fenceline. Separate from the benzene release, hydrocarbon impact and a Light Non-Aqueous Phase Liquid (LNAPL) plume has resulted from the historical petroleum refining activities at the plant. URS Corporation (URS), on behalf of SOPUS, performed an initial study in 2006 to help gather information on the extent of the benzene release and its impact. Since the 2006 investigation several investigations have followed and the resulting Conceptual Site Model (CSM) is detailed in Section 2 of this report.

In accordance with the March 16, 2011 letter, this report presents the conceptual and final design of a Soil Vapor Extraction (SVE) system and the information that was incorporated into the design is presented in the following organization.

- Section 2 summarizes the existing site conditions and the investigative history for the Site.
- Section 3 presents the remedial objectives for this proposed project.
- Sections 4 and Section 5 present the rationale for selecting the proposed technology (High Vacuum Extraction) and the design criteria which support the choice of technology.
- Section 6, 7, & 8 provides details of the design for the remediation system.
- Section 9 provides information regarding the permits required to construct and operate the remediation system.
- Section 10 provides the implementation scheduling and an outline of the project management procedures needed for construction initiation through close-out.
- Sections 11 & 12 provide the quality control and waste management procedures, respectively.
- Section 13 introduces the operation and maintenance plan (O&M Plan) which will be implemented.

The following design assumes that the extraction wells and piping will be located on WRR and Village property and the treatment system will be located on Conoco Phillips (COP) property. The access negotiations for the use of these two properties are underway.

Several investigations and sampling events consisting of the collection of vapor, soil, groundwater, and LNAPL samples have been conducted since 2006 and resulted in the current understanding of the existing site conditions.

The Village, shown in **Figure 1**, is located approximately 1.5 miles east of the Mississippi River within the American Bottoms floodplain. The surface topography across the floodplain generally slopes downward to the west-southwest, with a total drop in elevation of approximately 15 feet across the area. The regional geology consists of recent alluvial (i.e., river) deposits overlying Pleistocene (i.e., Ice Age) glacial outwash. The recent alluvial deposits consist of a complex, heterogeneous sequence of sands, silts, and clays. The underlying glacial outwash deposits consist of more uniform sands and gravels.

More specific to the site area, the subsurface conditions underlying the site generally consist of two primary strata, a layer of silty clay and the underlying sand layer. The clay layer is up to nine feet thick across the site while the sand layer extends to the bedrock, which typically exceeds 100 feet in depth. There are occasional interbedded silt or clay layers within the sand, but these do not appear to be laterally (or vertically) extensive.

The underlying sand layer is the primary source for large volume water production (e.g., industrial and municipal supply). This water bearing zone is known as the American Bottoms Aquifer. The water table for the aquifer generally begins at a depth of approximately 25 to 40 feet below ground surface (bgs) (approximately elevation 403 to 406). Therefore, there is generally a 15 to 30 foot thick vadose (unsaturated) zone in the sand. Groundwater is hydraulically connected with water in the Mississippi River, however, given the large distance from the river and nearby high-volume groundwater pumping (e.g., WRR, BP, etc.), the observed water level fluctuations due to river rise take longer to occur and the magnitude of the fluctuations are muted in comparison to observations made at locations further west. However, the groundwater elevations over the last two years have consistently increased to the point that during the 4th quarter 2010, they were up to eight feet higher than when routine gauging began in 2005.

Prior to development in the area, the natural movement of groundwater through the glacial outwash material was toward the west (toward the Mississippi River). Since development in the area, groundwater pumping has altered the regional groundwater flow in the area such that it now flows toward the nearby pumping centers at the WRR or BP.

As mentioned previously, the primary LNAPL plume is located further east in the refinery.

Petroleum vapors detected in the subsurface soil in the Village are primarily associated with the LNAPL plume beneath the WRR, and to a lesser extent, the dissolved phase impact beneath the eastern edge of the Village.

The 1986 benzene release occurred from a pipeline on the northwest corner of the intersection of Rand Avenue and Highway 111, near a commercial/industrial area immediately across the highway from the Roxana Public Works Yard. The groundwater flow direction, as a result of pumping the existing groundwater extraction wells as required by the RCRA Part B Permit, has caused any groundwater benzene impact to migrate toward the refinery pumping centers and is now primarily located near the Roxana Public Works Yard. The plume and vapors detected in the subsurface soil in the southern edge of the Village are associated with this release.

Figures 2 and **3** show the extent of vapor impact along the West Fenceline and within the Village.

SECTION THREE Remedial System Objectives

The primary objectives of the proposed remedial actions include the following:

1. Source remediation of the LNAPL (primarily BETX constituents) plume and the resulting vapors along the West Fenceline in the WRR.

2. Establishment of a pneumatic barrier to prevent vapors, which originate from the LNAPL plume within the WRR, from migrating into the Village.

3. Mitigate vapor intrusion issues in the Village, if they are identified.

There are multiple remedial technologies that are capable of achieving the objectives identified in Section 3. However, based on the experience that both SOPUS and URS have had using and pilot testing SVE systems in similar geology, SVE is analogous to a presumptive remedy. The following alternate technologies were compared to SVE.

4.1 REMEDIAL ALTERNATIVES

The primary remedial objectives listed in Section 3 are source control and vapor migration control. A brief discussion/evaluation of the various remedial technologies that may be applicable to this site but were not selected follow.

Air Sparging – Air sparging is most effective in treating dissolved phase impact in groundwater. While there is a dissolved phase plume associated with both the WRR and the Public Works area, the primary concern is vapor and LNAPL (at the refinery). If an air sparging system was installed, an SVE system would be required to remove the vapor generated from the sparge system. Therefore, the air sparging would likely be a dissolved phase remedial technology and, alone, would not meet the objectives of the system.

Free Phase LNAPL recovery – Free phase LNAPL recovery can be used to remove mass from the subsurface, however, some LNAPL will be left behind. In addition, this technology doesn't address vapors. As LNAPL is recovered, a small amount remains adhered to the soil particles and will not move to the extraction wells. This residual LNAPL will require additional remedial activities (technologies) to remove, should this be necessary. Therefore, due to the relatively large price for an active LNAPL recovery system, combined with the residual LNAPL that will be left after completion of the remediation, Free Phase LNAPL recovery was not deemed to be a preferable remedial technology.

Thermal treatment (either In-Situ Thermal Desorption (ISTD) or Electrical Resistivity Heating (ERH) – Both ISTD and ERH are capable of addressing the LNAPL and vapor issues on-site. However, both were deemed impractical for this site due to the high implementation costs, the relatively large number of heater wells that would be required, which is not practical due to the number of subsurface utilities in the area, and the potential to affect the utilities due to the heat generated. In addition, similar to air sparging, an SVE system would be necessary to remove the vapor generated from this treatment.

In-Situ Chemical Oxidation (ISCO) – Similar to thermal treatment, an ISCO treatment would require a significant number of injection or mixing points. This would likely be impractical due

to the large number of utilities in the area. In addition, ISCO would not provide any protection from vapors from continuing to enter the Village during the treatment.

4.2 SELECTED REMEDIAL TECHNOLOGY(S)

The selected remedy for this site is an SVE system. SOPUS has been involved with the operation of a large scale SVE system in Village of Hartford for approximately six years. This system has effectively treated both vapor and source material in Hartford, which has similar but less conducive geology. Over the six years that the system has been in operation, over 3.5 million pounds of hydrocarbons and 560,000 gallons of gasoline equivalent vapor has been removed from the subsurface as vapor and been treated. Based on extensive experience with operating the SVE system in Hartford, the success of that system, and more conducive geology in Roxana (no confining clay layers, large sand unit with at least 15-20 feet of open vadose zone) it was determined that the most appropriate remedial technology for this site is a similar SVE system.

The SVE system will reduce the potential for vapors to migrate into the Village from LNAPL and impacted soil and groundwater within the refinery, will be able to remediate source material along the fenceline, and will be able to remove impacted vapors from the eastern edge of the Village.

4.3 ESTIMATED REMEDIAL TIME

The remedial time frame is unknown. However, it is assumed that this system will operate for a number of years.

SECTION FIVE Data Evaluation

Prior to beginning the design process, SOPUS developed the CSM described above, which included the evaluation of vapor, soil, groundwater, and LNAPL data. This understanding of the site conditions was the basis for the determination that an SVE system is the most appropriate remedial technology.

The information required to design an SVE system includes system operation data (such as air flow, mass removal rates, and radius of influence) and mass distribution data (such as extent of LNAPL and nature of the LNAPL (residual LNAPL vs. recoverable LNAPL)). Due to the numerous investigations completed to date, the mass distribution was relatively well understood. Realistic estimates of the system operation data were able to be developed based on system operational information from the Hartford site and the mass distribution. However, more site specific data were necessary, therefore, to provide the data required to complete the design, SOPUS submitted a work plan for an SVE pilot test on December 30, 2010. There were two separate scopes of work:

1. SVE extraction to determine the radius of influence (well spacing), extraction rates and pressures for blower design, and vapor concentrations for treatment system design.
2. Data gap investigation to better define the extent of impact in proximity to the West Fenceline.

The pilot test was conducted from February 28, 2011 through March 24, 2011. A total 13 soil borings were advanced and logged; two were converted to SVE extraction wells and five were converted to vapor monitoring point (VMP) clusters. Soils samples were collected from the two SVE extraction wells and six soil borings. Following the installation of the SVE extraction wells and VMP clusters, the SVE extraction pilot tests were completed. The data obtained during the pilot test were adequate to fill the data gaps and provided the information required to complete the design.

SECTION SIX Final Design Procedures

This section details the procedures employed for preparing the remedial design of the SVE system. Previous sections have presented the background information leading up to this point in the process. Specifically, references and guidance associated with the application of SVE to the site are presented along with the procedures employed by URS to conceptualize, outline, plan, and present the system design. The conceptualization of the SVE system includes consideration of the data collected to date, the assumptions regarding the existing data or lack thereof, and the equations used to analyze the current conditions. The concept for the design is presented along with a review of the completeness of the data. Since the intent of the design of the SVE system is to remove contaminants from the subsurface, preliminary estimates of the ability of the design to achieve this objective are presented. Costs for the design, installation, and operation and maintenance of the system are included.

6.1 REFERENCES AND GUIDANCE

For this report various references were used to identify calculations as well as overall perspective as to the viability and operation of an SVE system at the WRR and Public Works property. The main references were the 1991 U.S. Environmental Protection Agency (EPA) *Soil Vapor Extraction Technology: Reference Handbook* and the 2006 U.S. EPA document *Off Gas Treatment Technology for Soil Vapor Extraction System: State of Practice*. These references were used as the basis for determining if an SVE system will be feasible for a site and it is the case for the WRR and the Public Works property. At this point the feasibility of an SVE system is then tested through a series of calculations. The majority of these calculations were presented in the Pilot Test Work Plan. These calculations were used to determine a projected radius of influence (ROI), an adequate pore volume removal of gases based on various flow rates, and mass removal rates per day. This information was then combined with information gained through the operation of the SVE system in Hartford to project the operation of an SVE system at the WRR and Public Works property.

The second step was to conduct the pilot test(s) and compare the actual data with the data generated from the calculations. Based on the demonstration of a 90 foot ROI at the public works, the viability of an SVE system was then justified and the final calculations were done to determine the operation parameters for the system. Most important was to size the actual well system and then determine the anticipated total flow rate. The blower and motor size were then determined which is then followed by friction loss calculations used to determine the optimal piping size to the various extraction points. The final point is to then take the analytical data from the influent vapor sample(s) and, based on the equipment specifications, determine what is

the most optimal method for treatment of the effluent from the system. The design is then completed based on this information.

6.2 DESIGN PROCESS

For this project, the design process includes 1) data collection and 2) conceptual design/final design. The data collection portion of the design process included drilling, soil sampling, and pilot testing. The newly obtained data was combined with data collected during previous field events for this site as well as data from nearby sites to provide a better understanding of the geologic and hydrogeologic setting of the area.

The conceptual design/final design process involves taking the data generated from the field activities and combining it with calculated data based on known equipment/piping parameters to complete the conceptual design.

6.3 DATA COLLECTION

6.3.1 Drilling and Soil Sampling Procedures

The CSM was updated with the stratigraphic and analytical data collected from the soil borings completed during the pilot test. The soil samples collected enhanced the understanding of the vertical distribution of the soil impacts as well as provided additional details on the physical properties of these soils.

Grab soil samples were collected from the borings for SVE-1 and SVE-2. These samples were submitted for analyses to URS' Overland Park, Kansas laboratory. The test type and method for each was as follows:

- Soil Classification (Unified Soil Classification System)
- Grain Size (ASTM Method D422)

These tests provided information into understanding of the physical characteristics of the soil in the vadose zone which allowed for an understanding of the air flow and contaminant transport in the subsurface. The grain size curves for these samples indicate the majority of the samples contain greater than 90% sand size particles. The bulk of this percentage is fine grained sand. The curves are provided as **Appendix A**.

6.3.2 Analytical and Physical Characteristics of the Vadose Zone Soils

It is anticipated that a portion of the petroleum impact within the subsurface has been submerged by the high water conditions described in Section 2, and will be exposed when the water table falls to previous elevations. Exposing this submerged impact will allow the SVE system to remove the higher concentration impacts meaning that more contaminant mass will be removed during these periods.

The predominant soil types encountered in the data gap borings indicated a surficial soil consisting of clayey silt (ML) to clayey silty sand (SM) to a depth ranging between 5 and 11 feet. The surficial soil is underlain by fine grained, poorly graded sand (SP).

6.3.3 Soil Vapor Extraction (SVE) Pilot Test Procedures

As discussed above, an extract test was planned on the two SVE extraction wells (SVE-1 at the WRR property and SVE-2 at the Village of Roxana Public Works Yard). One, 4-inch diameter, vapor extraction test well was installed to conduct the test at each location.

Vapor monitoring points were either already present or were installed at distances of 30, 60, and 90 feet from each extraction well. Four separate vapor monitoring points were installed at each location. The newly installed VMPs were constructed of 0.5-inch Schedule 40 PVC with a one foot screen. The screened intervals were located at depths of approximately 10, 20, 30 and 40 feet bgs at each VMP location. A filter pack was tremmied downward to a depth from 1 foot below each screen to 1 foot above each screen. The screened sections were segregated from one another by hydrated bentonite pellets.

The SVE testing phase involved applying a vacuum to each of the SVE wells during a series of separate SVE tests. The first test was conducted at SVE-2 (the Public Works Yard),which was followed by the test at SVE-1 (the WRR property). The following equipment was used to conduct the SVE test.

- Internal combustion engine (ICE) system capable of approximately 100 cubic feet per minute (cfm), 100-inches water column vacuum, and vapor treatment. A silencer/muffler due to the nearby residential neighborhood. Propane was used as a supplemental fuel to avoid shutdowns during testing.
- Treatment system with an inlet temperature gauge and flow meter (between knockout and blower) with sample port on discharge.
- Knockout tank with demister.

- Inlet and outlet relief valves.

An estimated airflow rate of 50 cubic feet per minute (cfm) was required to remove two pore volumes of air vapor from the subsurface within the area tested. It was assumed that if two pore volumes of air vapor can be removed then sufficient contaminant mass can be removed from the subsurface for the SVE system to be feasible. This is assuming a 60 foot radius of influence, 20 foot screened area with a porosity of 15% in the sand. The tests were to be operated at three separate flow rates of 50, 75, and 90 cfm to determine the most efficient operating range that will meet the objectives for the full scale system. The initial test was to be conducted at a flow rate of 50 cfm. During these tests the vapor temperature and pressure (vacuum) were monitored at the vapor extraction well and each VMP. Readings were recorded at approximately 2, 5, 10, and 15 minutes and every 15 minutes until the readings from the extraction well stabilize (within 5 percent of previous for three consecutive readings). After the test stabilized, the readings were collected once an hour until the end of the test. Prior to shutting down the system, an additional Tedlar bag was collected from the extraction well to determine field VOC measurements. Vacuum measurements were also obtained at outlying VMP wells. The measurements were obtained using a magnahelic gauge.

Following the tests at these air flow rates, the system was operated for three days at the maximum flow rate attainable (ranged up to 65 cfm). This test was done to determine the sustainability of the treatment of the vadose zone at the selected flow rate for the SVE system. A summa canister was collected from the intake to the ICE during this period and analyzed for VOCs via USEPA method TO-15.

A detailed discussion of the pilot tests is provided in the Pilot Test Report (currently being finalized).

6.3.4 SOIL VAPOR EXTRACTION (SVE) PILOT TEST DATA

6.3.4.1 Village of Roxana Public Works SVE Test Data

SVE extraction well SVE-2 is in the Village of Roxana Public Works Yard in the vicinity of VMP-10. SVE-2 is screened from 12 to 45 feet bgs. The three observation wells or vapor monitoring points utilized for this SVE test were designated VMP-29 (30 feet), VMP-10 (60 feet) and VMP-30 (90 feet).

At the time of the SVE testing, the depth to water was approximately 33 feet bgs.

The first test was attempted at a flow 50 cfm with an applied vacuum of 6 to 8 inches water column (WC). The ICE system shut down twice after a period of approximately 1 hour each time due to high VOC concentrations of 200,000 parts per million (ppm) (as measured with a PID). The ICE system shut off when the temperature reached 1,400 degrees Fahrenheit. The tests were stopped and a decision was made to decrease the flow rate for the following day to determine if the ICE system can operate at a lower flow rate with the high concentrations.

The test on the second day started with a flow rate of approximately 25 cfm and a vacuum of 6 to 8 inches WC. The vapor concentrations before treatment and discharge ranged between 10,000 ppm and peaked at 104,100 ppm but the ICE unit operated for the entire day. A summary of the applied vacuums and flow rates from SVE- 2 and the vacuums from the vapor monitoring locations during the second day of the SVE test are presented in the following table.

SVE-2 Applied Vacuum vs. Flow Rate (18 to 27 cfm)

Radius from SVE-2 (Feet)	Time (hours)	Applied Vacuum at Blower (inches WC)	Flow Rate, (scfm)	Vacuum		
				@ 11' bgs	@ 19' bgs	@ 27' bgs
30	1	2.15	20	0.5	0.2	0.22
	3	6.45	18	0.5	0.6	0.29
	6	8.6	NA	0.23	0.6	0.28
	7	8.6	27	0.255	0.6	0.3
60	1	2.15	20	0	0.4	0.1
	3	6.45	18	0	0.6	0.17
	6	8.6	NA	0	0.25	0.14
	7	8.6	27	0	0.28	0.16
90	1	2.15	20	0.035	0.04	submerged
	3	6.45	18	0.13	0.145	submerged
	6	8.6	NA	0.09	0.095	submerged
	7	8.6	27	0.14	0.15	submerged

Note: Yellow shading indicates vacuum reading exceeds the 0.1 inches WC to define Radius of Influence

In accordance with the definition of radius of influence (ROI) provided by IEPA in their March 16, 2011 letter, the ROI for an extraction well is defined by vacuum measurement, which exceeds 0.1 inches WC. The vacuum measurements collected during the 18 to 27 cfm test indicated that the ROI extends to at least 90 feet for SVE-2.

The test on the third day started out at a lower flow rate and was increased after the measurements stabilized. The flow rate began at approximately 40 cfm and a vacuum of 6 inches WC. After stabilizing the flow was increased to approximately 50 cfm. The vapor concentrations before treatment and discharge ranged between 10,000 ppm and peaked at 104,100 ppm but ran for the entire day.

A summary of the applied vacuums and flow rates from SVE- 2 and the vacuum at the vapor monitoring locations during the third day of the test are presented in the following table.

SVE-2 Applied Vacuum Vs Flow Rate (40 to 50 cfm)

Radius from SVE-2	Time (hours)	Applied Vacuum at Blower (inches WC)	Flow Rate, (scfm)	Vacuum		
				@ 11' bgs	@ 19' bgs	@ 27' bgs
30	1	6	42	0.42	0.4	0.44
	3	6	40	0..39	0.35	0.38
	6	7.4	50	0.464	0.4	0.45
	9	7.8	49	0.493	0.41	0.47
60	1	6	40	0	0.18	0.2
	3	6	40	0	0.16	0.16
	6	7.4	50	0	0.19	0.19
	7	7.8	49	0	0.22	0.22
90	1	6	40	0.15	0.155	submerged
	3	6	40	0.1	0.0875	submerged
	6	7.4	50	0.08	0.065	submerged
	7	7.8	49	0.12	0.11	submerged

Note: Yellow shading indicates vacuum reading exceeds the 0.1 inches WC to define Radius of Influence

The vacuum measurements collected during the 40 to 50 cfm test indicated that the ROI extends to at least 90 feet for SVE-2.

The test on the fourth day also was the start of the three day SVE test. The test was to be operated at a flow of between 60 and 70 cfm if the ICE unit was able to operate at that level with the benzene concentrations that were encountered in the vadose zone. It should be noted that this attempt was based on the assumption that the initial three days of removal of vapors from the vadose zone had depleted the highest benzene concentrations and that the system should be able to operate without overheating. The test began and the ICE flow rate continued to climb until it reached a range between 52 and 55 cfm. The ICE unit would not open the internal valve to the SVE unit any further and operated at the flow rate until approximately 13 hours into the test.

At this point the flow rate began to climb slowly upwards until approximately 24 hours into the test where it reached a flow rate of 64 cfm. The flow rate remained at 63 to 64 cfm for another 24 hours when on the morning of the second day it reached the peak of 65 cfm. The ICE unit maintained a flow rate of 64 to 65 cfm for the remainder of the test.

The vacuum at SVE-2 for this test began at approximately 5.4 inches WC and rose 8.3 inches WC at 2 hours into the test. The vacuum fluctuated between 7.5 and the peak of 11.2 inches WC until36 hours, when it stabilized and remained between 10.5 and 11.1 inches WC for the remainder of the test. A summary of the applied vacuums and flow rates from SVE-2 and the vacuum measurements at the vapor monitoring locations during the three day test are presented in the following table.

SVE-2 Applied Vacuum Versus Flow Rate of 52 to 65 cfm for 30 feet Radius						
	Time (hours)	Applied Vacuum at Blower (inches WC)	Flow Rate, (scfm)	Vacuum		
				@ 11' bgs	@ 19' bgs	@ 27' bgs
30	1	7.8	52	0.464	0.5	0.49
	23	10.5	64	0.674	0.6	0.64
	47	11.1	65	0.733	0.7	0.8
	70	11.1	64	0.725	0.7	0.8
60	1	7.8	52	0	0.19	0.2
	23	10.5	64	0	0.26	0.3
	47	11.1	65	0	0.26	0.3
	70	11.1	64	0	0.25	0.29
90	1	7.8	52	0.13	0.105	submerged
	23	10.5	64	0.3	0.25	submerged
	47	11.1	65	0.2	0.2	submerged
	70	11.1	64	0.2	0.2	submerged

Note: Yellow shading indicates vacuum reading exceeds the 0.1 inches WC to define Radius of Influence

The vacuum measurements collected during the 52 to 65 cfm test indicated that the ROI extends to at least 90 feet for SVE-2.

The internal ICE PID measured concentrations between 4,000 and 14,000 ppmv for the duration of the test. One field vapor sample from SVE- 2 was collected using a Summa Canister and submitted for laboratory analysis during the three day pilot test. The results were 3,700 ppbv for benzene.

6.3.4.2 Village of Roxana Public Works Unsaturated Zone Characteristics

The pilot test data indicate that the site is suitable for soil vapor extraction. As previously noted the unsaturated soils consist primarily of a surficial soil of clayey silt (ML) to clayey silty sand (SM) to a depth ranging between 5 and 11 feet. The surficial soil is underlain by fine grained, poorly graded sand (SP). The soil maintains a fine to a fine to medium grain SP lithology to a

depth greater than 100 feet bgs according to a boring south of the treatment area. As previously noted the grain size curves for soil samples from SVE-2 indicate the majority of the samples contain greater than 90% sand size particles with many samples having a percentage exceeding 98%. The bulk of this percentage is fine grained with some medium grained. The uniformity of the grain size, especially within the sand fraction, indicates a higher porosity and permeability which indicates more air flow. This was verified by an ROI of 90 feet during all three SVE pilot tests.

It was further substantiated by the rapid drop in soil vapor concentrations once the air flow rate was established. It was assumed that there would be high concentrations to start because the subsurface has been under ambient conditions without a catalyst to cause air movement and removal of vapors from the vadose zone. The levels went from greater than 200,000 ppm on the first day when the system was operated for a total period 2 hours to a range of 4,000 to 14,000 ppm during a three day sustained test. The evacuation of the extremely high concentrations was almost immediate indicating excellent air flow in the vadose zone and recovery through the extraction well.

Test data indicates that any benzene impacts to the site groundwater will decrease due to the SVE system. This is due to partitioning of the contaminants from the liquid phase to the gas phase. This transition is caused by the vacuum being exhibited to the pore spaces in the sand. As the SVE system removed the impacted vapors from the pore spaces in the vadose zone above the water table, the void left open will be filled by more vapors caused by volatilization of the liquid phase. These steps will be continuously repeated causing an overall decrease in the impact to the subsurface in the Public Works area.

6.3.4.3 Wood River Refinery SVE Test Data

Test well SVE-1 was located on the WRR near AST #27 and within 175 feet and 75 feet of W-85 and VMP-4 respectively. SVE-1 is screened from 12 to 55 feet bgs. The three observation wells or vapor monitoring points utilized for this SVE test were designated VMP-26 (30 feet), VMP-27 (60 feet) and VMP-28 (90 feet).

At the time of the first attempt at an SVE testing, the depth to water was approximately 40 feet bgs.

The first test was attempted to be run at a flow 50 cfm. The vapor concentrations before treatment and discharge to the ICE started at 200,000 and peaked at 400,000 ppm. These concentrations allowed the ICE unit to only operate at a flow rate of 5 to 10 cfm. Attempts were

made to measure vacuum at the VMPs, however, none of the measurements showed a vacuum, they all showed positive pressure. This indicated that this low flow rate was not sufficient to produce a vacuum at these chosen monitoring points. The vacuum level at the extraction well was 15 to 20 inches WC.

Attempts were also made at two other wells within the refinery property. These attempts resulted in a similar response in that insufficient flow was able to be generated in order to make measurements at the selected monitoring points and/or the well screen became occluded with groundwater.

The pilot tests using the ICE unit were then discontinued in the refinery area because sufficient data had already been collected to move forward with the final design.

6.3.4.4 WRR Unsaturated Zone Characteristics

As with the Public Works area, the unsaturated soils consist primarily of a surficial soil consisting of clayey silt (ML) to clayey, silty sand (SM) to a depth ranging between 5 and 11 feet. The surficial soil is underlain by fine grained, poorly graded sand (SP) . The soil maintains a fine to a fine to medium grain SP lithology to a depth greater than 100 feet bgs according to a boring (MW-6D) south of the treatment area. As previously noted, the grain size curves for soil samples from SVE-1 indicate the majority of the samples contain greater than 90% sand size particles with many samples having a percentage exceeding 98%. The bulk of this percentage is fine grained with some medium grained. The uniformity of the grain size, especially within the sand fraction, indicates a higher porosity and permeability which indicates more air flow. For the purposes of this design plan, the findings in the Public Works area will also be used for the refinery with the exception that the ROI will be assumed to be 60 feet. It is believed that this ROI can be maintained using a thermal oxidizer as the off gas treatment method for the high concentrations that are expected in this area. However, it is possible based on the results of the pilot test at Public Works and similar geology that the ROI could reach 90 feet or more.

Based on URS' professional experience with SVE systems at other sites across the nation in similar geological formations, any LNAPL as well as petroleum impacts to the site groundwater will decrease due to the SVE system. This is due to partitioning of the contaminants from the liquid phase to the gas phase. This transition is caused by the vacuum being exhibited to the pore spaces in the sand. As the SVE system removes the impacted vapors from the pore spaces in the vadose zone, the void left open will be filled by more vapors caused by volatilization of the liquid phase. These steps will be continuously causing an overall decrease in the LNAPL as

well as the concentrations of the petroleum constituents found in the impacted groundwater in the treatment area.

6.3.5 Summary of Design Parameters Based on Data Collection

The data collection portion of the design process has indicated that the following parameters exist for this particular site:

- The depth to the water table is currently at a depth of approximately 30 to 40 feet bgs over both areas.
- Historical groundwater elevations indicate that the elevation of the groundwater table may decline to a depth between 45 and 55 feet bgs.
- The soils present in the vadose zone beneath the surficial silts to sandy silts consist of poorly graded sands which increase in grain size with depth.
- The soil is relatively homogeneous in the areas that were investigated.
- LNAPL is present in a portion of the refinery wells.
- The optimum flow and vacuum for an SVE system based on current conditions at the Public Works Yard are between 50 and 65 cfm with the vacuum being 10 to 11 inches WC.
- The ROI, based on the optimum flow and vacuum, for the Public Works Yard is 90 feet.
- The concentrations of the vapors removed were extremely high for both areas which indicated that a thermal oxidation unit is necessary to remediate the off gas from the SVE system.

A schematic showing the SVE extraction wells and associated ROI and the mass distribution is provided on **Figure 5.**

6.4 CONCEPTUAL DESIGN/FINAL DESIGN

The data generated from the field work was then used in the office to do the actual design of the SVE system. The field data was compared to what the objectives are for the system and the calculations were done to see if an SVE system will be feasible to attain those goals. As expected, the pilot tests indicated that, considering the soil type and the physical characteristics of the contaminants of concern, SVE would be a feasible method for use at the Site.

This information was based on calculations that were included in the pilot test work plan and were verified with the data generated by the actual pilot tests. The next step was sizing the equipment assuming a ROI of 60 feet in the refinery and 90 feet in the Public Works area. The system was designed based on an assumed flow rate of 60 cfm per well with a vacuum between 10 and 20 inches WC. This information is then used to calculate the pressure loss due to friction of the air movement through the SVE system. The pipe size was determined to be 4-inches in diameter, which will allow for minimal pressure loss and more efficient remediation. The calculations for pressure loss to each leg are as follows:

Length of Carbon Steel Pipe (feet)	Pressure (PSI)/Vacuum (inches WC) at the Blower	Pressure (PSI)/Vacuum (inches WC) at the end of the Pipe Run	Pressure (PSI)/Vacuum (inches WC) Drop Over the Length of the Pipe
2,250	0.72/20	0.579/16	0.141/4
1,700	0.72/20	0.613/17	0.107/3
1,350	0.72/20	0.634/17.6	0.086/2.4
1,000	0.72/20	0.655/18.1	0.065/1.9
500	0.72/20	0.685/19	0.035/1
350	0.72/20	0.694/19.2	0.026/0.8

The pressure loss calculations are presented as **Appendix B**.

It was also determined, based on current and potential deeper depths to the top of the water table, that the bottom of the screen will be at or near the deepest recorded depth of the water table. The top of the screen will be approximately 15 feet bgs in the refinery and 20 feet bgs at the public works.

The final design parameters are:

- The horizontal extent of the area to be treated extends from Second to Eighth Street along the west fence line and the entire Public Works property.
- The vertical extent is the vadose zone above the current and expected future water table elevations.

- The greatest distance for piping could exceed 2,000 feet with the remediation equipment housed in a newly fabricated building on either COP property or Public Works property. Access is being negotiated with both parties.
- The SVE equipment necessary to handle a 24 well extraction system with an assumed flow of 60 cfm per well and a total flow of 1,320 cfm is a Sutorbilt blower with a 15 horsepower motor.
- The system will be split into 7 legs with sample ports, flow meters and ball valves on each leg.
- The soil vapor from the Public Works area will be handled through a separate vapor/moisture separator from the recovered vapors from the refinery because the condensate that forms from the Public Works wells will be considered as containing a listed hazardous waste (U019) due to the nature of the benzene release that impacted this area. This will also include the waste handling system beyond the separators.
- The COP construction requirements will be followed for relevant aspects of construction within the WRR.
- Heat trace and insulation will be needed for all above ground SVE lines so that condensate will not freeze.
- The piping at least in WRR will be mostly carbon steel. PVC piping may be used in some locations where practical and allowable.
- The power requirement for the all the equipment is 3 phase, 480 volts with two transformers set for the building.

This information was then combined and the sheets of the layout of the system were developed. The system design is discussed in Section 7, with additional details included in **Appendix C**.

6.5 SITE SAFETY AND SECURITY PROVISIONS

The site safety will be governed by the URS Health & Safety Plan and the applicable COP and SOPUS health & safety procedures and facility requirements. The overall security for the equipment will be the fence lines that surround each of the areas. Secondary security for the treatment system and associated equipment will be a locked building. The secondary security for the equipment associated with each extraction well will be lockable well vaults at each location.

The keys for the fence at public works plus all secondary security will be maintained by the URS field team. The primary security at the refinery is the facility guard gates.

6.6 PRELIMINARY COST ESTIMATE

In accordance with the Guidance Regarding the Contents of a Basis for Design Report, a detailed cost estimate, to construct the proposed SVE system described in this report is presented below.

ACTIVITY	COST
SVE System Installation	
URS Labor	$ 180,000
Mobilization/Demobilization	$ 15,400
Site Prep	$ 8,300
QA/QC	$ 24,500
Carbon Steel Piping	$ 693,400
PVC Piping	$ 13,200
Excavation and Backfill	$ 45,400
Air Knifing	$ 70,000
Concrete	$ 32,900
Asphalt	$ 13,300
Well Tie-In	$ 40,000
Drilling	$ 184,000
SVE Manifold	$ 10,000
RTO	$ 350,000
Blower/VLS System	$ 46,500
Building	$ 100,000
Telemetry/Controls	$ 15,000
Misc. Equipment	$ 10,000
Laboratory	$ 2,000
GRAND TOTAL	**$ 1,853,900**

The SVE system will utilize 24 extraction wells; SVE-3 through SVE-26 installed to depths ranging from 45 to 55 feet bgs (the approximate depth of the deepest recorded water level). Each of wells will be constructed of 4-inch diameter PVC with slotted PVC well screen extending from approximately 10 feet bgs to the total depth of the boring. Care will be taken to set and construct these wells so that there will not be collapse of the alluvial sand into the annular space around the well screen.

Each extraction well will be connected to the header line by a 4-inch inside diameter (ID) carbon steel pipe. A total of seven header lines (5 from the refinery and 2 from Public Works) will extend to the remediation building (building) on either COP property or Public Works. The SVE lines will be installed partly below grade for SVE-5 and above grade from wells SVE-6 through SVE-19 on the refinery property, and all below grade for the wells on Public Works property (SVE-20 through SVE-26). All the refinery piping will go below ground if and where it exits the WRR property and enters the Public Works property. All the above ground SVE lines will be protected from freezing with heat trace tape and insulation.

Each SVE well will be equipped to produce up to 65 cfm at a vacuum of 10 to 20 inches WC, however, specific air flow rates at the each well or header line can be adjusted to allow for more air flow to occur from a well or header line that exhibits higher concentrations.

The SVE effluent contaminant levels and odor will need to be controlled to meet discharge limits imposed by IEPA. Recovered vapors will be treated prior to being discharged to the atmosphere in accordance with the Federally Enforceable State Operating Permit (FESOP). The FESOP application for this system is provided in **Appendix D.**

Prior to entering the thermal oxidation unit, the vapor will go through one of two knockout tanks to separate the condensate from the vapor. The water collected in these tanks will be transferred (via submersible transfer pumps) to one of two 500 above ground storage tanks (ASTs). Details of this portion of the system are discussed in greater detail later in this plan.

Two new power pole mounted transformers and a telephone box will be installed on the southeast corner of the Public Works property.

The SVE system will be operated continuously 24 hours a day 7 days a week and due to the location, particular care will be taken to reduce the potential effects of this system (noise and odor) on residents, patrons, and workers in the area.

7.1 SVE SYSTEM INSTALLATION

The 24 SVE extraction wells will be installed at the locations shown in **Drawing C102** – Proposed SVE System (**Appendix C**). Each well will be constructed with a PVC screen with a slot size of 0.010-inches. A sand pack consisting of 10-20 sand or equivalent will extend from the bottom of the borehole upward to a depth of approximately 2 feet above the top of the screen. The sand pack will be covered with a bentonite pellet seal. The seal will three feet thick and will be placed in 6-inch lifts and hydrated with water prior to the placement of any concrete. A cement/bentonite grout will be tremmied into the augers above the seal. The grout will be mixed at a ratio that corresponds to a minimum of 20 % solids by weight. The well casing and screen will be new materials with flush threads. See **Drawing C201** – SVE Well Detail and Pipe Layout (**Appendix C**) for well construction details.

The wells shall not be developed for a minimum of 48 hours after grouting after which the wells shall be developed by pumping and surging until the water from the well is free of fine sand, silt or other fine particles. It is anticipated that well development will include the removal of groundwater equal to 5-10 well volumes. Water developed from the wells shall be containerized and disposed off-site in a manner which meets city, county, state and federal requirements.

Individual 4-inch ID carbon steel pipe will be installed from each of the SVE wells. The carbon steel piping will meet the COP specifications in relation to which schedule of piping; welding connections, and any ASTM standards that are required to be followed during installation. It should be noted that all piping will be pressure tested prior to installing the heat trace tape and insulation. There will be a total of seven separate lines from the 24 SVE wells. The piping runs as they pertain to specific wells is as follows:

Run Number	SVE Wells	Color Designation
1	SVE-5 through SVE-7	Red
2	SVE-8 through SVE-10	Blue
3	SVE -11 through SVE -13	Yellow
4	SVE-14 through SVE-16	Green
5	SVE-17 through SVE-19	Black
6	SVE-20 through SVE-23	Orange
7	SVE-24, SVE-26 & SVE-27	White

SVE wells connected to the system will require piping attached to the well in such a manner as to allow the piping to drain toward the well. Survey documentation will be required as to the pitch of the lines. At a minimum, two points at each end of each leg of the system will be surveyed. Pipe runs greater than 50 feet in length will have an additional survey point in the approximate middle third of the piping run. A piping map including a profile for all piping and slope verification will be provided as part of the as-built drawings for the site.

The piping will all be above grade and be secured to concrete sleepers located every 25 feet. A steel I-beam will be attached to a concrete base. The SVE piping will be attached to the I-beam using steel anchors with a pipe shoe between them to reduce the potential for corrosion of the pipe. The design and construction of each sleeper will meet COP specifications. A view of a typical sleeper is presented in the plan set as **Drawing No. C201** (**Appendix C**). The horizontal piping will extend as necessary to the building located on the Public Works Yard property. All connections will be water tight to minimize the chance for freezing in cold weather. A discussion of the SVE system within the remediation building is provided in later sections of this plan.

7.2 ELECTRICAL WORK

The power supply shall be a 3 phase, 480-volt supply with a minimum 250-amp service. The Vendor shall supply a fused service box and manual shut-off. The equipment will be placed on a new power pole that will be installed on the Site. The Vendor must have a licensed electrician certify that the remedial system, including the control panel has been constructed according to the National Electric Code (NEC) or Underwriter's Laboratory (UL) guidelines. A signed electrical inspection sheet by a licensed electrician will be submitted with the "As Built" drawings.

All electrical work shall meet the current NEC and shall comply with all city, county, state, federal and utility company requirements. All conduits exposed to the weather shall be galvanized, steel conduit. All equipment shall be grounded as required by NEC and utility company requirements. Three feet of clean space for standing and working will be provided in front of all panels.

The Vendor shall verify the service needed and prepare costs to perform the work in accordance with the actual conditions at the site. The expected electrical improvements are shown on **Drawing E101** (**Appendix C**).

The control system provided will include electrical controls for the SVE blower and all associated controls. The panel will be mounted on the exterior of the remediation building and will be locked to prevent unauthorized access. Keys to all locks at the remediation system will be provided to URS for SOPUS.

The panel shall be as shown on **Drawing E105 (Appendix C)** with a rating of NEMA 4 or better for external mounting. The control system will be designed for operation on 480 volt, 3 phase, 4-wire incoming electric service. It will be designed to provide control for the 15 horsepower SVE blower, heat trace tapes and all control pilot alarms and interlocks to include a power distribution block, motor starters with overload relays, an overload reset, a hand/off/auto switch, a red alarm light, an hour meter, one alarm reset, one level control, relay timer and other equipment. All electrical fuses and switches will be selected for a minimum 10-year life under a 24-hour a day, seven day a week use.

The panel shall include a Wireless Remote Access System, autodialer with phone line surge suppression for monitoring the system and calling in the event of alarm conditions. The system shall include twenty digital contact inputs and battery backup in case of power failure.

7.3 EQUIPMENT

7.3.1 Building

A new building will be fabricated to allow for safe operation of the treatment system. The design and construction of the building will meet COP specifications if the building is completed on COP property. Initially, the SVE lines will be installed below the floor elevation. After installation of the lines, the area will be covered with crushed rock to 6-inches and then a 6-inch thick layer of 3,000 psi concrete for a slab. The compaction of all backfill material will be tested in accordance with the specifications in **Appendix C**. The Vendor will need to make sure that all backfilling methods will assure that there will not be subsidence of the backfill material that will cause cracking or deformation of the asphalt drives or concrete floor of the building.

The building will be fitted with Class 1, Division 2 components including intrinsically safe lights and power ventilation units capable of dissipating heat generated by the blower. The heater and ventilation fans shall each be thermostatically controlled. Vents shall be placed on a different wall than the ventilation fans. The main electrical panel shall have a service disconnect for main power and breakers for the light, heater, fan, and control panel.

Ventilation for the building will include the equipment identified on **Drawing C103 (Appendix C)**. The shutters should each be covered by a 14 gauge steel sound cover sized to cover the outside opening. The covers shall have an enamel finish inside and out of all components, 1 inch thick polyurethane foam sound insulation on walls and ceiling of the cover and must extend a minimum of six inches out from the outer wall. The covers will be open on the bottom and have a one-inch flanged lip for mounting to the outside of the building.

The building has large overhead doors with no center post. The doors will be capable of opening wide for the installation or removal of equipment. The SVE unit will be installed per Class I, Division 2 Hazardous Location requirements.

The electrical controls will be mounted on the building exterior. Provisions shall be made for all inlet and outlet lines for the SVE system. Care shall be exercised to assure the structural integrity of the building through installation and use of all equipment. Care shall be taken to secure the discharge stack for the SVE system. All equipment shall be secured from tampering by vandals.

A convenience outlet with a Ground Fault Circuit Interrupter will be installed at the remediation building.

The PVC pipe and fittings for the SVE manifold will be 2 inch Schedule 40 PVC. The piping and fittings from the manifold and throughout the majority of the remainder of the trailer used for the SVE system is 2 inch Schedule 40 PVC. The fittings and piping for the waste water handling part of the SVE system will be 1-inch, Schedule 80 including the line leading to the knockout tanks. The piping and fittings from the discharge point on the blower will be 3 inch carbon steel.

The SVE unit shall be installed per Class I, Division 2 Hazardous Location requirements. Within a five foot radius of any exhaust opening shall be wired per Class I, Division 2, Group D area.

7.3.2 SVE System

The SVE system will be installed in the building. Off-gas treatment will be a thermal oxidation unit. The SVE blower location and equipment drawings are shown in **Drawing C103** – SVE Building Layout (**Appendix C**). The piping and instrumentation diagram for the SVE system is shown in **Drawing P101** – SVE Process & Instrumentation Diagram (**Appendix C**).

The SVE blower shall be as presented on the attached drawings or equivalent. The blower is sized to supply a minimum of 2,370 standard cubic feet per minute (scfm) at a vacuum of 10 to 20 inches WC. The motor will be a 15 horsepower, 230 volt, and three-phase explosion proof motor integrally mounted with the blower.

The unit will include two 140 gallon knockout tanks or equivalent. There will be one knockout tank for the WRR portion because it is a BTEX plume and one for the Public Works property because it is a benzene plume and the water these waste streams are managed separately. A high level float switch will be provided on each knockout tank to shut down the SVE system if one of the knockout tanks is full. The transfer pumps leading from each knockout tank will be the type of pump specified on the attached sheets or equivalent. The pump will move the fluids collected in the knockout tanks to two 500 gallon ASTs. There will be an AST for each knockout tank and the AST will have secondary containment. There will be a discharge point for each AST.

The SVE system shall have a manual fresh air dilution valve with an inlet silencer mounted before the moisture separator tank. The inlet silencer will be a Solberg Model CSL 335P-400 inlet filter/silencer or equivalent. The Vendor shall ground the moisture separation tank during installation at the site. The Vendor shall warrant all equipment for proper operation for 24 months after start up.

The SVE unit will include an automatic vacuum relief valve installed at the blower inlet or on the separator tank, which is adjustable from 0 to 88 inches of water. The type of valve is presented on the attached drawings or equivalent. Vacuum gauges shall be included before the filter and between water knockout and the filter and between the filter and the blower. The gauges will display vacuum readings in inches of water with a range of 0 to 60 inches of water. An inline filer with polyester element shall be provided. A spare filter will be provided with the system when delivered to the site. The filter will not be integrally mounted in the tank. The specified types of gauges and filters are presented on the sheets or an equivalent.

The system will be equipped on the discharge line with a temperature gauge capable of reading from 50 to 500 degrees Fahrenheit.

The Vendor shall provide a manifold pipe system to allow the blower to pull air from seven separate SVE legs and a manual dilution line. Each line shall contain an outlet or valve for obtaining air samples and vacuum readings, a two-inch PVC ball valve and a flow meter. Each flow meter will be installed with appropriate straight pipe at the inlet and outlet. The flow meters shall be a 2 inch rotometer with a range of 40-240 scfm. A sampling tap and valve shall be installed on the pipe manifold to the blower and on the discharge line from the blower.

The off gas treatment system will be connected to the blower by way of the discharge line. The initial treatment system will be a regenerative thermal oxidation (RTO) unit with a 30 to 35 foot stack. The type of RTO is presented on the attached sheets. An equivalent model may be chosen but will need approval of the design team. The stack will need to be anchored to the building to within the anticipated maximum sustained winds for Roxana, Illinois. A rain cap shall be installed on the discharge stack. The rain cap shall not direct the air flow down to the ground. As the SVE system progresses and remediates this zone, a different off gas treatment technology may be appropriate, in which case, we would incorporate that technology.

An operation and Maintenance Manual shall be provided for the system. A copy of the manual shall be left at the site and shall be secured in a weather-protected area.

SECTION EIGHT Deviation From Conceptual Design

This report is a combined Conceptual Design (also known as Basis for Design) and Final Design Report, therefore, there is not an approved Conceptual Design to compare to. However, a conceptual approach to the remedial system was presented in the Pilot Test Work Plan submitted to IEPA on December 30, 2010 (URS 2010). This section will provide a brief description of the changes to the conceptual approach since submittal of that work plan.

There are two primary changes/adjustments to the conceptual approach.

1. The width of the treatment area is not a controlling factor.
2. Skimmers are not planned to be installed in this system. Any necessary active LNAPL recovery will be addressed by a separate system.

The original approach assumed a treatment area width of at least three times the depth to water, such that if operation of the SVE system is discontinued, vapors from the remaining LNAPL and groundwater will naturally degrade prior to impacting the Village. This overall objective remains unchanged, however, it is anticipated that the design radius of influence coupled with the required inward groundwater gradient and LNAPL extraction moving the source material into the central portion of the WRR will allow the remaining impacted vapors to natural degrade and preclude them from migrating into the Village once the system operation is discontinued.

The conceptual approach presented in the pilot test work plan indicated that a skimmer system will be installed in wells in which there is sufficient LNAPL to support such a system. Free phase LNAPL recovery will be evaluated and any active recovery system will be handled outside of this system.

SECTION NINE Permitting

The following permits will be required for the construction and operation of the remediation system for Roxana.

Construction permit for Federally Enforceable State Operating Permit (FESOP) source

The air emission construction permit was submitted on June 9, 2011 as a FESOP source since the system will be owned by SOPUS and operated by URS at the Roxana Public Works Treatment Plant. The construction permit will allow operation of the system for one (1) year while the FESOP permit application for operation is compiled and submitted during the one (1) year construction period. Both the construction permit and operation permit will cover the following emission points: one (1) Regenerative Thermal Oxidizer, two (2) 140-gallon drums, and two (2) 500-gallon tanks. Since the FESOP construction application must be submitted 90 days prior to the construction, application will be sent concurrently with the submittal of the Conceptual/Final Design Report to reduce lead time. The forms included in the construction application are the 197-FEE, APC-682, APC-220 data for emission source, APC-260 data for air pollution control equipment and are presented in **Appendix D**.

Local permits

A building permit may be required for construction/fabrication of the new building and this need will be determined once a location is identified. An electrical permit will be necessary for all electrical work required at the site and in the building. Submittal of the permit applications to the City of Roxana is required 1 week prior to construction.

Spill Preventions Control and Countermeasure

The design currently includes two (2) 500 gallon tanks for condensate storage and two (2) 140-gallon tanks for condensate knockout. Since the system is will be on COP property, there are two options regarding SPCC compliance:

1. COP can include the SVE system/tanks as part of their SPCC Plan, in which case, they will be provided with all relevant information on the system/tanks and they will update their plan as appropriate. They will then need to provide a copy of the plan to SOPUS so that we can follow all applicable requirements of the plan.
2. COP can exclude the SVE system/tanks from their SPCC Plan, in which case, SOPUS will be responsible for complying with all SPCC rules and regulations pertaining to the SVE system/tanks.

At this time, the collective storage is below 1,320 gallons therefore, if COP chooses to exclude the SVE system/tanks from their SPCC Plan, an SPCC Plan specifically for the SVE system/tanks will not be necessary. However, in the event additional storage is required, an SPCC plan will be created.

Stormwater Construction Permit

A NPDES stormwater construction permit will not be needed for the construction activities planned since the composite disturbed area will be less than 1 acre. The construction site consists of 0.01 acres. The stormwater runoff calculations (**Appendix C**) for the site show that the post-construction runoff rate for the 2 year, 24 hour and the 100 year, 24 hour are 0.0003 cfs and 0.0008 cfs greater than the pre-construction rates respectively. Therefore based on the minimal increase of stormwater runoff from the project site to adjacent areas, a stormwater permit will not be necessary.

10.1 LONG-LEAD PROCUREMENT CONSIDERATIONS

The items which will require a large amount of time to obtain include the FESOP construction permit, the RTO, and the SVE blower. The FESOP application will require 90 days from submittal for the IEPA review and issue the approved permit. To address the long lead time, the air permit will be submitted concurrently with the submittal of the Conceptual/Final Design Report. The RTO and the SVE blower will require a fourteen (14) week lead time for order and delivery from the manufacturers. The RTO will be an Anguil Model 50 (or approved equivalent) and the SVE blower will be a Sutorbilt 7LP or equivalent. To address this lead time, these items will be sent out for bid prior to obtaining IEPA approval of this design.

10.2 PROJECT MANAGEMENT

The key personnel involved in completing the design of the remediation system are as follows:

Program Manager:	Robert Billman
Project Manager:	Steven Shroff
Design Team:	Leslie Voss, P.E.
	Rick Horner

URS Corporation will supply qualified personnel for the construction oversight and operations of the remediation system. The personnel tentatively scheduled for construction and operation are as follows:

Program Manager:	Robert Billman
Project Manager:	Steven Shroff
Site Safety Officer:	Kelly Hurst
Construction Oversight:	Rich Hart
	Nathan McNurlen
Operation Team:	Rich Hart
	Nathan McNurlen

10.3 SCHEDULE

The SVE system implementation will continue during IEPA review this design. Concurrently with the submission of the design, SOPUS has submitted the FESOP application for construction of the SVE system, which cannot proceed prior to approval of the FESOP or an agreement with the IEPA Air Permit Section that the construction can proceed at risk. Therefore, a waiver to allow construction to proceed prior to approval of the permit will be requested.

Following submission of the design SOPUS will develop and submit the various bid documents and assuming that a waiver to proceed with construction is granted the following timeline is anticipated (from submission of the design):



This timeline will be expedited as much as possible, to that end, a meeting will be held to discuss beginning construction activities prior to approval of the air permit.

SECTION ELEVEN Construction Quality Assurance/Quality Control

The main component of the Quality Assurance/Quality Control (QA/QC) portion of the installation is to verify that the equipment that was brought to the site and installed at the site match or are equivalent to what was specified in the design plan. The URS construction oversight person will maintain a list of the pieces of equipment that were originally specified as a part of the SVE system. When each piece of equipment is installed the URS construction oversight person will record the equipment information on a form that lists the specified equipment. The recorded information will include, at a minimum, the brand name; model number; serial number; size if listed; and the electrical specifications that are listed on the equipment information plate. If the equipment is different than what was specified then work will be stopped on the project until an agreement is made between SOPUS, URS and the contractor as to the change.

The consideration for a piece of equipment being equivalent is to be made prior to beginning construction at the site. The process involves the construction contractor submitting a request with their bid. The request will include the contractor submitting a memo outlining the substitution and also provide sufficient information so that the SOPUS and URS project team can make the evaluation as to the equivalency of the new piece of equipment. The additional information for the equipment will include, at a minimum, the cut sheets for the piece of equipment that is being specified.

Additional requirements needed for changes to the original design involve specific power requirements for pieces of equipment needing electrical energy. The contractor will need to pay special attention to the electrical requirements of the proposed equipment so that there will not be an overload if different equipment is added to the system prior to it being operational. If the proposed equipment has increased power requirements then the contractor will also have to modify the electrical controls which will involve additional requests for change to the plans. Requirements for changes to the electrical specifications will require the contractor providing a new set of plans for the electrical portion of the system. The new set of electrical plans will require the contractor reimbursing a State of Illinois registered professional electrical engineer for reviewing and sealing the new set of electrical plans for the purposes of assuring the system will work as well or better than originally specified.

Prior to start up the contractor and or their representative will accompany SOPUS and URS representatives for a complete system walk through. The purpose of the walk through is to make sure there is power reaching those pieces of equipment needed electrical energy and that all fluid levels/lubricant levels are within the required operating range. The system walk through will

also include checking all float-type level switches to make sure these are operational and that closing the contacts on all high high level switches shuts down the power to the entire system and makes it non-operational until the situation is resolved. One last check will be to make sure that all filters are in place for the operation of the SVE system blower.

Other components to the QA/QC include verification by the contractor that all welds and or connections meet the COP relevant standards and are not leaking prior to the placement of the heat trace and insulation on the carbon steel pipe. Each line will be pressure tested to make sure there is no loss of pressure for the duration of the tests.

A survey of the elevation of the top of all piping from the wells to the headers will be maintained by the contractor to make sure there is minimal opportunity for the movement and or accumulation of condensate in any portion of the piping. This will minimize the possible reduction and or loss of vacuum to any of the wells.

The oversight and QA/QC of the backfilling of all trenches will be overseen by a URS staff member trained and experienced in the placement and compaction of backfill material. All backfill material will placed in pre-compaction lifts measuring 6-inches or less, will be compacted using a vibratory roller, and will be free of any material where the longest axis is greater than 2-inches in length. Compaction test will be completed in accordance with the specifications provided in **Appendix C**

The QA/QC for asphalt repaving of surfaces will include the placement of asphalt in the parking area of the OMC Building on the refinery property and at the location of the treatment system. The QA/QC of the asphalt on the refinery property will be conducted by COP employees based on their specifications, which were the basis for some of the specifications presented in **Appendix C**. The placement in this area will be governed by the specifications presented in the Village of Roxana codes.

The QA/QC for concrete work within the refinery will be handled by COP specifications and inspectors. The concrete work in the refinery will be for the base of the sleepers. The exact procedures and measurements for the sleepers are presented in the specification presented as **Appendix C**. The specifications for concrete forming and pouring on the Village property are presented in **Appendix C**.

All of the QA/QC documentation will be maintained for a period of seven years by the contractor and will also be included as an attachment in the “as built” report.

Construction Quality Assurance/Quality Control

A construction quality assurance/quality control plan describing the procedures which will be followed to ensure the corrective measure is constructed/installed in accordance with the approved plans and specifications will be developed.

SECTION TWELVE Waste Management

The anticipated wastes resulting from the construction and operation of the remediation system will be soil, groundwater, and condensate water.

The procedures for the characterization of the wastes will follow the steps described below:

1. A sample will be collected from the waste stream for transport in laboratory provided containers. (soil will be a composite sample; groundwater and condensate water will be a grab sample by bailer)

2. When this sample is collected by the field team and sent to the lab, an email will be sent the office with the date the sample was collected, and the type of sample that was collected for tracking and recording.

3. The laboratory will analyze for the following constituents to determine if the sample is characteristically hazardous or non-hazardous:

- pH
- Paint Filter
- Reactive Cyanide
- Reactive Sulfide
- Total Phenolics
- Flash Point
- TOX (Milam only)
- TCLP Organics
    - benzene
    - carbon tetrachloride
    - chlorobenzene
    - chloroform
    - o-cresol
    - m-cresol
    - p-cresol
    - 1,4-dichlorobenzene
    - 1,2-dichloroethane
    - 1,1-dichloroethene
    - 2,4-dinitrotoluene
    - hexachlorobenzene
    - hexachloro-1,3 butadiene
    - hexachloroethane
    - methyl ethyl ketone
    - nitrobenzene
    - pentachlorophenol
    - pyridine
    - tetrachloroethylene
    - trichloroethylene
    - 2,4,5- trichlorophenol
    - 2,4,6- trichlorophenol
    - vinyl chloride

- TCLP Metals
  - o arsenic
  - o barium
  - o cadmium
  - o chromium
  - o lead
  - o mercury
  - o selenium
  - o silver

4. When the sample analysis is finalized, the laboratory will email the results to the field and office.

5. The field team will coordinate with the office to characterize the waste, prepare the manifest on USEPA Form 8700-22 according to 40 CFR 262 (Uniform Hazardous Waste Manifest and Instructions), and determine the appropriate labels and placards.

a. If waste is determined to be hazardous, wastes must be managed according to the relevant RCRA 90-Day Requirements and SOPUS guidance.

i. Inspection and management of hazardous waste containers will follow the container management standards in 40 CFR 256 Subpart I - Use and Management of Containers

b. For hazardous waste, a Land Disposal Restriction Notice must be filed with State

6. Once the waste is characterized, the hazardous waste will be designated for transport and disposal. Currently, hazardous wastes are treated at the Veolia Environmental Services facility in Sauget, Illinois and non-hazardous waste is disposed at the Waste Management Milam Landfill in East St. Louis.

7. When the waste is removed from the site, through a licensed appropriate hauler, the field team will email the office with the following details:

a. Date the shipment was shipped from the site

b. Number of shipments that left the site

c. Lists of manifests that left the site

d. Transporter hired to remove the wastes

8. Files will be maintained by updating the tracking spreadsheet with additional tracking information and maintaining the records (for at least 3 years).

URS will operate and maintain the SVE system on behalf of SOPUS. URS operators will be on site daily.

13.1 OPERATION AND MAINTENANCE

A separate SVE Operation and Maintenance Plan (O&M) has been prepared to provide general guidance for the startup, shutdown, operation, preventative maintenance, troubleshooting, and performance monitoring of the vapor recovery and treatment components of the SVE. Procedures detailed in the SVE O&M plan were developed per the manufacturer's guidance. A general overview of this plan is provided below and a complete draft version is presented in **Appendix E**.

Throughout the SVE O&M Plan, a number of blank spaces exist that will be filled in once final selection of certain components of the SVE system have been made and the system installed. The revised O&M Plan will be submitted as part of the Construction Completion Report following installation of the system.

13.2 VAPOR MONITORING POINT INSTALLATION

Vapor monitoring points will be installed at 13 additional locations to supplement the existing monitoring network as shown on **Figure 5**. Three vapor monitoring points will be installed at each location with one at the top of the sand unit, one at or near the bottom of the extraction well screen, and one in the middle of the vadose zone. The vapor monitoring ports at each VMP location will be installed together in a hollow-stem auger or Geoprobe® boring. Each vapor monitoring port will consist of a 0.5-inch outer diameter by 6-inch long Geoprobe® Systems stainless steel screen connected to a 0.125-inch diameter stainless steel or teflon riser tubing extending to the ground surface. A sand pack will be placed in the annular space from approximately six inches below to six inches above each stainless steel screen. Granular bentonite seals will be placed between individual vapor monitoring port screen/sand pack intervals. The remaining annular space will be filled with cement bentonite grout to the ground surface and completed at the surface with a flush-mounted protective cover.

13.3 MONITORING AND SAMPLING

Routine SVE well monitoring and maintenance will initially be conducted on a daily basis at each of the 24 SVE wells as outlined below. Additional monitoring and maintenance of approximately 45 VMP locations, each consisting of multiple wells screened at different depths,

will performed in conjunction with the SVE wells. Sampling will be sequenced to ensure SVE and VMP well data corresponds spatially and temporally. The scope of data collection includes:

- Pressure, air flow, fluid level, and screening measurements at all operational SVE wells (**Figure 5**)
- Pressure, gauging and screening measurements at specified VMPs (**Figure 5**)

The scope and schedule of data collection is presented in the table below:

Activity		Frequency				Equipment	SOP
		Initial to 2 weeks	2 weeks to 1 month	1 month to 3 months	> 3 months		
SVE Wells (24)	Soil Vapor Screening	Daily	Weekly	Monthly	Quarterly	Tedlar bag Vacuum chamber Vacuum pump	Roxana SOP-03
	Vacuum/Pressure Measurement					Digital manometer	Roxana SOP-01
	Flow Measurement					Digital manometer Pitot tube	Roxana SOP-01
	Fluid Level Measurement					Interface meter	Roxana SOP-01
System VMP Wells (34)	Initial Vacuum/Pressure Measurement	Daily	Weekly	Monthly	Quarterly	Digital manometer	Roxana SOP-02 Roxana SOP-04
	Well Purging					60 mL syringe	Roxana SOP-02
	Soil Vapor Screening					Tedlar bag Peristaltic pump	Roxana SOP-02
	Venting					None	Roxana SOP-02
	Stabilized Vacuum Pressure Measurement					Digital manometer	Roxana SOP-02 Roxana SOP-04
	Soil Vapor Field Laboratory Screening					TVA-1000 (PID/FID) ppbRAE (PID) Landtec Gem 2000 (O2, CO2)	Roxana SOP-03
Village VMP Wells (11)	Initial Vacuum/Pressure Measurement	Monthly	Monthly	Monthly	Quarterly	Digital manometer	Roxana SOP-02 Roxana SOP-04
	Well Purging					60 mL syringe	Roxana SOP-02
	Soil Vapor Screening					Tedlar bag Peristaltic pump	Roxana SOP-02
	Venting					None	Roxana SOP-02
	Stabilized Vacuum Pressure Measurement					Digital manometer	Roxana SOP-02 Roxana SOP-04
	Soil Vapor Field Laboratory Screening					TVA-1000 (PID/FID) ppbRAE (PID) Landtec Gem 2000 (O2, CO2)	Roxana SOP-03

The daily gauging will be reduced to weekly after the first two weeks of operation. The gauging frequency will then be reduced to monthly after the first month and quarterly after the first quarter.

SECTION FOURTEEN References

Illinois Environmental Protection Agency (IEPA). November 15, 2010. Letter of work plan approval with conditions. Sent to URS Corporation.

Shell Oil Products US. September 20, 2010. *Vapor Intrusion Investigation Work Plan.* Prepared by URS Corporation.

Shell Oil Products US. November 2010. *3rd Quarter 2010 - Soil Vapor Monitoring Report, Roxana Illinois.* Prepared by URS Corporation.

URS Corporation. 2010A. *Roxana /Route 111 Investigation and Rand Avenue Remediation Health and Safety Plan.* Prepared for Shell Oil Products US, December 2010.

URS Corporation. 2010B. *Environmental and Geotechnical Work 2010 Health and Safety Plan.* Prepared for ConocoPhillips, March 2010.

U.S. Environmental Protection Agency (USEPA). 1991. *Soil Vapor Extraction Technology: Reference Handbook.* Cincinnati, Ohio: Office of Research and Development. EPA/540/2-91/003.

U.S. Environmental Protection Agency (USEPA). 2006. *Off Gas Treatment Technology for Soil Vapor Extraction System:State of the Practice.* EPA/542/R/05/028.

TABLE 1
ROXANA PILOT TEST STUDY
AIR SAMPLE ANALYTICAL DATA

Sample ID	Sample Date	1,2,4-Trimethylbenzene			1,3,5-Trimethylbenzene			1,3-Butadiene			2,2,4-Trimethylpentane			2-Butanone			2-Propanol			4-Ethyltoluene		
		Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals
AE#1	3/16/2011	<0.1	U		<0.1	U		0.093			<0.096	U		<0.24	U		<0.2	U		<0.1	U	
AE#2	3/17/2011	<0.042	U		<0.042	U		0.077			<0.04	U		<0.1	U		<0.084	U		<0.042	U	
AE#3	3/18/2011	<0.099	U		<0.099	U		0.13			<0.094	U		<0.24	U		<0.2	U		<0.099	U	
AE#4	3/19/2011	<0.04	U		<0.04	U		0.21			<0.038	U		<0.097	U		<0.081	U		<0.04	U	
AE#5	3/21/2011	0.025			<0.013	U		<0.006	U		0.38			0.068			<0.026	U		<0.013	U	
AE#6	3/22/2011	<0.042	U		<0.042	U		<0.019	U		0.5			<0.1	U		<0.084	U		<0.042	U	
AE#7	3/23/2011	<0.02	U		<0.02	U		<0.0092	U		1.7			0.1			<0.041	U		<0.02	U	
AE#8	3/24/2011	0.012			<0.0098	U		0.43			0.05			0.13			0.023			0.024		
Inf. PT/PW	3/19/2011	<0.05	U		<0.05	U		<0.023	U		1.5			<0.12	U		<0.1	U		<0.05	U	

Sample ID	Sample Date	4-Methyl-2-pentanone			Acetone			Benzene			Bromodichloromethane			Carbon disulfide			Chlorobenzene			Chloroethane		
		Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals
AE#1	3/16/2011	<0.084	U		0.34			4.2			<0.14	U		<0.26	U		<0.095	U		<0.22	U	
AE#2	3/17/2011	<0.035	U		0.26			0.51			<0.057	U		<0.11	U		<0.039	U		<0.09	U	
AE#3	3/18/2011	<0.083	U		0.3			0.23			<0.14	U		<0.25	U		<0.093	U		<0.21	U	
AE#4	3/19/2011	<0.034	U		<0.078	U		0.23			<0.055	U		<0.1	U		<0.038	U		<0.086	U	
AE#5	3/21/2011	<0.011	U		<0.026	U		1.9			<0.018	U		<0.034	U		<0.012	U		<0.028	U	
AE#6	3/22/2011	<0.035	U		<0.081	U		2.7			<0.057	U		<0.1	U		<0.039	U		<0.09	U	
AE#7	3/23/2011	<0.017	U		<0.04	U		2.3			<0.028	U		<0.052	U		<0.019	U		<0.044	U	
AE#8	3/24/2011	0.0094			0.69			1.8			<0.013	U		<0.025	U		<0.0092	U		<0.021	U	
Inf. PT/PW	3/19/2011	<0.042	U		0.34			12			<0.069	U		<0.13	U		<0.047	U		<0.11	U	

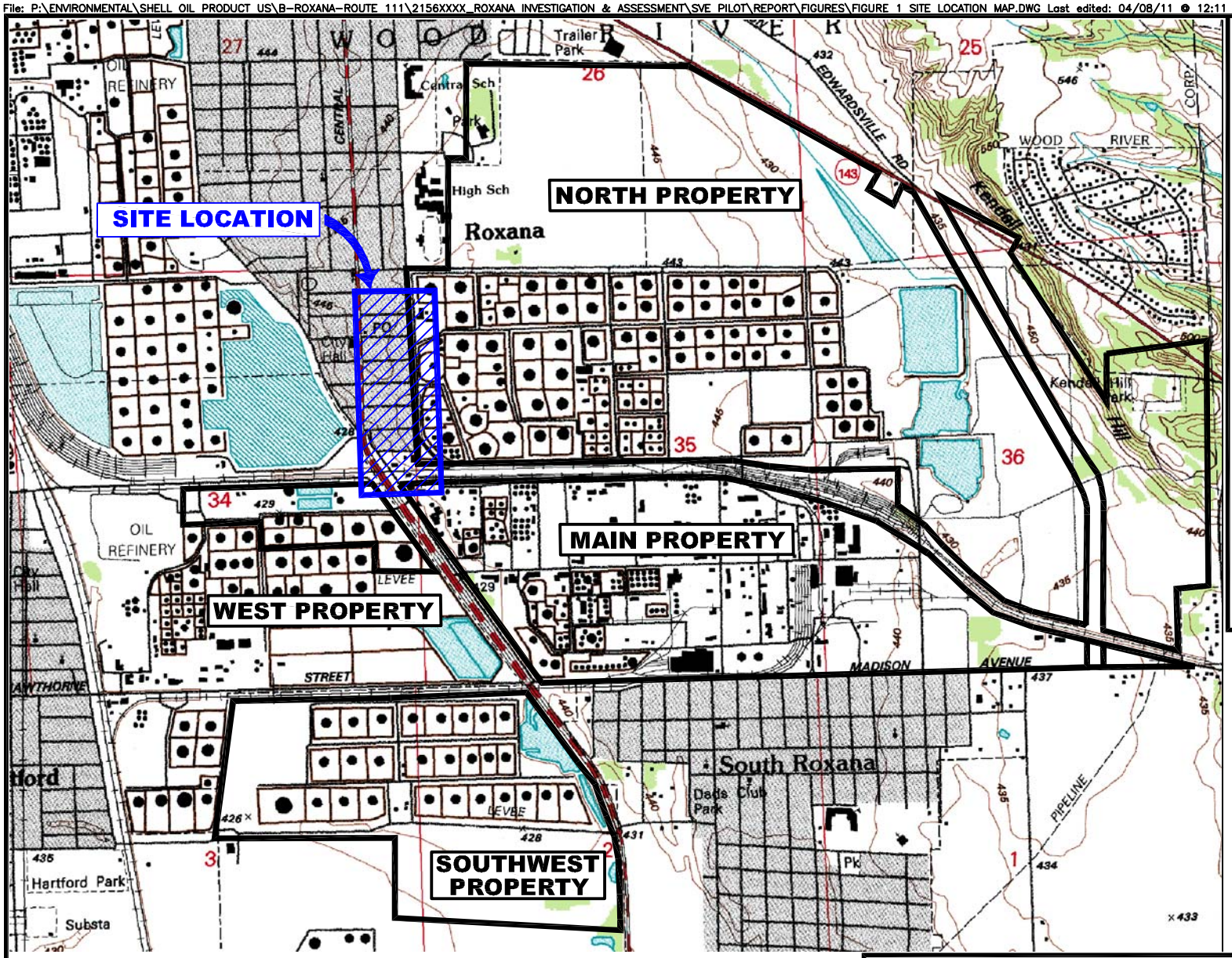
Sample ID	Sample Date	Chloroform			Cyclohexane			Dichlorodifluoromethane			Dichloromethane (Methylene			Ethanol			Ethylbenzene			Heptane		
		Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals
AE#1	3/16/2011	<0.1	U		<0.071	U		<0.1	U		<0.072	U		0.23			<0.089	U		<0.084	U	
AE#2	3/17/2011	<0.042	U		<0.029	U		<0.042	U		0.031			0.11			<0.037	U		<0.035	U	
AE#3	3/18/2011	<0.099	U		<0.07	U		<0.1	U		<0.07	U		<0.15	U		<0.088	U		<0.083	U	
AE#4	3/19/2011	<0.04	U		<0.028	U		<0.04	U		<0.028	U		0.086			<0.036	U		<0.034	U	
AE#5	3/21/2011	<0.013	U		0.04			<0.013	U		<0.0094	U		0.17			0.072			0.065		
AE#6	3/22/2011	<0.042	U		0.06			<0.042	U		<0.03	U		0.17			<0.037	U		0.043		
AE#7	3/23/2011	<0.02	U		0.07			<0.021	U		<0.014	U		0.14			0.05			<0.017	U	
AE#8	3/24/2011	<0.0097	U		0.022			<0.0098	U		<0.0069	U		0.19			0.12			0.045		
Inf. PT/PW	3/19/2011	<0.05	U		0.11			<0.051	U		<0.036	U		<0.077	U		<0.044	U		<0.042	U	

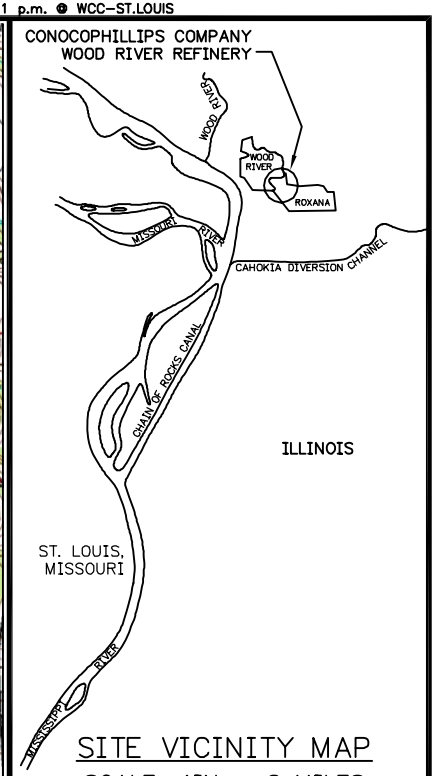
TABLE 1
ROXANA PILOT TEST STUDY
AIR SAMPLE ANALYTICAL DATA

Sample ID	Sample Date	Hexane			Isopropylbenzene (Cumene)			m,p-Xylene			n-Propylbenzene			o-Xylenes			Styrene			Tetrachloroethene		
		Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals
AE#1	3/16/2011	0.076			0.32			<0.089	U		<0.1	U		<0.089	U		0.094			<0.14	U	
AE#2	3/17/2011	<0.03	U		0.13			<0.037	U		<0.042	U		<0.037	U		0.047			0.093		
AE#3	3/18/2011	<0.071	U		<0.099	U		<0.088	U		<0.099	U		<0.088	U		<0.086	U		<0.14	U	
AE#4	3/19/2011	<0.029	U		<0.04	U		<0.036	U		<0.04	U		<0.036	U		<0.035	U		<0.056	U	
AE#5	3/21/2011	0.54			0.038			0.11			<0.013	U		0.033			0.012			<0.018	U	
AE#6	3/22/2011	0.45			<0.042	U		0.054			<0.042	U		<0.037	U		<0.036	U		<0.058	U	
AE#7	3/23/2011	0.24			<0.02	U		0.069			<0.02	U		0.027			<0.018	U		<0.028	U	
AE#8	3/24/2011	0.1			<0.0098	U		0.15			<0.0098	U		0.045			0.051			<0.013	U	
Influent	3/19/2011	0.089			<0.05	U		<0.044	U		<0.05	U		<0.044	U		<0.044	U		<0.07	U	

Sample ID	Sample Date	Tetrahydrofuran			Toluene			Trichlorofluoromethane		
		Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals	Result	Lab Quals	URS Quals
AE#1	3/16/2011	<0.061	U		0.25			<0.12	U	
AE#2	3/17/2011	<0.025	U		0.13			<0.048	U	
AE#3	3/18/2011	<0.06	U		0.11			<0.11	U	
AE#4	3/19/2011	<0.024	U		0.052			<0.046	U	
AE#5	3/21/2011	0.0089			0.48			<0.015	U	
AE#6	3/22/2011	<0.025	U		0.37			<0.048	U	
AE#7	3/23/2011	0.014			0.55			<0.023	U	
AE#8	3/24/2011	0.21			0.63			<0.011	U	
PT/PW	3/19/2011	<0.03	U		<0.039	U		<0.058	U	

File: P:\ENVIRONMENTAL\SHELL OIL PRODUCT US\B-ROXANA-ROUTE 111\2156XXXX_ROXANA INVESTIGATION & ASSESSMENT\SVE PILOT\REPORT\FIGURES\FIGURE 1 SITE LOCATION MAP.DWG Last edited: 04/08/11 @ 12:11 p.m. @ WCC-ST.LOUIS





SITE VICINITY MAP
SCALE: 1IN = 8 MILES

LEGEND
- WOOD RIVER REFINERY PROPERTY BOUNDARY
- INVESTIGATION AREA

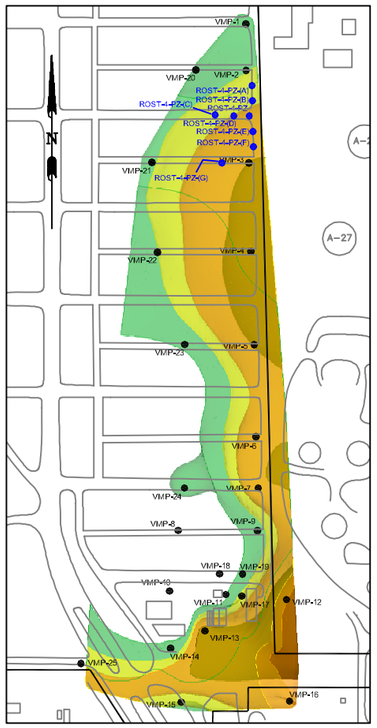
CONTOUR INTERVAL = 5 FT

Ø 2000
SCALE FEET

N

SOURCE:
MAP TAKEN FROM ELECTRONIC USGS DIGITAL RASTER GRAPHIC 7.5 MINUTE TOPOGRAPHIC MAP OF WOOD RIVER, ILL-MO REVISED 1994.

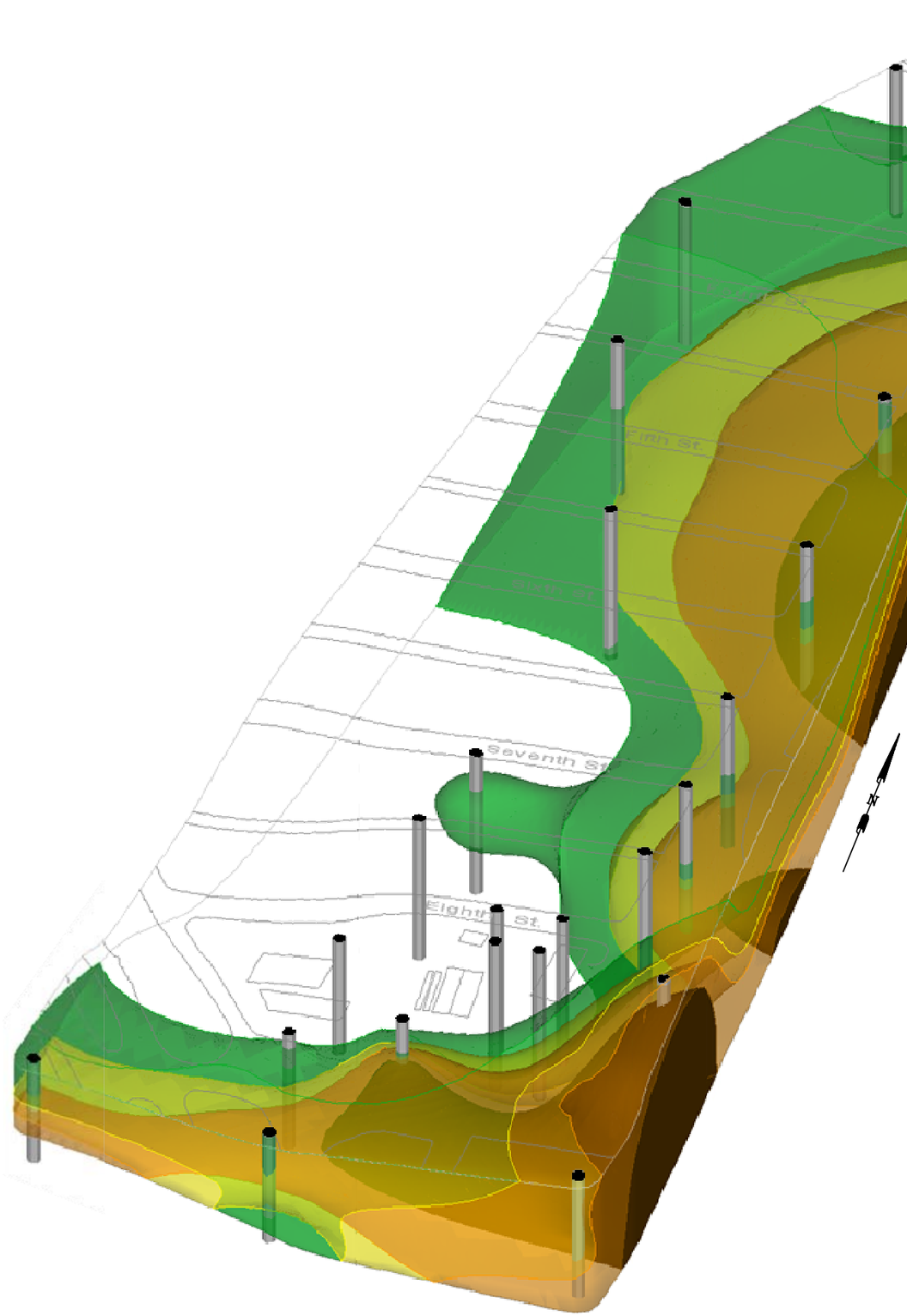
SHELL OIL PRODUCTS US ROXANA, ILLINOIS	PROJECT NO. 21562593
URS	
DRN. BY: djd 4/8/11 DSGN. BY: djd CHKD. BY: rh	Site Location Map FIG. NO. 1



KEY MAP

Ø 500

SCALE FEET



Benzene Soil Vapor
Concentration Legend

- 370 – 2,800 ug/m^3
- 2,800 – 10,000 ug/m^3
- 10,000 – 100,000 ug/m^3
- > 100,000 ug/m^3

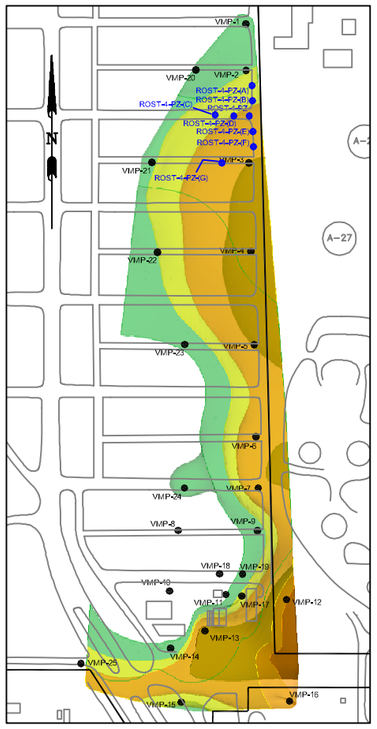
NOTE:
IMAGES GENERATED USING CTECH ENVIRONMENTAL VISUALIZATION SYSTEM MODELING SOFTWARE. CONCENTRATIONS BETWEEN KNOWN DATA POINTS (E.G. VMP WELLS) ARE INTERPOLATIONS AND EXTRAPOLATIONS OF THE MEASURED DATA. BENZENE CONCENTRATIONS ARE SHOWN IN A 3D OBLIQUE VIEW WITH SEMI–TRANSPARENT CONCENTRATION BANDS. AS A RESULT, ALL CONCENTRATIONS CAN BE SEEN REGARDLESS OF DEPTH.

SHELL OIL PRODUCTS US ROXANA, ILLINOIS	PROJECT NO. 21562593

URS

DRN. BY: djd May 2011 DSGN. BY: djd CHKD. BY: nm	1Q11 Soil Vapor–Benzene	FIG. NO. 2

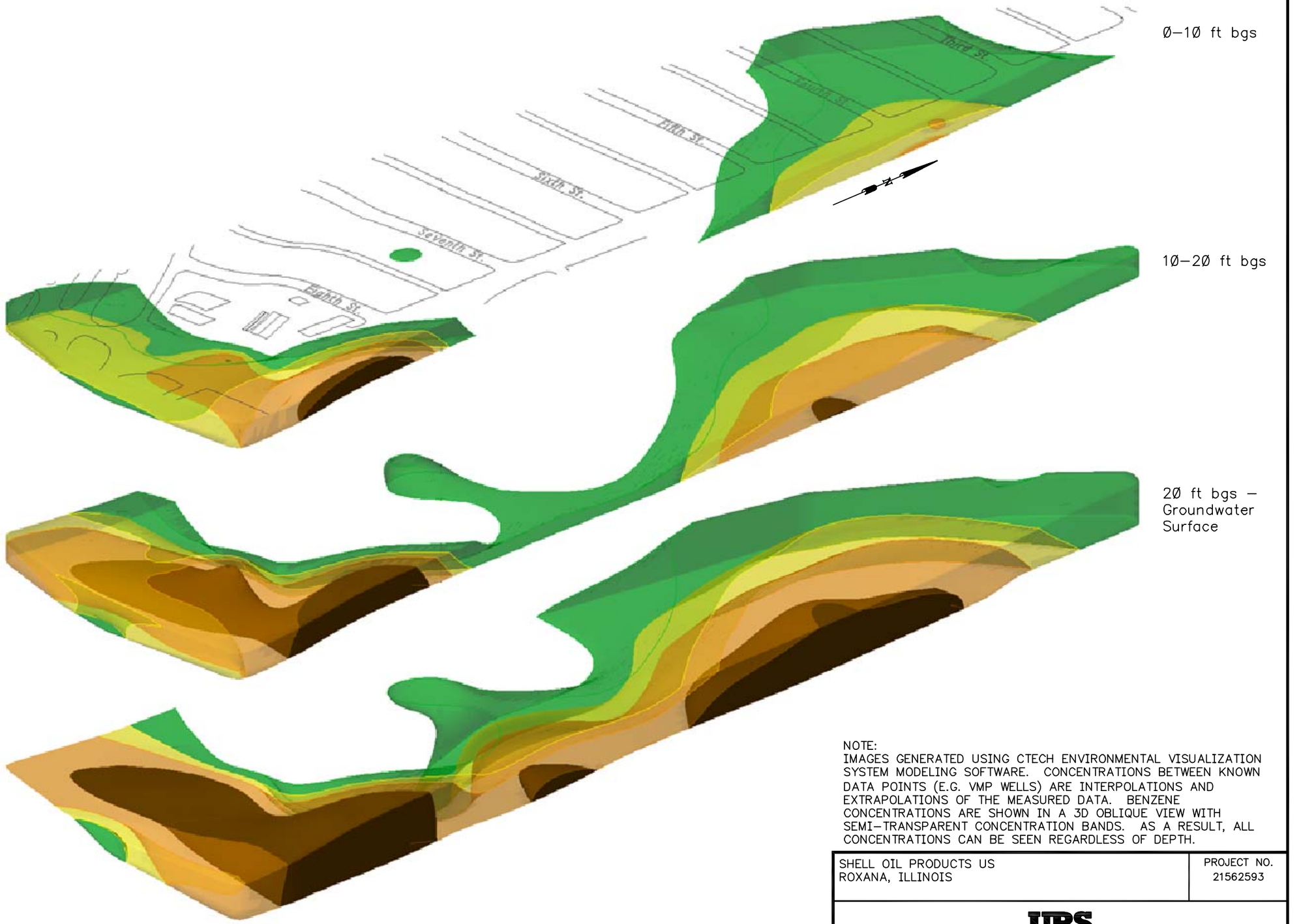
File: P:\ENVIRONMENTAL\SHELL Oil PRODUCT (SVE-ROXANA-ROUTE 1)\21562XXX-ROXANA INVESTIGATION & ASSESSMENT\CONCEPTUAL DESIGN REPORT\DRAFT REPORT\FIGURES\VG 2-1Q11 SOIL VAPOR-BENZENE.DWG Last edited: MAY 17, 11 @ 2:44 p.m. by: david.deguire



KEY MAP

Ø 5ØØ

SCALE FEET



Ø–1Ø ft bgs

1Ø–2Ø ft bgs

2Ø ft bgs – Groundwater Surface

Benzene Soil Vapor
Concentration Legend

- 37Ø – 2,8ØØ ug/m^3
- 2,8ØØ – 1Ø,ØØØ ug/m^3
- 1Ø,ØØØ – 1ØØ,ØØØ ug/m^3
- > 1ØØ,ØØØ ug/m^3

NOTE:
IMAGES GENERATED USING CTECH ENVIRONMENTAL VISUALIZATION SYSTEM MODELING SOFTWARE. CONCENTRATIONS BETWEEN KNOWN DATA POINTS (E.G. VMP WELLS) ARE INTERPOLATIONS AND EXTRAPOLATIONS OF THE MEASURED DATA. BENZENE CONCENTRATIONS ARE SHOWN IN A 3D OBLIQUE VIEW WITH SEMI–TRANSPARENT CONCENTRATION BANDS. AS A RESULT, ALL CONCENTRATIONS CAN BE SEEN REGARDLESS OF DEPTH.

SHELL OIL PRODUCTS US ROXANA, ILLINOIS	PROJECT NO. 21562593

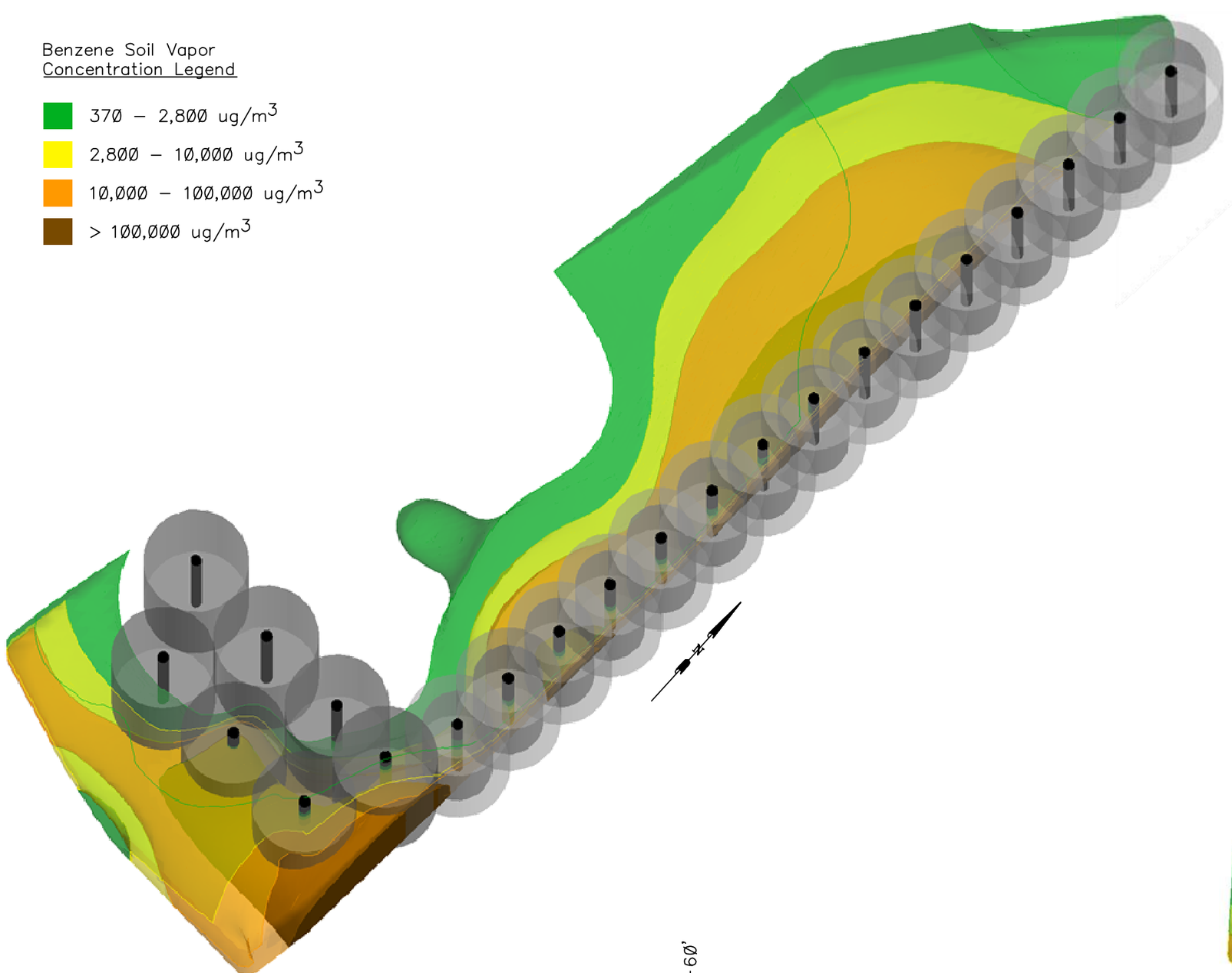
URS

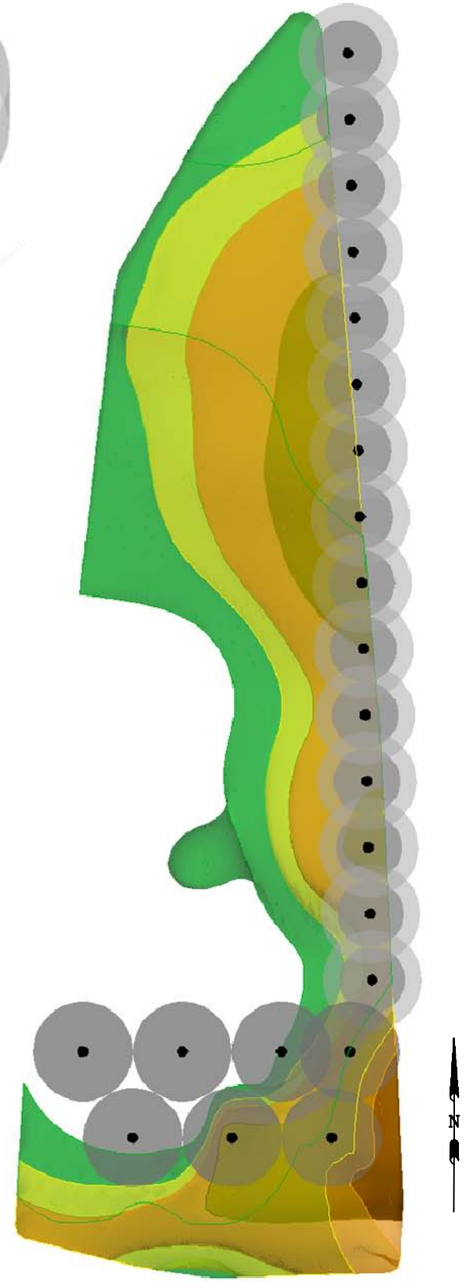
DRN. BY: djd May 2Ø11 DSGN. BY: djd CHKD. BY: nm	**1Q11 Soil Vapor–Benzene 1Ø ft Horizontal Slices**	FIG. NO. 3

File: P:\ENVIRONMENTAL\SHELL OIL PRODUCT US\S-ROXANA-ROUTE 111\21562XXX-ROXANA INVESTIGATION & ASSESSMENT\CONCEPTUAL DESIGN REPORT\DRAFT REPORT\FIGURES\FIG 3-1Q11 SOIL VAPOR-BENZENE 10 FT HORIZONTAL SLICES.DWG Last edited: MAY 17, 11 @ 2:46 p.m. by: david_deguire

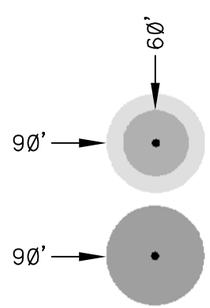
Benzene Soil Vapor
Concentration Legend

- 370 – 2,800 ug/m^3
- 2,800 – 10,000 ug/m^3
- 10,000 – 100,000 ug/m^3
- > 100,000 ug/m^3





NOTE:
IMAGES GENERATED USING CTECH ENVIRONMENTAL VISUALIZATION SYSTEM MODELING SOFTWARE. CONCENTRATIONS BETWEEN KNOWN DATA POINTS (E.G. VMP WELLS) ARE INTERPOLATIONS AND EXTRAPOLATIONS OF THE MEASURED DATA. BENZENE CONCENTRATIONS ARE SHOWN IN A 3D OBLIQUE VIEW WITH SEMI–TRANSPARENT CONCENTRATION BANDS. AS A RESULT, ALL CONCENTRATIONS CAN BE SEEN REGARDLESS OF DEPTH.

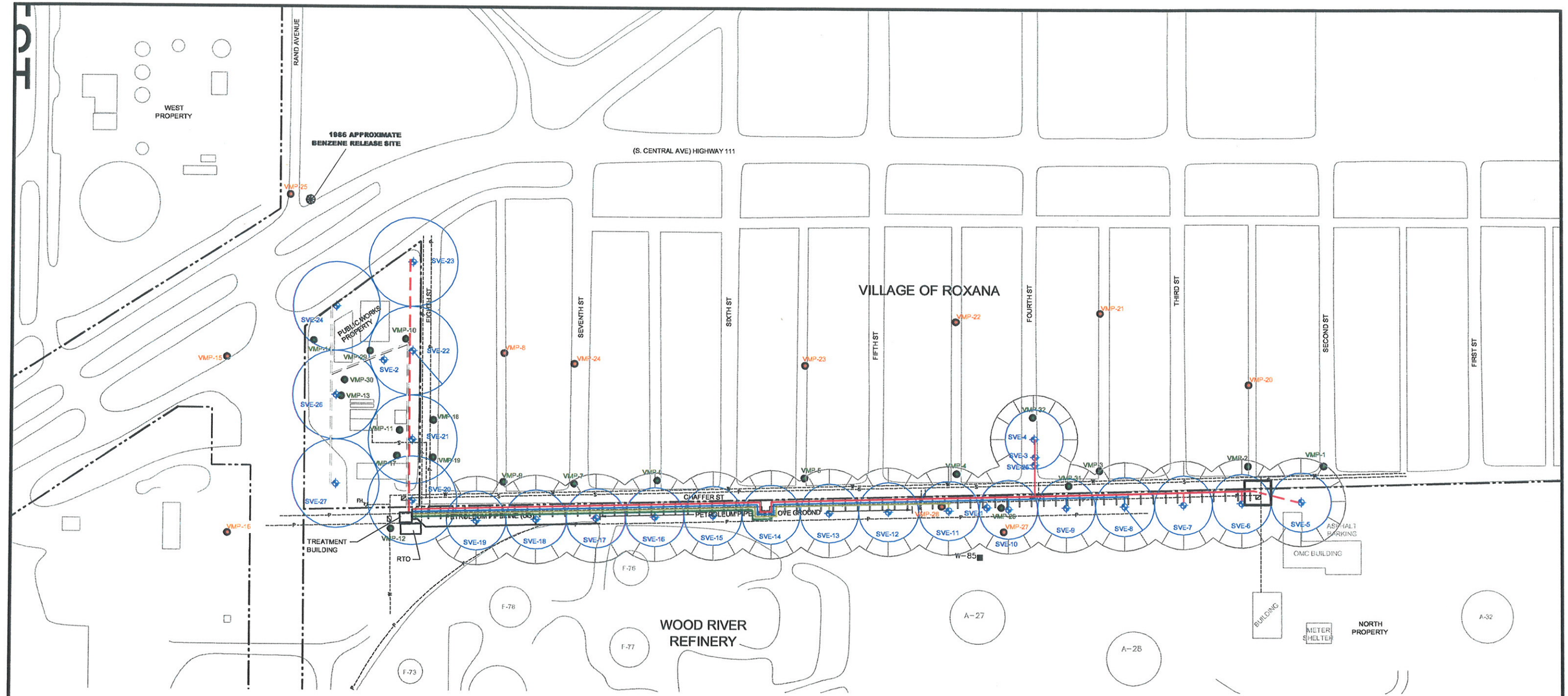


ESTIMATED RADIUS OF INFLUENCE (60' & 90')

ESTIMATED RADIUS OF INFLUENCE (90')

SHELL OIL PRODUCTS US ROXANA, ILLINOIS		PROJECT NO. 21562593
URS		
DRN. BY: djd May 2011 DSGN. BY: djd CHKD. BY: nm	1Q11 Soil Vapor–Benzene Proposed SVE Well ROI	FIG. NO. 4

File: P:\ENVIRONMENTAL\SHELL OIL PRODUCT US\S-ROXANA-ROUTE 111\21562XXX-ROXANA INVESTIGATION & ASSESSMENT\CONCEPTUAL DESIGN REPORT\DRAFT REPORT\FIGURES\FIG 4_1Q11 SOIL VAPOR-BENZENE PROPOSED SVE WELL ROI.DWG Last edited: MAY 17, 11 @ 2:47 p.m. by: david.deguire



LEGEND:

- VAPOR MONITORING POINT (VMP) LOCATION - INITIAL MONTHLY MONITORING/LONG-TERM QUARTERLY MONITORING
- VAPOR MONITORING POINT (VMP) LOCATION - INITIAL DAILY MONITORING/LONG-TERM QUARTERLY MONITORING
- SVE EXTRACTION WELL - INITIAL DAILY MONITORING/LONG-TERM QUARTERLY MONITORING
- UNDERGROUND PIPING (DASHED)
- ABOVEGROUND PIPING
- PROPERTY BOUNDARY
- ESTIMATED RADIUS OF INFLUENCE
- POTENTIAL TREATMENT ZONE BASED ON A RADIUS OF INFLUENCE OF 90 FEET

NOTES:
1. WELL LOCATIONS ARE PROPOSED AND WILL BE MOVED AS CLOSE TO THE FENCE LINE AS IS SAFE.
2. VMP-33 THROUGH VMP-45 ARE PROPOSED LOCATIONS.

IDENTIFICATION TAPE (FADE RESISTANT / SELF ADHESIVE)

LEG #	SVE WELLS	COLOR
1	SVE-3 THROUGH SVE-7 AND SVE-25	RED
2	SVE-8 THROUGH SVE-10	BLUE
3	SVE-11 THROUGH SVE-13	YELLOW
4	SVE-14 THROUGH SVE-16	GREEN
5	SVE-17 THROUGH SVE-19	BLACK
6	SVE-20 THROUGH SVE-23	ORANGE
7	SVE-24, SVE-26 & SVE-27	WHITE

N

200 0 200

SCALE IN FEET

DRAFT

SHELL OIL PRODUCTS US
ROXANA, ILLINOIS

PROJECT NO. 21562593

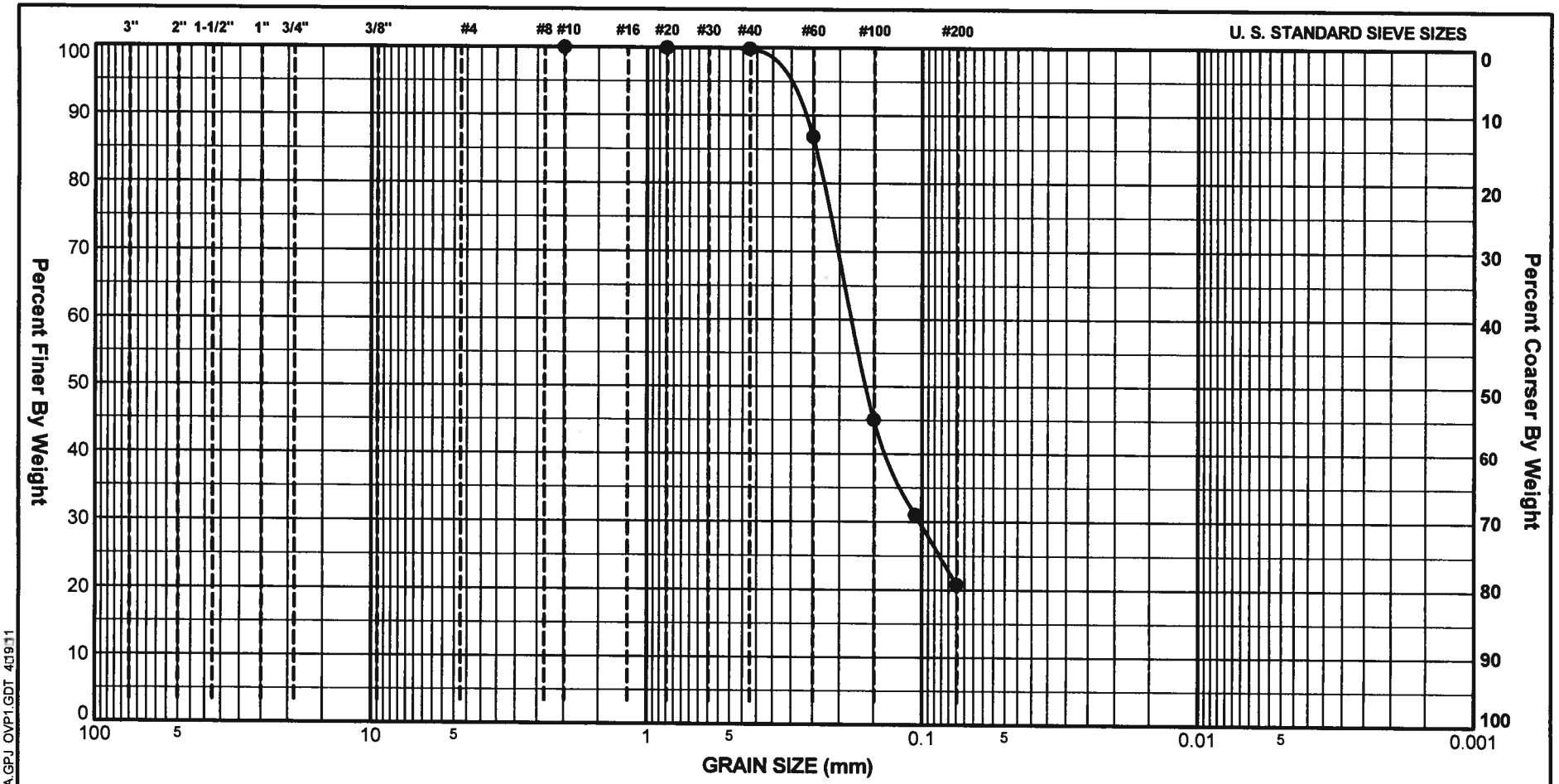
URS

DRN. BY: djd May 2011
DSGN. BY: ctd
CHKD. BY: nm

Proposed Soil Vapor Extraction System

FIG. NO. 5

APPENDIX A Particle Size Analysis



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

SYMBOL	BORING NO.	DEPTH (feet)	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_u	C_c	LL	PL	PI	% Gravel	% Sand	% Silt	% Clay	SAMPLE DESCRIPTION
●	SVE-1	10'	0.2442	0.1800	0.1593	0.1024								0.0	79.2	20.8		CLAYEY SAND SC

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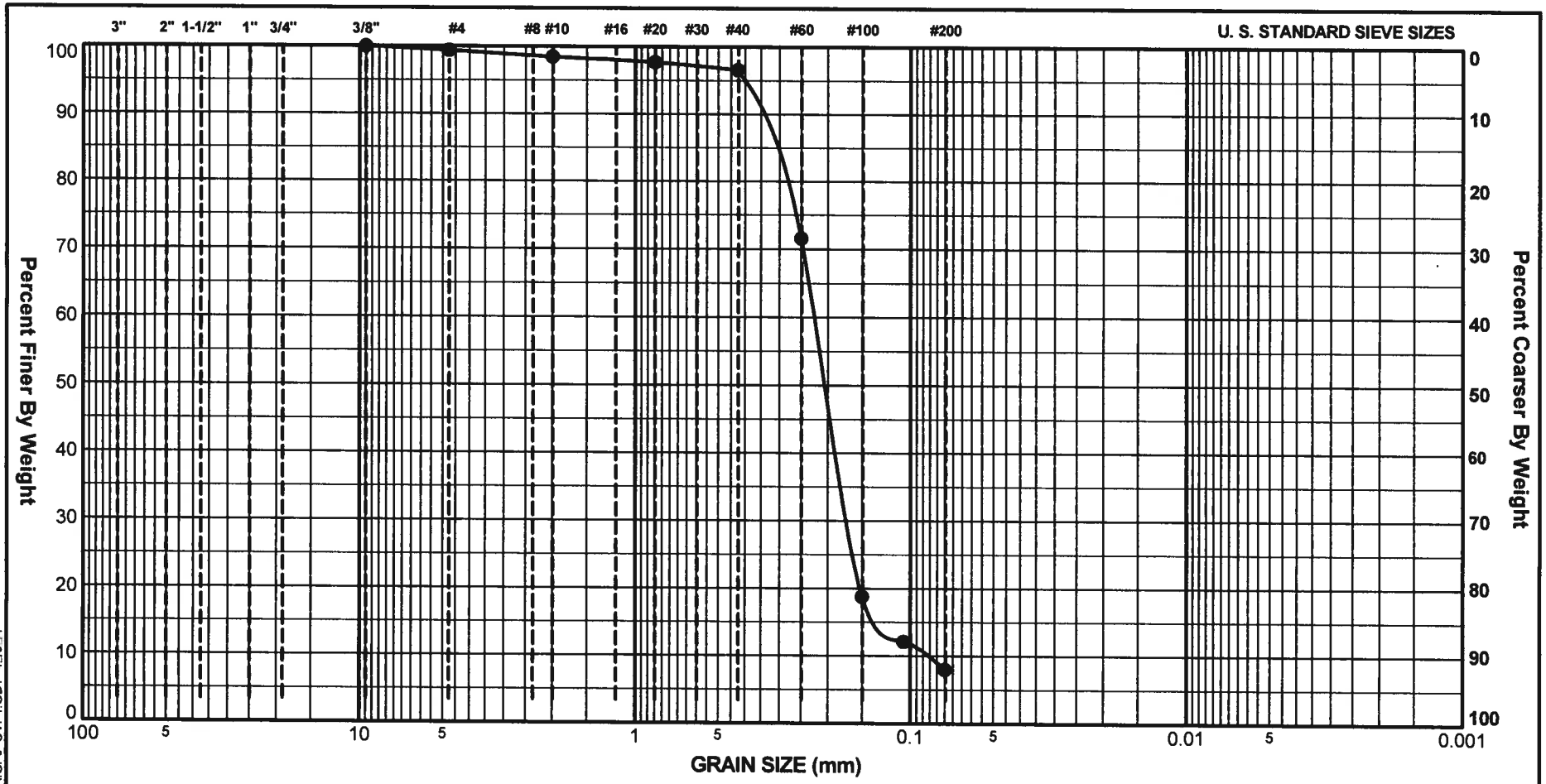
Figure No.

OVP GRAIN SIZE TO 3 INCHES 21562593SHELLROXANNA.GPJ OVP1.GDT 4/19/11



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

SYMBOL	BORING NO.	DEPTH (feet)	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_u	C_c	LL	PL	PI	% Gravel	% Sand	% Silt	% Clay	SAMPLE DESCRIPTION
●	SVE-1	20'	0.3324	0.2235	0.2029	0.1672	0.1231	0.0887	2.52	1.41	NP	NP	NP	0.6	91.4	8.0		POORLY GRADED SAND with SILT SP-S

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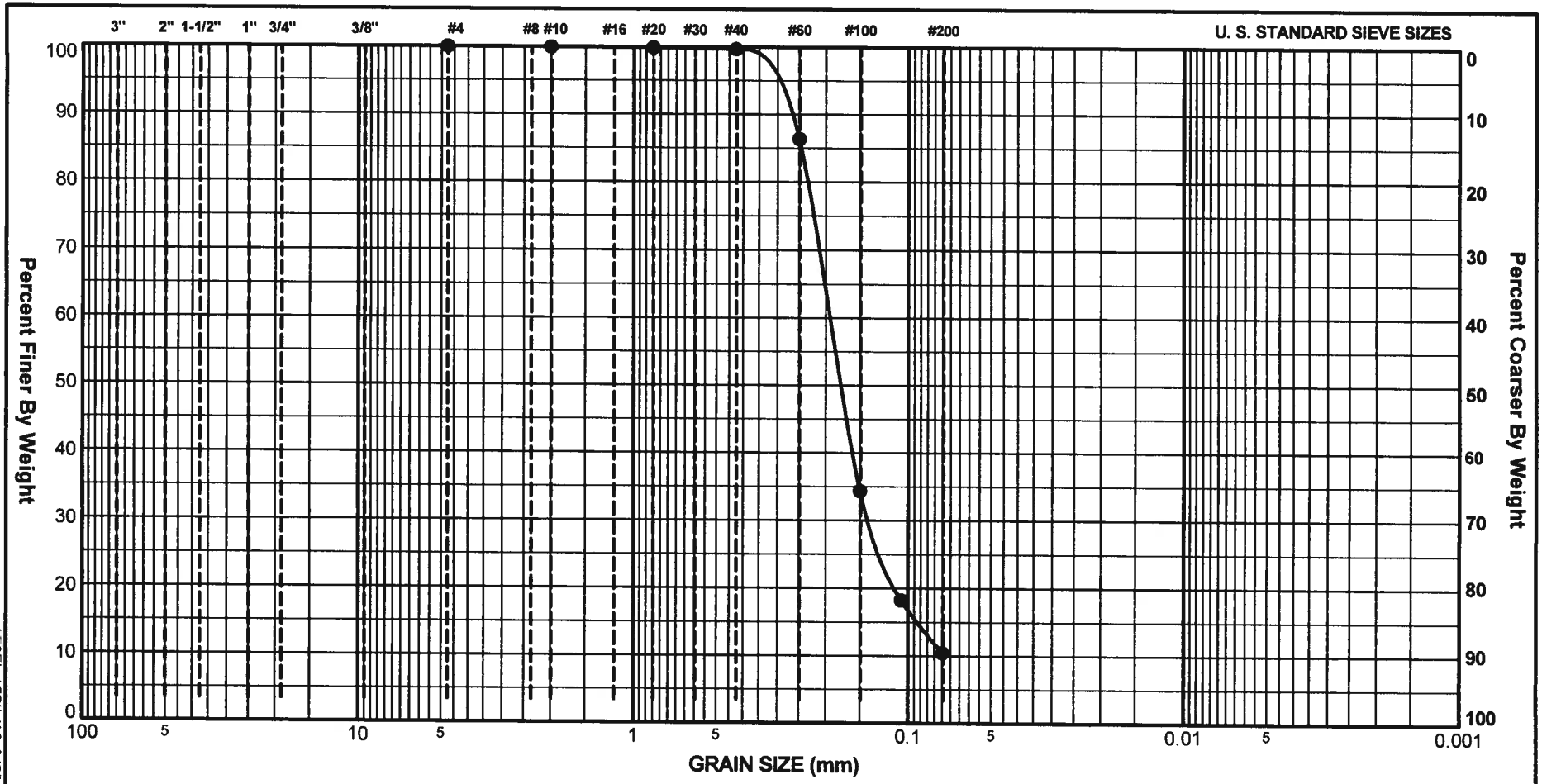
Figure No.

OVP GRAIN SIZE TO 3 INCHES 21562593SHELLROXANNA.GPJ OVP1.GDT 4/19/11



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

SYMBOL	BORING NO.	DEPTH (feet)	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_u	C_c	LL	PL	PI	% Gravel	% Sand	% Silt	% Clay	SAMPLE DESCRIPTION
●	SVE-1	30'	0.2466	0.1930	0.1749	0.1366	0.0918		2.62	1.31	NP	NP	NP	0.0	89.6	10.4		POORLY GRADED SAND with SILT SP-S

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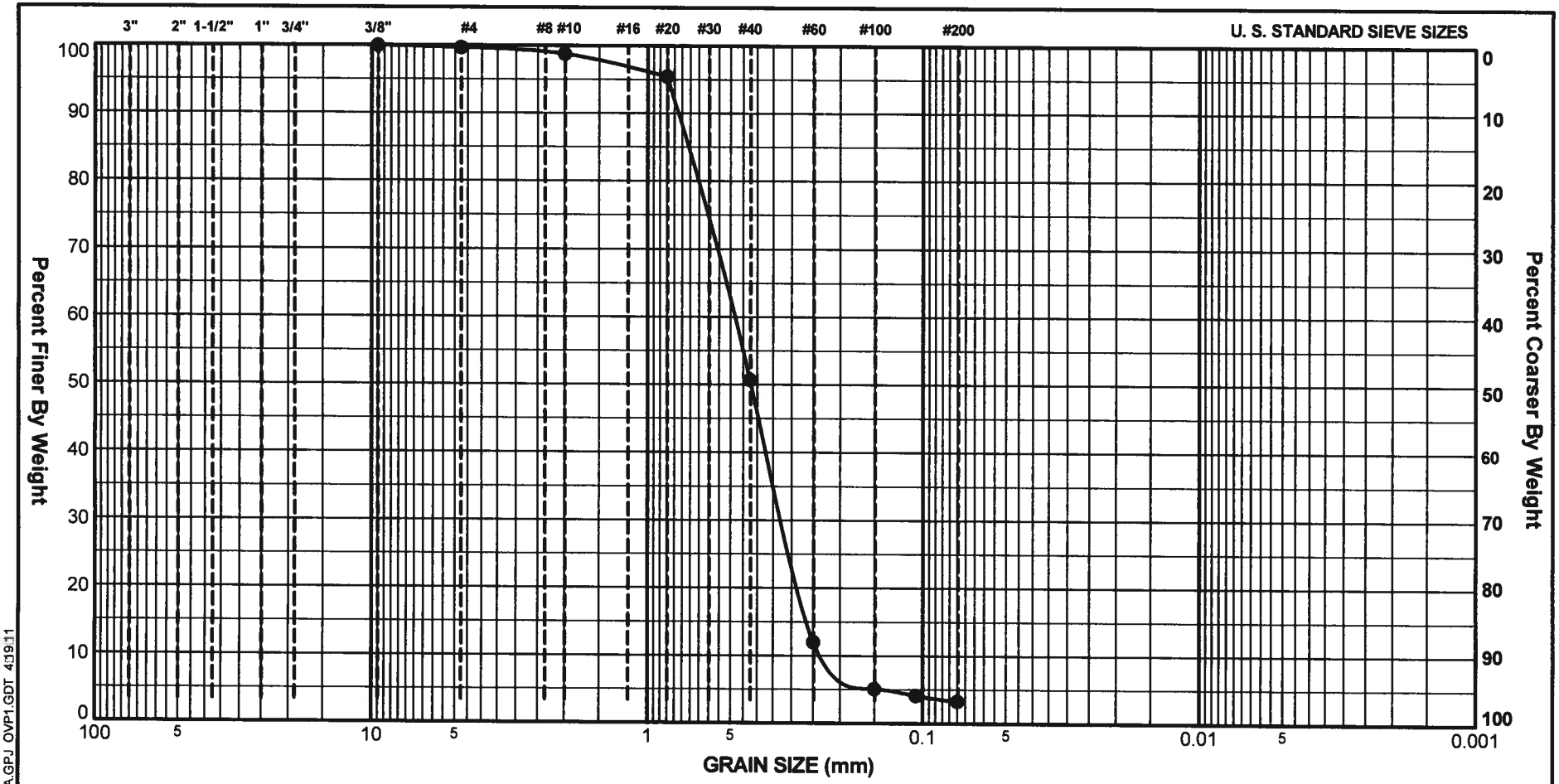
Figure No.

OVP GRAIN SIZE TO 3 INCHES 21562593SHELLROXANNA.GPJ OVP1.GDT 4/19/11



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

SYMBOL	BORING NO.	DEPTH (feet)	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_u	C_c	LL	PL	PI	% Gravel	% Sand	% Silt	% Clay	SAMPLE DESCRIPTION
●	SVE-1	35'	0.7230	0.4910	0.4210	0.3200	0.2605	0.2156	2.28	0.97	NP	NP	NP	0.3	96.4	3.3		POORLY GRADED SAND SP

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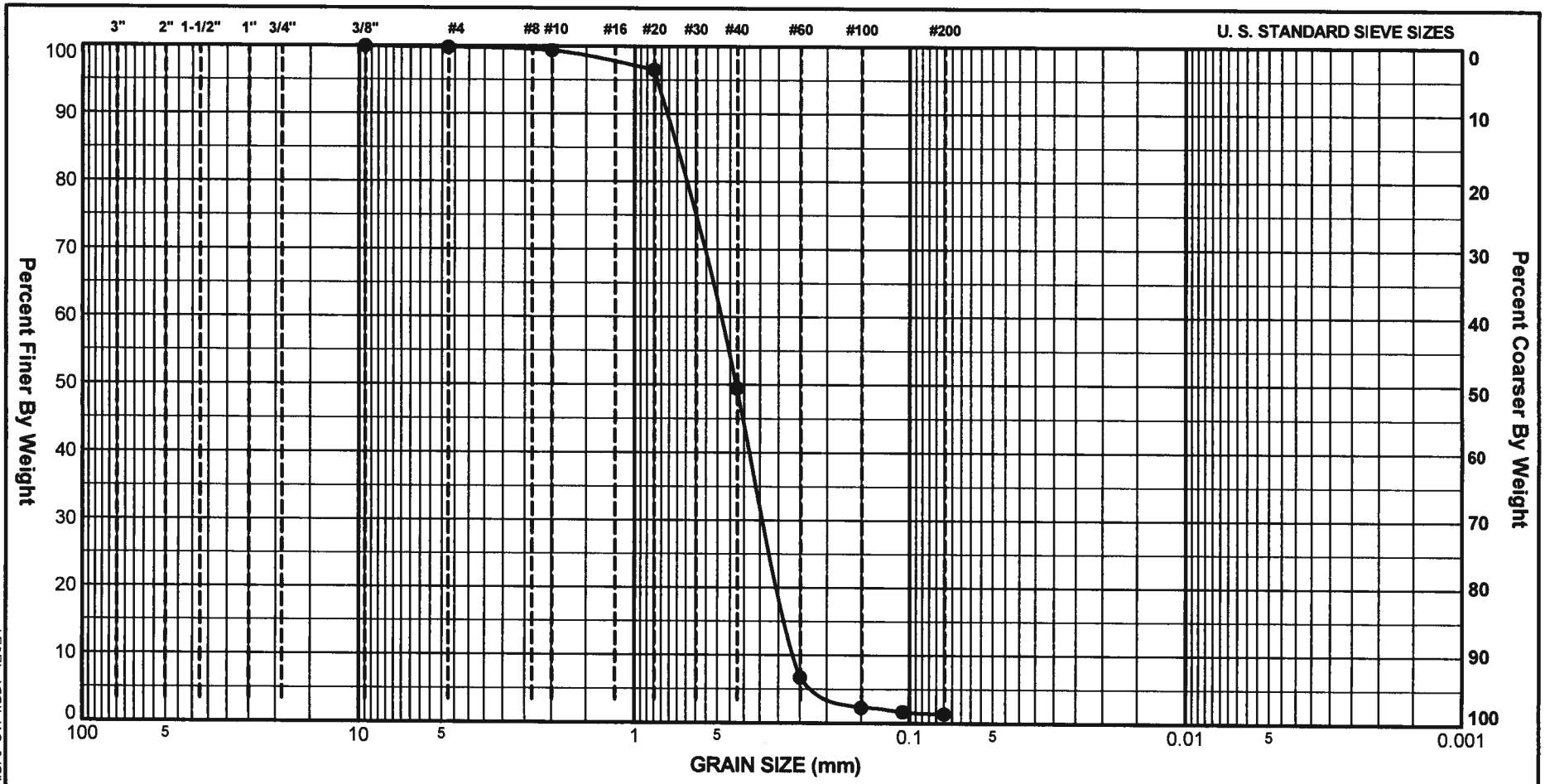
Figure No.

OVP GRAIN SIZE TO 3 INCHES 21562593SHELLROXANNA.GPJ OVP1.GDT 4/19/11



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

SYMBOL	BORING NO.	DEPTH (feet)	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_u	C_c	LL	PL	PI	% Gravel	% Sand	% Silt	% Clay	SAMPLE DESCRIPTION
●	SVE-1	40'	0.7174	0.4964	0.4284	0.3338	0.2771	0.2604	1.91	0.86	NP	NP	NP	0.2	98.4	1.4		POORLY GRADED SAND SP

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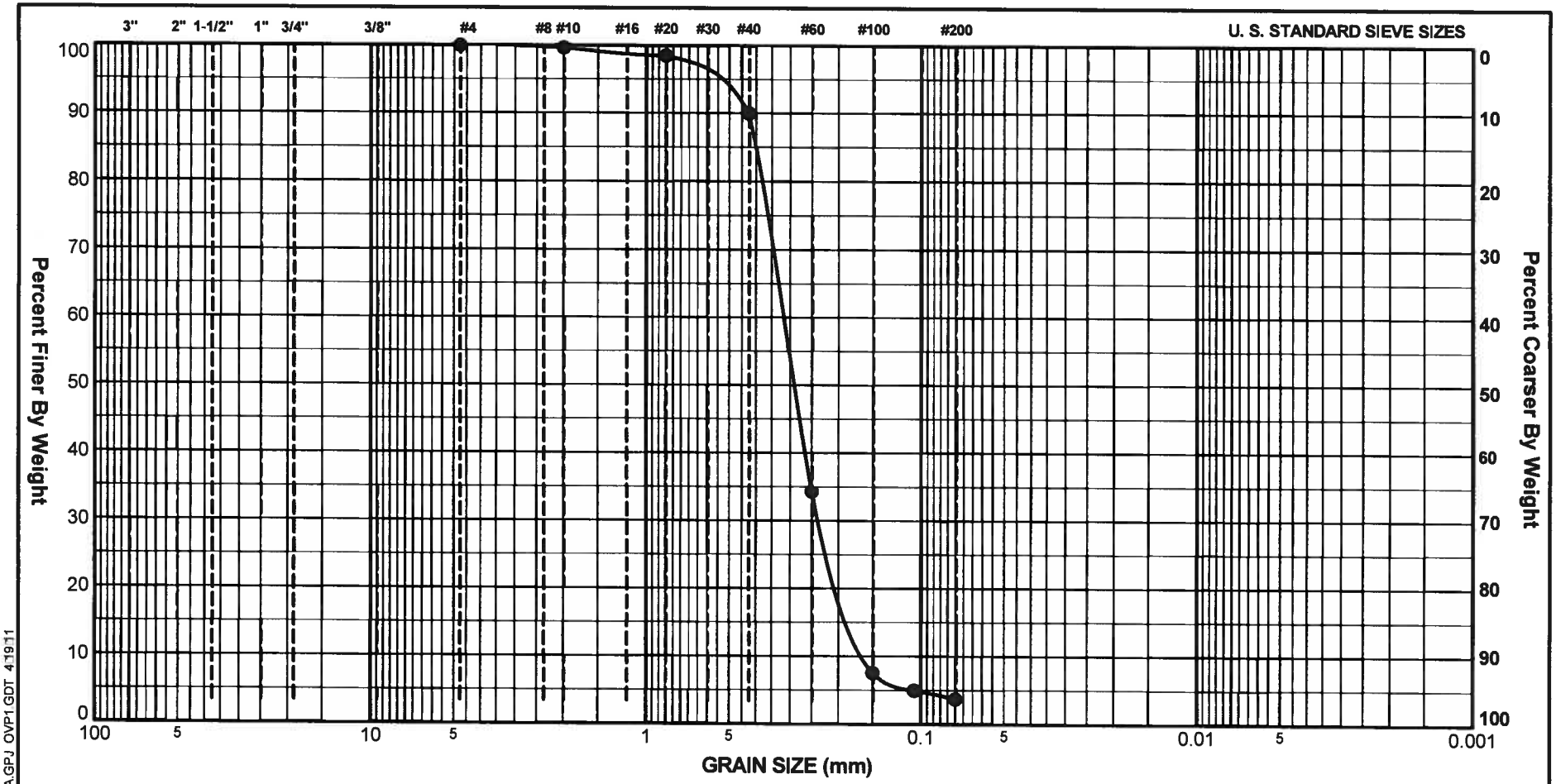
Figure No.

OVP GRAIN SIZE TO 3 INCHES 21562593SHELLROXANNA.GPJ OVP1.GDT 4/19/11



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

SYMBOL	BORING NO.	DEPTH (feet)	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_u	C_c	LL	PL	PI	% Gravel	% Sand	% Silt	% Clay	SAMPLE DESCRIPTION
●	SVE-1	45'	0.4053	0.3193	0.2903	0.2302	0.1729	0.1571	2.03	1.06	NP	NP	NP	0.0	96.3	3.7		POORLY GRADED SAND SP

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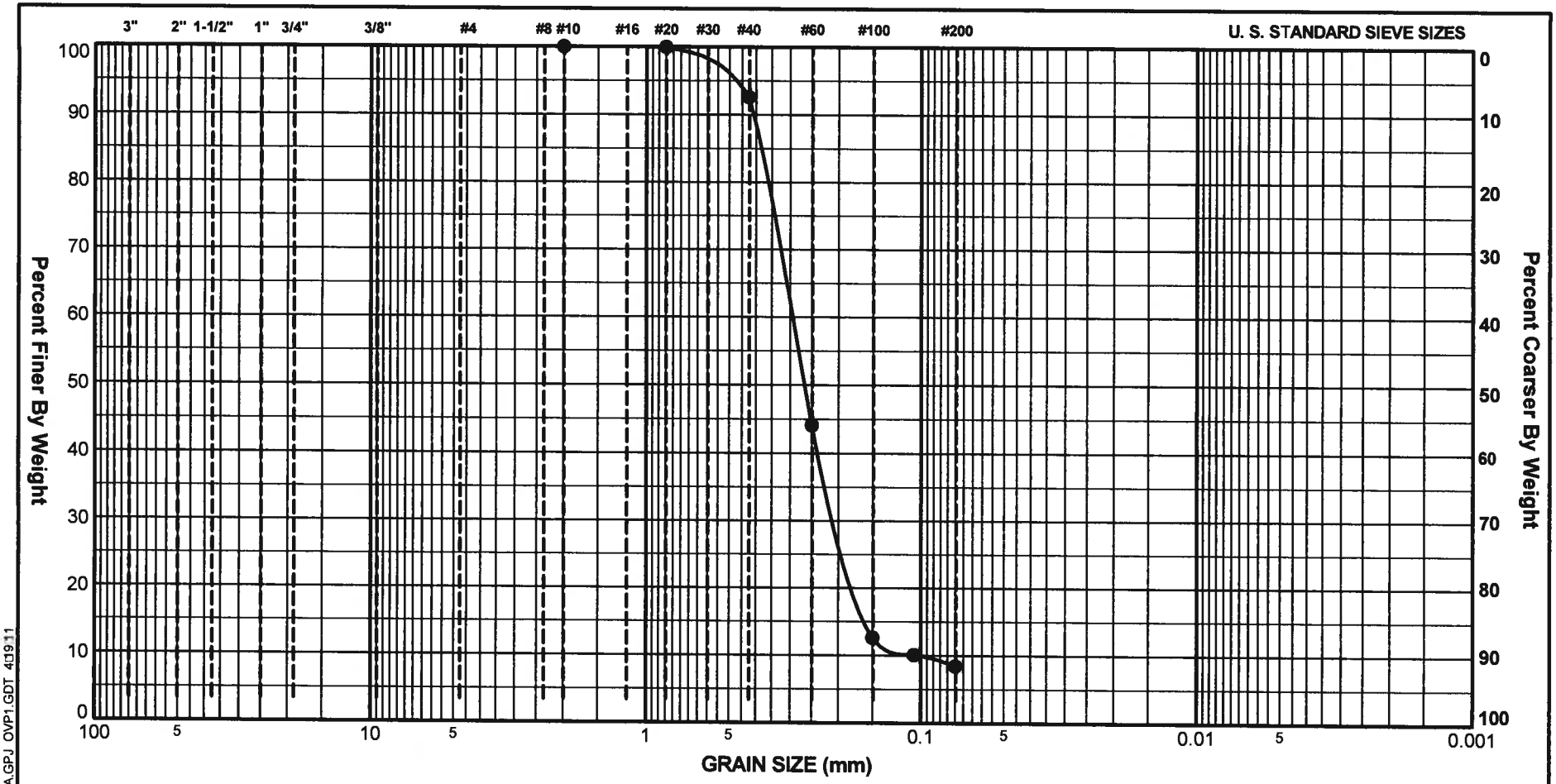
Figure No.

OVP GRAIN SIZE TO 3 INCHES 21562593SHELLROXANNA.GPJ OVP1.GDT 4/19/11



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

SYMBOL	BORING NO.	DEPTH (feet)	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_u	C_c	LL	PL	PI	% Gravel	% Sand	% Silt	% Clay	SAMPLE DESCRIPTION
●	SVE-1	55'	0.3910	0.2974	0.2666	0.1988	0.1559	0.1043	2.85	1.27	NP	NP	NP	0.0	91.5	8.5		POORLY GRADED SAND with SILT SP-S

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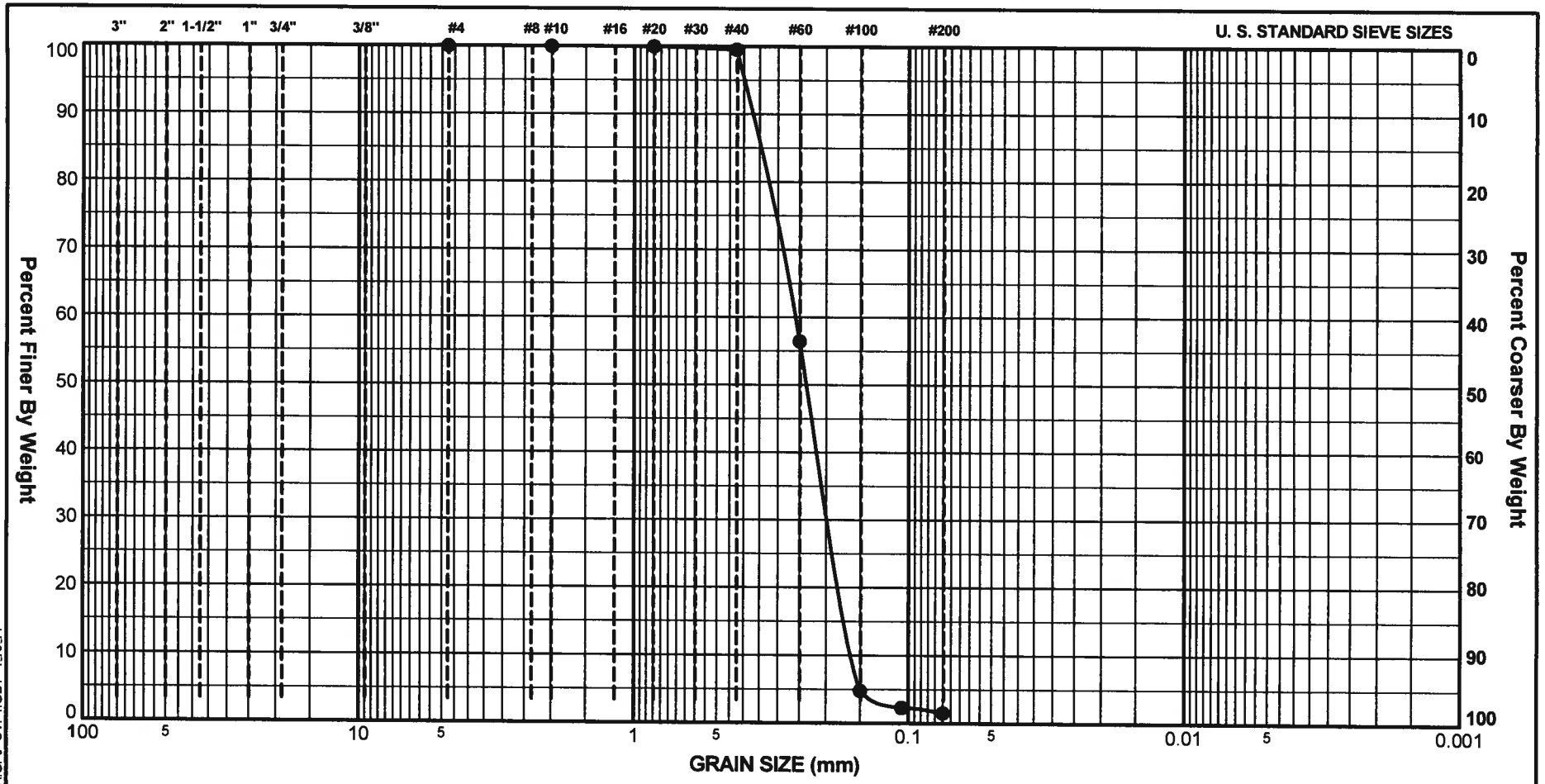
Figure No.

OVP GRAIN SIZE TO 3 INCHES 21562593SHELLROXANNA.GPJ OVP1.GDT 4/19/11



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

SYMBOL	BORING NO.	DEPTH (feet)	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_u	C_c	LL	PL	PI	% Gravel	% Sand	% Silt	% Clay	SAMPLE DESCRIPTION
●	SVE-2	10'	0.3554	0.2613	0.2346	0.1925	0.1659	0.1579	1.65	0.90	NP	NP	NP	0.0	98.5	1.5		POORLY GRADED SAND SP

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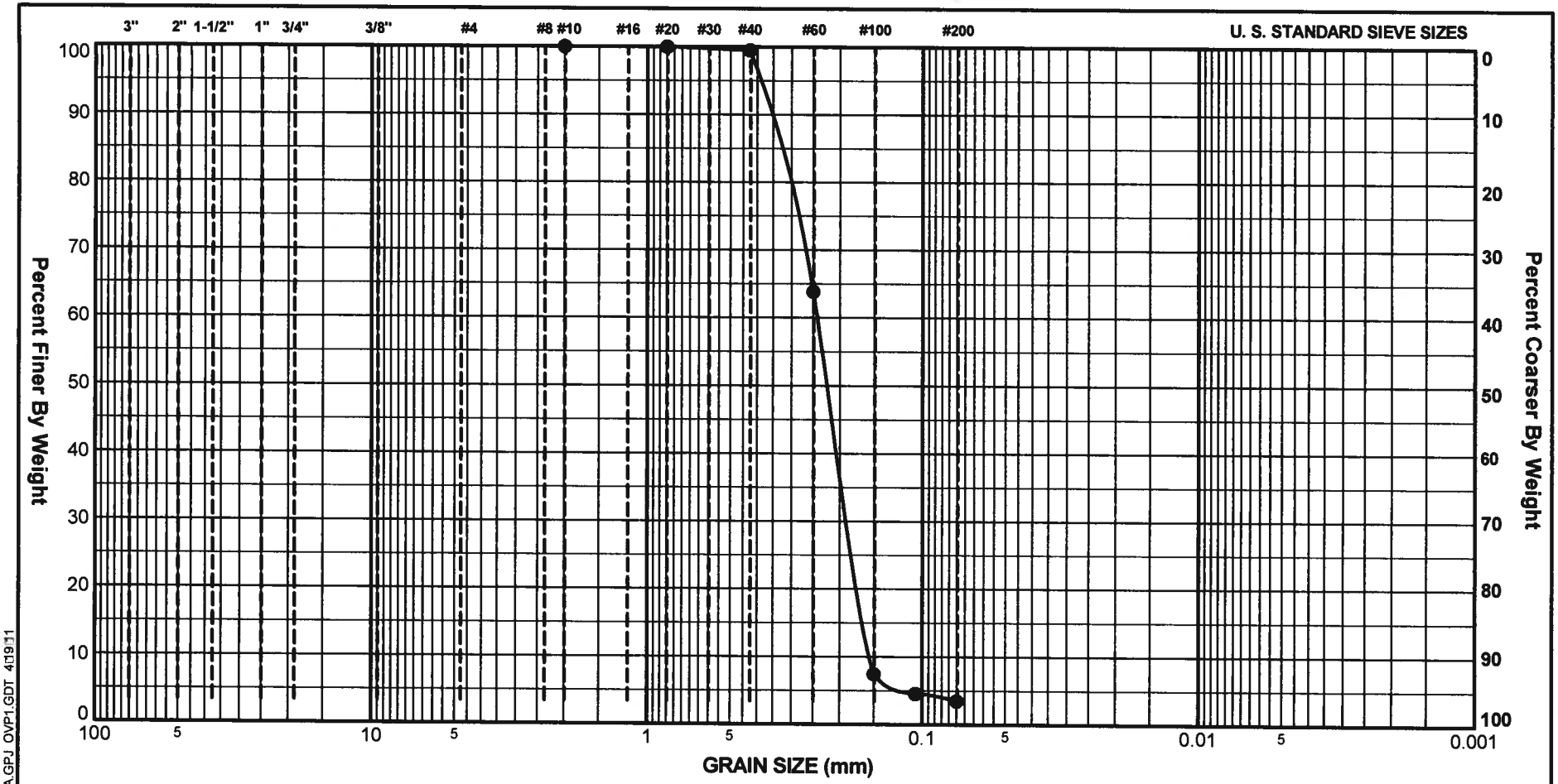
Figure No.

OVP GRAIN SIZE TO 3 INCHES 21562593SHELLROXANNA.GPJ OVP1.GDT 4/19/11



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

SYMBOL	BORING NO.	DEPTH (feet)	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_u	C_c	LL	PL	PI	% Gravel	% Sand	% Silt	% Clay	SAMPLE DESCRIPTION
●	SVE-2	20'	0.3426	0.2415	0.2206	0.1840	0.1606	0.1535	1.57	0.91	NP	NP	NP	0.0	96.5	3.5		POORLY GRADED SAND SP

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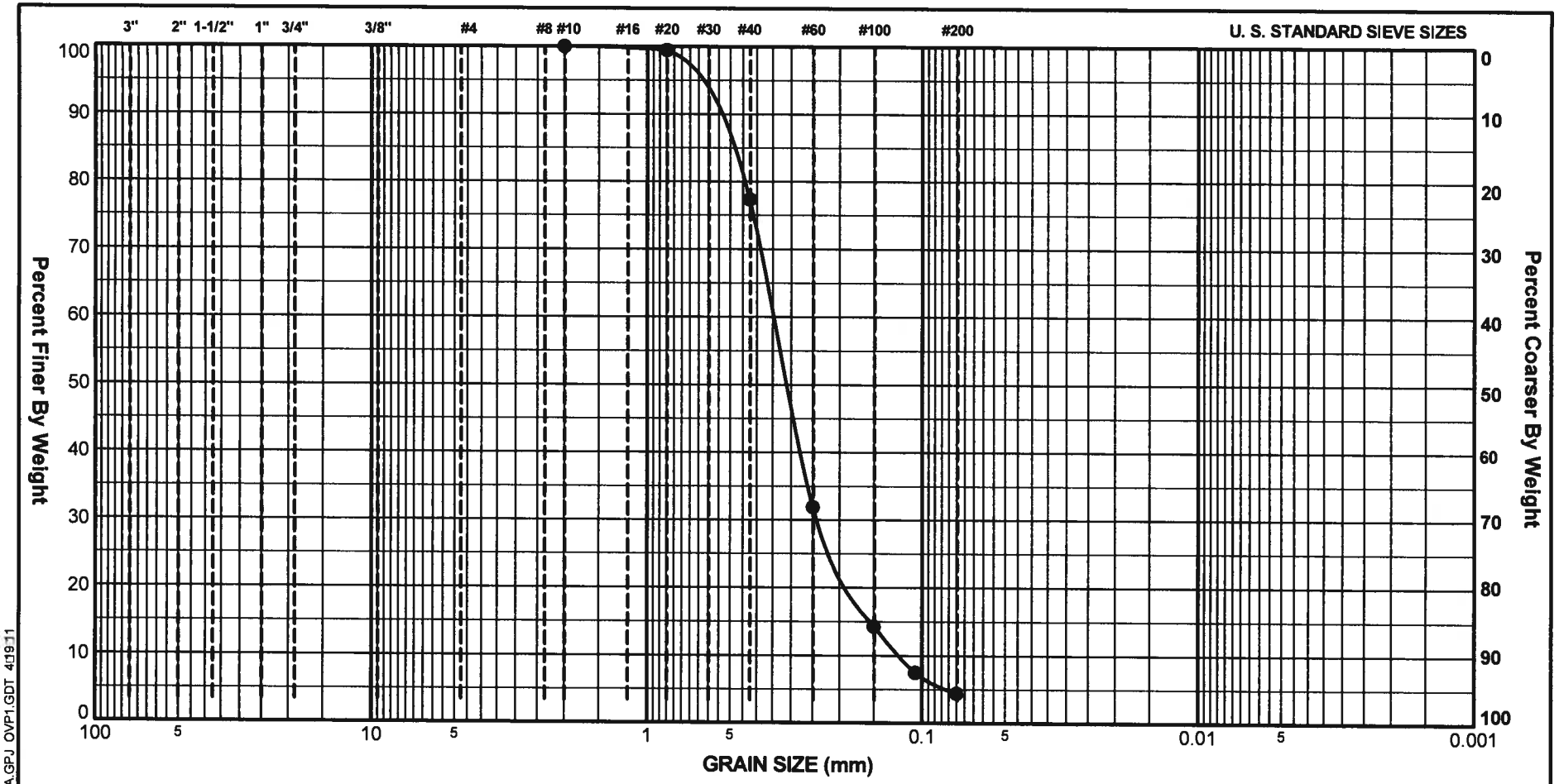
Figure No.

OVP GRAIN SIZE TO 3 INCHES 21562593SHELLROXANNA.GPJ OVP1.GDT 4/19/11



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

SYMBOL	BORING NO.	DEPTH (feet)	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_u	C_c	LL	PL	PI	% Gravel	% Sand	% Silt	% Clay	SAMPLE DESCRIPTION
●	SVE-2	30'	0.5398	0.3470	0.3088	0.2365	0.1531	0.1204	2.88	1.34	NP	NP	NP	0.0	95.6	4.4		POORLY GRADED SAND SP

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Roxanna, Illinois

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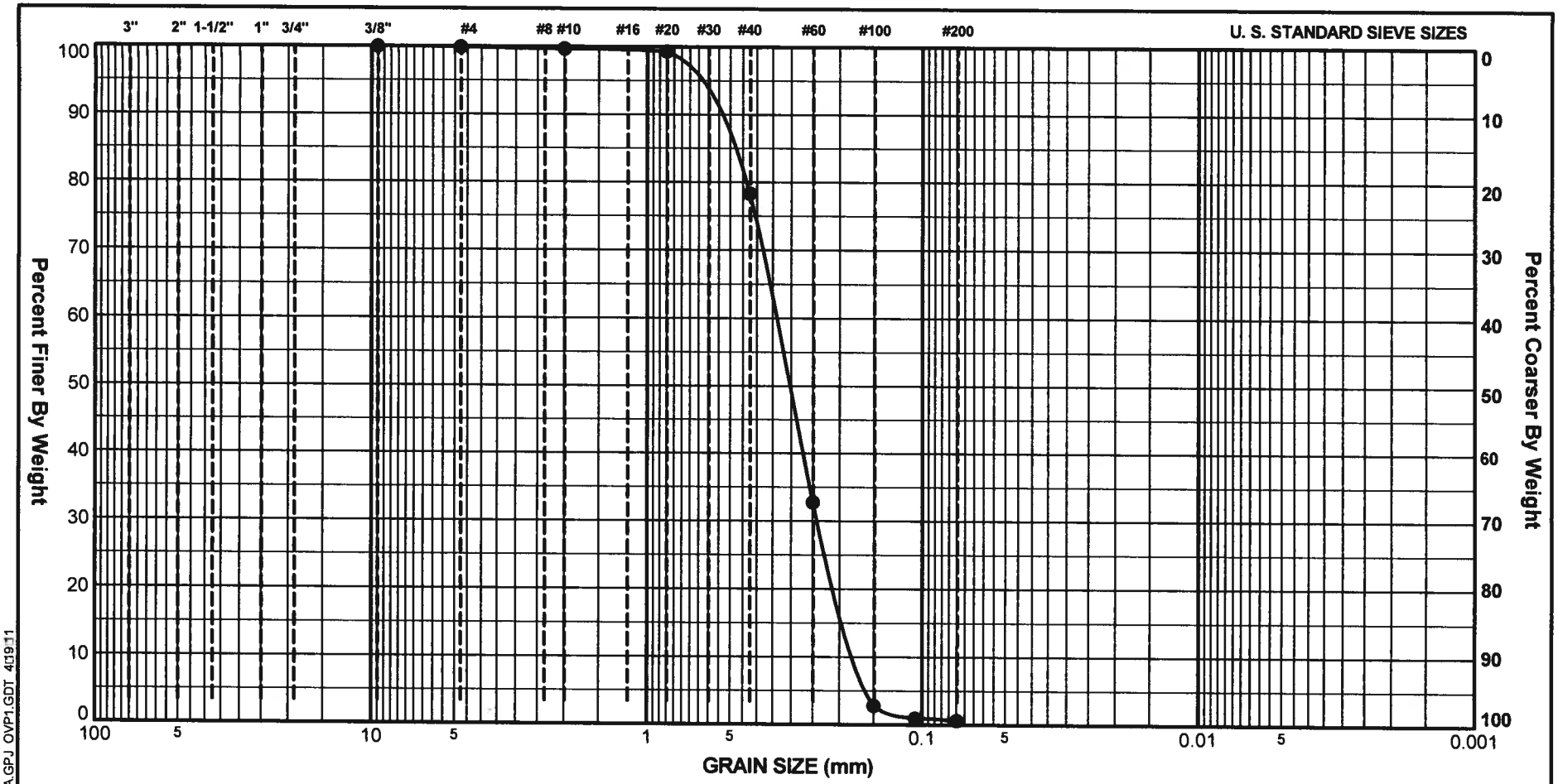
Proj. No.21562593

Figure No.

OVP GRAIN SIZE TO 3 INCHES 21562593SHELLROXANNA.GPJ OVP1.GDT 4/19/11



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

SYMBOL	BORING NO.	DEPTH (feet)	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_u	C_c	LL	PL	PI	% Gravel	% Sand	% Silt	% Clay	SAMPLE DESCRIPTION
●	SVE-2	35'	0.5296	0.3433	0.3056	0.2385	0.1847	0.1696	2.02	0.98	NP	NP	NP	0.1	99.3	0.6		POORLY GRADED SAND SP

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URS

SHELL-West Fence Line
Roxanna, Illinois

GRADATION CURVES

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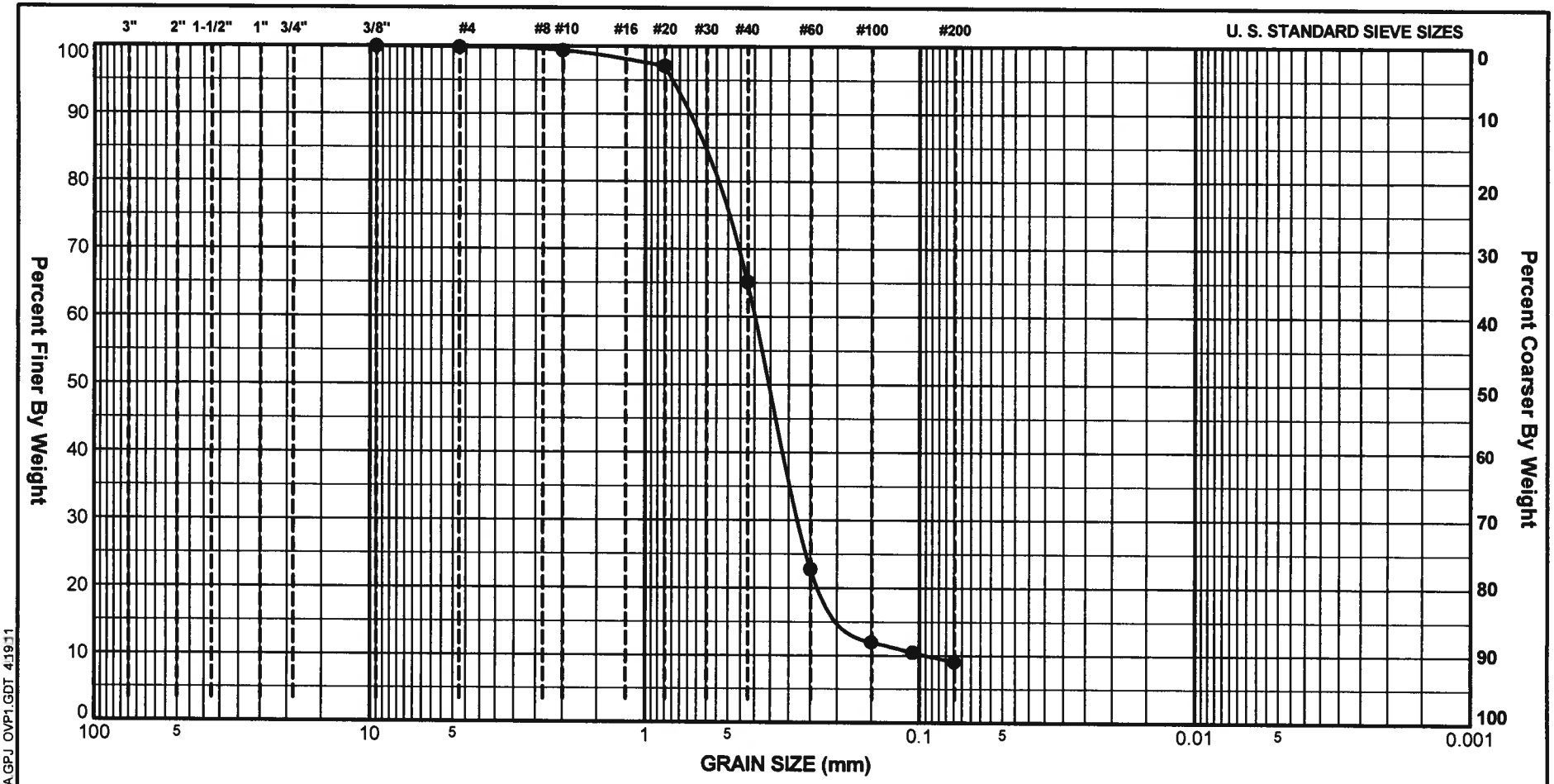
Date: 4/19/2011

Proj. No.21562593

Figure No.

OVP GRAIN SIZE TO 3 INCHES 21562593SHELLROXANNA.GPJ OVP1.GDT 4/19/11



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

SYMBOL	BORING NO.	DEPTH (feet)	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_u	C_c	LL	PL	PI	% Gravel	% Sand	% Silt	% Clay	SAMPLE DESCRIPTION
●	SVE-2	45'	0.6534	0.3984	0.3515	0.2736	0.1730	0.0945	4.22	1.99	NP	NP	NP	0.1	90.8	9.1		POORLY GRADED SAND with SILT SP-S

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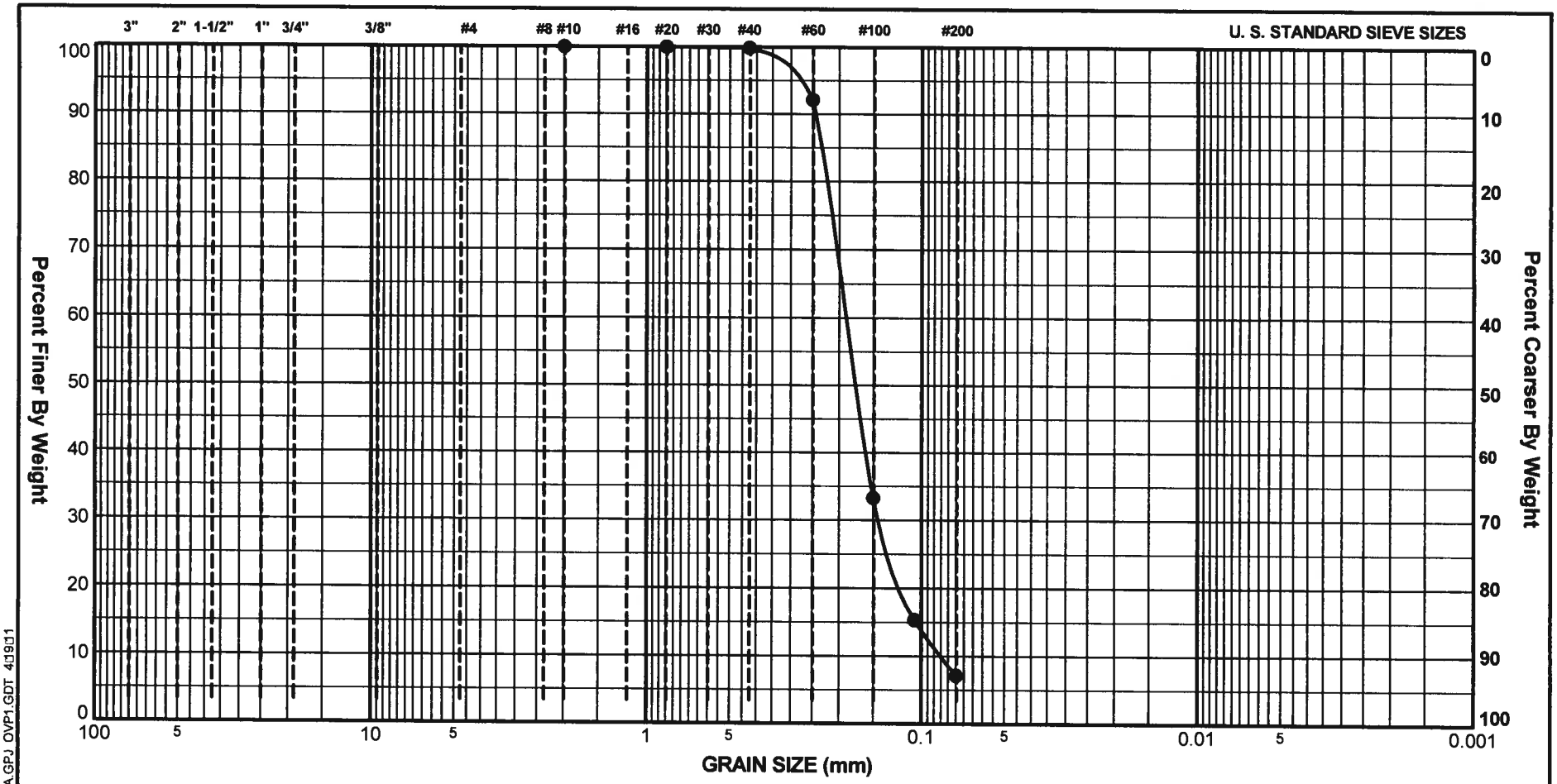
Figure No.

OVP GRAIN SIZE TO 3 INCHES 21562593SHELLROXANNA.GPJ OVP1.GDT 4/19/11



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

SYMBOL	BORING NO.	DEPTH (feet)	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_u	C_c	LL	PL	PI	% Gravel	% Sand	% Silt	% Clay	SAMPLE DESCRIPTION
●	V□P-26	11.0'-12.0'	0.2350	0.1891	0.1734	0.1408	0.1045	0.0846	2.24	1.24	NP	NP	NP	0.0	92.8	7.2		POORLY GRADED SAND with SILT SP-S□

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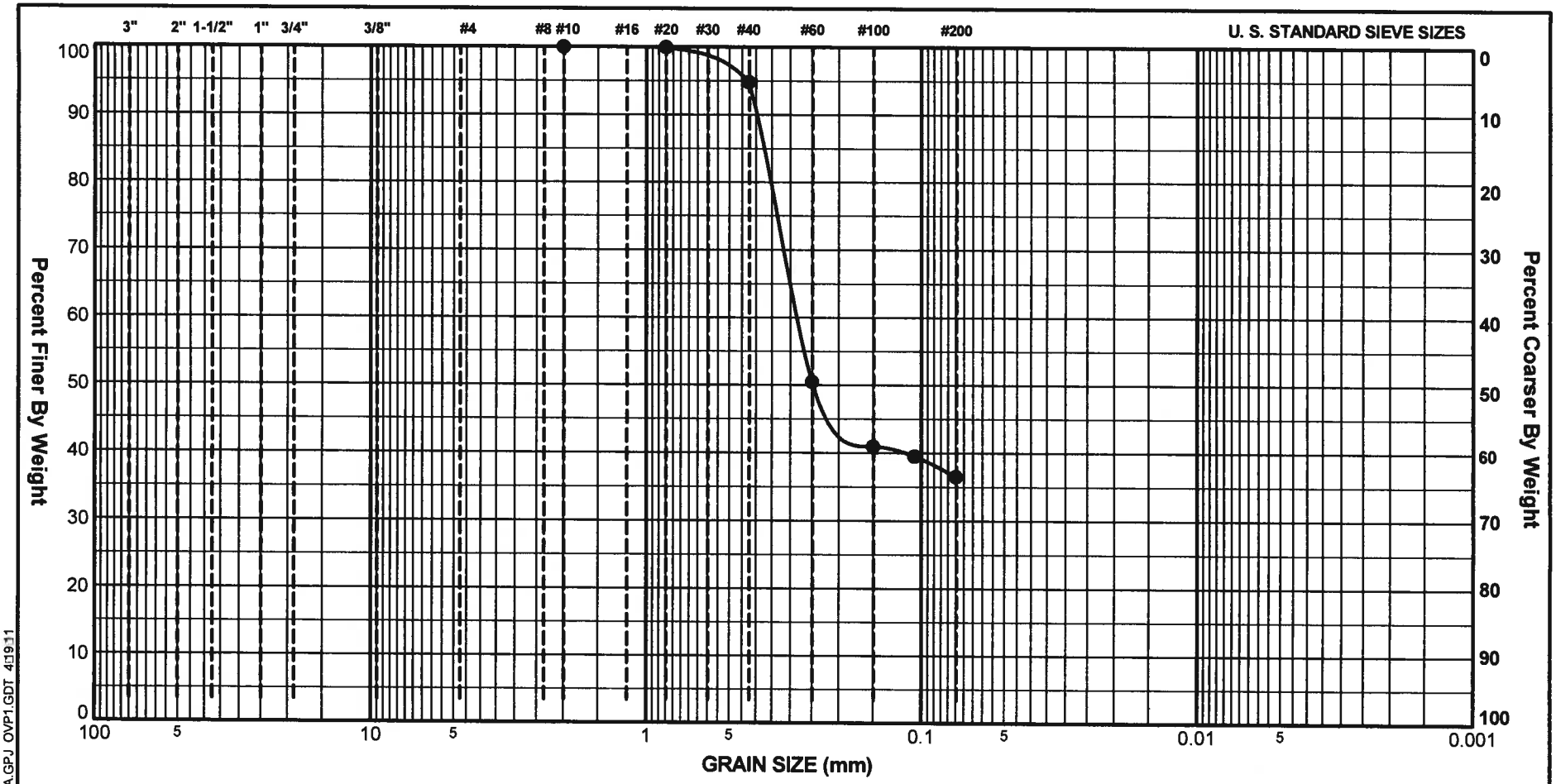
Figure No.

OVP GRAIN SIZE TO 3 INCHES 21562593SHELLROXANNA.GPJ OVP1.GDT 4□9□1



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

SYMBOL	BORING NO.	DEPTH (feet)	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_u	C_c	LL	PL	PI	% Gravel	% Sand	% Silt	% Clay	SAMPLE DESCRIPTION
●	V□P-26	31.0'-32.0'	0.3778	0.2802	0.2438						NP	NP	NP	0.0	63.5	36.5		SILTY SAND S□

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Date: 4/19/2011

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Figure No.

OVP GRAIN SIZE TO 3 INCHES 21562593SHELLROXANNA.GPJ OVP1.GDT 4□9□11

APPENDIX B SVE System Calculations

Calculation report

Pipe pressure drop calculator

1. volume flow rate (q):
q : 179.68016 ft^3/min

2. weight flow rate (w):
w : 39.881046 lb/h

3. pipe length (L):
L : 2250 ft

4. pipe diameter (D):
D : 4 in

5. pipe roughness (kr):
kr : 0.061 mm

6. density (ρ):
ρ : 0.0037 lb/ft^3

7. kinematic viscosity (v):
v : 303.7655 mm^2/s

8. dynamic viscosity (μ):
μ : 0.018 cP

9. K factor - minor lossed coefficient (K):
K : 22.23

10. velocity (V):
V : 34.29369 ft/s

11. cross section area (A):
A : 12.566371 in^2

12. friction coefficient (f):
f : 0.04114046

13. Reynolds number (Re):
Re : 3498.399

14. boundary layer (δ):
δ : 5.049816 mm

15. pressure on the pipe start (p_1):
p_1 : 0.72 psi

16. pressure on the pipe end (p_2):
p_2 : 0.57900006 psi

17. pressure drop (p_1-p_2):
p_1-p_2 : 0.141 psi

Calculators

Pressure drop and flow rate
Pipe diameter and flow velocity
Compressible air flow
Isothermal gas flow
Natural gas flow
LPG
Control valve sizing
Gas control valve sizing
Venturi tube flow rate meter
Orifice plate flow rate meter
Nozzle and Venturi nozzle
Prandtl probe
Thermal energy
Reynolds number
Resistance coefficient K

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Calculation report

Pipe pressure drop calculator

1. volume flow rate (q):
q : 177.73341 ft^3/min

2. weight flow rate (w):
w : 39.44895 lb/h

3. pipe length (L):
L : 1700 ft

4. pipe diameter (D):
D : 4 in

5. pipe roughness (kr):
kr : 0.061 mm

6. density (p):
p : 0.0037 lb/ft^3

7. kinematic viscosity (v):
v : 303.7655 mm^2/s

8. dynamic viscosity (μ):
μ : 0.018 cP

9. K factor - minor lossed coefficient (K):
K : 22.23

10. velocity (V):
V : 33.92229 ft/s

11. cross section area (A):
A : 12.566371 in^2

12. friction coefficient (f):
f : 0.04125261

13. Reynolds number (Re):
Re : 3460.5112

14. boundary layer (δ):
δ : 5.0981607 mm

15. pressure on the pipe start (p_1):
p_1 : 0.72 psi

16. pressure on the pipe end (p_2):
p_2 : 0.61300004 psi

17. pressure drop (p_1-p_2):
p_1-p_2 : 0.107 psi

Calculators
Pressure drop and flow rate
Pipe diameter and flow velocity
Compressible air flow
Isothermal gas flow
Natural gas flow
LPG
Control valve sizing
Gas control valve sizing
Venturi tube flow rate meter
Orifice plate flow rate meter
Nozzle and Venturi nozzle
Prandtl probe
Thermal energy
Reynolds number
Resistance coefficient K

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Calculation report

Pipe pressure drop calculator

1. volume flow rate (q):
q : 176.496 ft^3/min

2. weight flow rate (w):
w : 39.1743 lb/h

3. pipe length (L):
L : 1350 ft

4. pipe diameter (D):
D : 4 in

5. pipe roughness (kr):
kr : 0.061 mm

6. density (p):
p : 0.0037 lb/ft^3

7. kinematic viscosity (v):
v : 303.7655 mm^2/s

8. dynamic viscosity (μ):
μ : 0.018 cP

9. K factor - minor lossed coefficient (K):
K : 22.23

10. velocity (V):
V : 33.68615 ft/s

11. cross section area (A):
A : 12.566371 in^2

12. friction coefficient (f):
f : 0.041324712

13. Reynolds number (Re):
Re : 3436.4219

14. boundary layer (δ):
δ : 5.1294174 mm

15. pressure on the pipe start (p_1):
p_1 : 0.72 psi

16. pressure on the pipe end (p_2):
p_2 : 0.634 psi

17. pressure drop (p_1-p_2):
p_1-p_2 : 0.086 psi

Calculators
Pressure drop and flow rate
Pipe diameter and flow velocity
Compressible air flow
Isothermal gas flow
Natural gas flow
LPG
Control valve sizing
Gas control valve sizing
Venturi tube flow rate meter
Orifice plate flow rate meter
Nozzle and Venturi nozzle
Prandtl probe
Thermal energy
Reynolds number
Resistance coefficient K

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Calculation report

Pipe pressure drop calculator

1. volume flow rate (q):
q : 174.52556 ft^3/min

2. weight flow rate (w):
w : 38.73695 lb/h

3. pipe length (L):
L : 1000 ft

4. pipe diameter (D):
D : 4 in

5. pipe roughness (kr):
kr : 0.061 mm

6. density (p):
ρ : 0.0037 lb/ft^3

7. kinematic viscosity (v):
v : 303.7655 mm^2/s

8. dynamic viscosity (μ):
μ : 0.018 cP

9. K factor - minor lossed coefficient (K):
K : 22.23

10. velocity (V):
V : 33.310028 ft/s

11. cross section area (A):
A : 12.566371 in^2

12. friction coefficient (f):
f : 0.041440878

13. Reynolds number (Re):
Re : 3398.0522

14. boundary layer (δ):
δ : 5.1800613 mm

15. pressure on the pipe start (p_1):
p_1 : 0.72 psi

16. pressure on the pipe end (p_2):
p_2 : 0.6550001 psi

17. pressure drop (p_1-p_2):
p_1-p_2 : 0.065 psi

Calculators

Pressure drop and flow rate
Pipe diameter and flow velocity
Compressible air flow
Isothermal gas flow
Natural gas flow
LPG
Control valve sizing
Gas control valve sizing
Venturi tube flow rate meter
Orifice plate flow rate meter
Nozzle and Venturi nozzle
Prandtl probe
Thermal energy
Reynolds number
Resistance coefficient K

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Calculation report

Pipe pressure drop calculator

1. volume flow rate (q):
q : 168.19159 ft^3/min

2. weight flow rate (w):
w : 37.33109 lb/h

3. pipe length (L):
L : 500 ft

4. pipe diameter (D):
D : 4 in

5. pipe roughness (kr):
kr : 0.061 mm

6. density (p):
p : 0.0037 lb/ft^3

7. kinematic viscosity (v):
v : 303.7655 mm^2/s

8. dynamic viscosity (μ):
μ : 0.018 cP

9. K factor - minor lossed coefficient (K):
K : 22.23

10. velocity (V):
V : 32.101116 ft/s

11. cross section area (A):
A : 12.566371 in^2

12. friction coefficient (f):
f : 0.041825645

13. Reynolds number (Re):
Re : 3274.7283

14. boundary layer (δ):
δ : 5.350358 mm

15. pressure on the pipe start (p_1):
p_1 : 0.72 psi

16. pressure on the pipe end (p_2):
p_2 : 0.685 psi

17. pressure drop (p_1-p_2):
p_1-p_2 : 0.035 psi

Calculators

Pressure drop and flow rate
Pipe diameter and flow velocity
Compressible air flow
Isothermal gas flow
Natural gas flow
LPG
Control valve sizing
Gas control valve sizing
Venturi tube flow rate meter
Orifice plate flow rate meter
Nozzle and Venturi nozzle
Prandtl probe
Thermal energy
Reynolds number
Resistance coefficient K

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Calculation report

Pipe pressure drop calculator

1. volume flow rate (q):
q : 163.9492 ft^3/min

2. weight flow rate (w):
w : 36.389465 lb/h

3. pipe length (L):
L : 350 ft

4. pipe diameter (D):
D : 4 in

5. pipe roughness (kr):
kr : 0.061 mm

6. density (ρ):
ρ : 0.0037 lb/ft^3

7. kinematic viscosity (v):
v : 303.7655 mm^2/s

8. dynamic viscosity (μ):
μ : 0.018 cP

9. K factor - minor lossed coefficient (K):
K : 22.23

10. velocity (V):
V : 31.291464 ft/s

11. cross section area (A):
A : 12.566371 in^2

12. friction coefficient (f):
f : 0.042093616

13. Reynolds number (Re):
Re : 3192.133

14. boundary layer (δ):
δ : 5.4712977 mm

15. pressure on the pipe start (p_1):
p_1 : 0.72 psi

16. pressure on the pipe end (p_2):
p_2 : 0.69400007 psi

17. pressure drop (p_1-p_2):
p_1-p_2 : 0.026 psi

Calculators
Pressure drop and flow rate
Pipe diameter and flow velocity
Compressible air flow
Isothermal gas flow
Natural gas flow
LPG
Control valve sizing
Gas control valve sizing
Venturi tube flow rate meter
Orifice plate flow rate meter
Nozzle and Venturi nozzle
Prandtl probe
Thermal energy
Reynolds number
Resistance coefficient K

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APPENDIX C Design Package (Specs and Drawings)

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ALUMINUM ASSOCIATION (AA)
AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)
AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
AMERICAN WELDING SOCIETY (AWS)
ASTM INTERNATIONAL (ASTM)
NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

1.2 GENERAL REQUIREMENTS

All exterior and interior signage shall be provided by a single manufacturer. Exterior signage shall be of the design, detail, sizes, types, and message content shown on the drawings, shall conform to the requirements specified, and shall be provided at the locations indicated. Signs shall be complete with lettering, framing (as detailed) and related components for a complete installation. Submit one sample of each type of sign. Each sample shall consist of a complete sign panel with letters and symbols.

1.2.1 Wind Load Requirements

Exterior signage shall be designed to withstand a 90 mph wind load. Submit design analysis and supporting calculations performed in support of specified signage.

1.2.2 Character Proportions and Heights

Characters and numbers on indicated signs shall be sized according to the viewing distance from which they are to be read. The minimum height is measured using an upper case letter "X". Lower case characters are permitted.

1.3 SUBMITTALS

Owner or Owner's Representative approval is required for all submittals. Submit the following in accordance with Section 00910 SUBMITTALS:

SD-02 Shop Drawings

Approved Detail Drawings

SD-03 Product Data

Modular Exterior Signage System Installation
Exterior Signage
Wind Load Requirements

SD-04 Samples

Exterior Signage
Interior Signage

SD-10 Operation and Maintenance Data

Protection and Cleaning
Approved Manufacturer's Instructions
Protection and Cleaning

Two copies of operating instructions outlining the step-by-step procedures required for system operation. Two copies of maintenance instructions listing routine procedures, repairs, and guides.

1.4 QUALIFICATIONS

Signs, plaques, and dimensional letters shall be the standard product of a manufacturer regularly engaged in the manufacture of the products. Items of equipment shall essentially duplicate equipment that has been in satisfactory use at least 2 years prior to bid opening.

1.5 DELIVERY AND STORAGE

Materials shall be wrapped for shipment and storage, delivered to the jobsite in manufacturer's original packaging, and stored in a clean, dry area in accordance with manufacturer's instructions.

1.6 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a one year period shall be provided.

PART 2 PRODUCTS

Signs, plaques, and dimensional letters shall be the standard product of a manufacturer regularly engaged in the manufacture of such products that essentially duplicate signs that have been in satisfactory use at least 2 years prior to bid opening.

2.1 MODULAR EXTERIOR SIGNAGE SYSTEM
Exterior signage shall consist of a system of coordinated directional, identification, and regulatory type signs located where shown. Dimensions, details, materials, message

content, and design of signage shall be as shown. Submit manufacturer's descriptive data and catalog cuts.

2.1.1 Free-Standing Base Mount Pylon/Monolith Type Signs

2.1.1.1 Framing

Interior framing shall consist of aluminum or galvanized steel tube columns welded to companion plates. Perimeter framing shall consist of aluminum or steel angle framing welded to the post and plate system as designed. Framing members shall be designed to permit access to electrical equipment. Mounting shall be provided as shown. Framing members of steel shall be finished with semi-gloss baked enamel or two-component acrylic polyurethane. Openings shall be sealed from moisture and made tamper-proof.

2.1.1.2 Exterior Sheeting Panels

Modular panels shall be provided in sizes shown on drawings. Panels shall be fabricated a minimum of 0.090 inch thick aluminum or steel. Top and end panels shall be removable and shall be secured by 3/16 inch socket head jack nuts. Finish for metal panels shall be anodized conforming to AA DAF-45.

2.1.1.3 Mounting

Mounting shall be provided by securing to concrete foundation as shown.

2.1.1.4 Finishes

Base finish shall be anodized conforming to AA DAF-45. Metal panel system finish shall be anodized conforming to AA DAF-45.

2.1.2 Panel and Post/Panel Type Signs

2.1.2.1 Posts

One-piece aluminum or galvanized steel posts shall be provided with minimum 0.125 inch wall thickness. Posts shall be designed to accept panel framing system described. The post shall be designed to permit attachment of panel framing system without exposed fasteners. Caps shall be provided for each post.

2.1.2.2 Panel Framing System

Panel framing consisting of aluminum sections and interlocking track components shall be designed to interlock with posts with concealed fasteners.

2.1.2.3 Panels

Modular message panels shall be provided in sizes shown on drawings. Panels shall be fabricated a minimum of 0.125 inch aluminum. Panels with metal return sheeting shall have welded corners, ground smooth. Panels shall be heliarc welded to framing system.

2.1.2.4 Finishes

Post finish shall be anodized conforming to AA DAF-45. Metal panel system finish shall be anodized conforming to AA DAF-45.

2.1.2.5 Mounting

Removable mounting shall be provided by a steel flange embedded in concrete as shown.

2.2 BUILDING DIRECTORIES

Building directories shall be lobby directories or floor directories, and shall be provided with a changeable directory listing consisting of the areas, offices and personnel located within the facility. Dimensions, details, and materials of sign and message content shall be as shown on the drawings.

2.3 METAL PLAQUES

Design and location of plaques shall be as shown.

2.3.1 Cast Metal Plaques

2.3.1.1 Fabrication

Cast metal plaques shall have the logo, emblem and artwork cast in the flat relief technique. Plaques shall be fabricated from prime aluminum.

2.3.1.2 Size

Plaque size shall be as shown.

2.3.1.3 Border

Border shall be plain edge.

2.3.1.4 Background

Background texture shall be fine pebble.

2.3.1.5 Mounting

Mounting shall be rosettes and toggle bolts.

2.3.1.6 Finish

Finishes shall consist of aluminum light colored sandblasted background. Letters shall be satin polished and entire plaque shall be sprayed with two coats of clear lacquer.

2.3.3 Frost and Surface Oxidized Plaques

2.3.3.1 Fabrication

Plaque shall be frosted and surface oxidized one - piece stainless steel 0.125 inch thick.

2.3.3.2 Size

Plaque size shall be as shown.

2.3.3.3 Finish

Material finish shall be [polished]. Frosted areas shall be oxidized black for aluminum or stainless steel.

2.4 ANODIC COATING

Anodized finish shall conform to AA DAF-45 as follows:

Clear (natural) designation AA-M10-C22-A31, Architectural Class II 0.4 mil or thicker.

2.5 STEEL PRODUCTS

Structural steel products shall conform to ASTM A 36/A 36M . Sheet and strip steel products shall conform to ASTM A 1011/A 1011M . Welding for steel products shall conform to AWS D1.2/D1.2M.

2.6 ANCHORS AND FASTENERS

Exposed anchor and fastener materials shall be compatible with metal to which applied and shall match in color and finish and shall be non-rusting, non-corroding, and non-staining. Exposed fasteners shall be tamper-proof.

2.7 SHOP FABRICATION AND MANUFACTURE

2.7.1 Factory Workmanship

Work shall be assembled in the shop, as far as practical, ready for installation at the site. Work that cannot be shop assembled shall be given a trial fit in the shop to ensure proper field assembly. Holes for bolts and screws shall be drilled or punched. Drilling and punching shall produce clean, true lines and surfaces. Welding to or on structural steel shall be in accordance with AWS D1.1/D1.1M. Welding shall be continuous along the entire area of contact. Exposed welds shall be ground smooth. Exposed surfaces of work shall have a smooth finish and exposed riveting shall be flush. Fastenings shall be concealed where practical. Items specified to be galvanized shall be by hot-dip process after fabrication if practical. Galvanization shall be in accordance with ASTM A 123/A 123M and ASTM A 653/A 653M, as applicable. Other metallic coatings of steel sheet shall be in accordance with ASTM A 924/A 924M. Joints exposed to the weather shall be formed to exclude water. Drainage and weep holes shall be included as required to prevent condensation buildup.

2.7.2 Dissimilar Materials

Where dissimilar metals are in contact, or where aluminum is in contact with concrete, mortar, masonry, wet or pressure-treated wood, or absorptive materials subject to wetting, the surfaces shall be protected with a coat of asphalt varnish or a coat of zinc-molybdate primer to prevent galvanic or corrosive action.

2.7.3 Shop Painting

Surfaces of miscellaneous metal work, except nonferrous metal, corrosion resisting steel, and zinc-coated work, shall be given one coat of zinc-molybdate primer or an approved rust-resisting treatment and metallic primer in accordance with manufacturer's standard practice. Surfaces of items to be embedded in concrete shall not be painted. Upon completion of work, damaged surfaces shall be recoated.

PART 3 EXECUTION

3.1 INSTALLATION

Signs, plaques, or dimensional letters shall be installed in accordance with approved manufacturer's instructions at locations shown on the approved detail drawings ; submit drawings showing elevations of each type of sign; dimensions, details, and methods of mounting or anchoring; shape and thickness of materials; and details of construction.

A schedule showing the location, each sign type, and message shall be included. Signs shall be installed plumb and true at mounting heights indicated, and by method shown or specified. Signs mounted on other surfaces shall not be installed until finishes on

such surfaces have been completed. Submit manufacturer's installation instructions and cleaning instructions.

3.1.1 Anchorage

Anchorage and fastener materials shall be in accordance with approved manufacturer's instructions for the indicated substrate. Anchorage not otherwise specified or indicated shall include slotted inserts, expansion shields, and powder-driven fasteners when approved for concrete; toggle bolts and through bolts for masonry; machine carriage bolts for steel; lag bolts and screws for wood.

3.1.2 Protection and Cleaning

The work shall be protected against damage during construction. Hardware and electrical equipment shall be adjusted for proper operation. Glass, frames, and other sign surfaces shall be cleaned in accordance with manufacturer's instructions. After signs are completed and inspected, cover all project identification, directional, and other signs which may mislead the public. Covering shall be maintained until instructed to be removed by the Owner or Owner's Representative or until the facility is to be opened for business. Submit 2 copies of maintenance instructions listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. The instructions shall include simplified diagrams for the equipment as installed. Signs shall be cleaned, as required, at time of cover removal.

PART 1 GENERAL

1.1 MEASUREMENT PROCEDURES

1.1.1 Excavation

The unit of measurement for excavation and borrow will be the cubic yard, computed by the average end area method from cross sections taken before and after the excavation and borrow operations, including the excavation for ditches, gutters, and channel changes, when the material is acceptably utilized or disposed of as herein specified. The measurements will include authorized excavation of rock (except for piping trenches that is covered below), authorized excavation of unsatisfactory subgrade soil, and the volume of loose, scattered rocks and boulders collected within the limits of the work; allowance will be made on the same basis for selected backfill ordered as replacement. The measurement will not include the volume of subgrade material or other material that is scarified or plowed and reused in-place, and will not include the volume excavated without authorization or the volume of any material used for purposes other than directed. The volume of overburden stripped from borrow pits and the volume of excavation for ditches to drain borrow pits, unless used as borrow material, will not be measured for payment. The measurement will not include the volume of any excavation performed prior to the taking of elevations and measurements of the undisturbed grade.

1.1.2 Piping Trench Excavation

Measure trench excavation by the number of linear feet along the centerline of the trench and excavate to the depths and widths specified for the particular size of pipe. Replace unstable trench bottoms with a selected granular material. Include the additional width at manholes and similar structures, the furnishing, placing and removal of sheeting and bracing, pumping and bailing, and all incidentals necessary to complete the work required by this section.

1.1.3 Rock Excavation for Trenches

Measure and pay for rock excavation by the number of cubic yards of acceptably excavated rock material. Measure the material in place, but base volume on a maximum 30 inches width for pipes 12 inches in diameter or less. Provide the measurement to include all authorized overdepth rock excavation as determined by the Owner's Representative. For manholes and other appurtenances, compute volumes of rock excavation on the basis of 1 foot outside of the wall lines of the structures.

1.1.4 Topsoil Requirements

Separate excavation, hauling, and spreading or piling of topsoil and related miscellaneous operations will be considered subsidiary obligations of the Contractor, covered under the contract unit price for excavation.

1.1.5 Overhaul Requirements

Allow the unit of measurement for overhaul to be the station-yard. The overhaul distance will be the distance in stations between the center of volume of the overhaul material in its original position and the center of volume after placing, minus the free-haul distance in stations. The haul distance will be measured along the shortest route determined by the Owner's Representative as feasible an satisfactory. Do no measure or waste unsatisfactory materials for overhaul where the length of haul for borrow is within the free-haul limits.

1.1.6 Select Granular Material

Measure select granular material in place as the actual cubic yards replacing wet or unstable material in trench bottoms within the limits shown. Provide unit prices which include furnishing and placing the granular material, excavation and disposal of unsatisfactory material, an additional requirements for sheeting and bracing, pumping, bailing, cleaning, and other incidentals necessary to complete the work.

1.2 PAYMENT PROCEDURES

Payment will constitute full compensation for all labor, equipment, tools, supplies, and incidentals necessary to complete the work.

1.2.1 Classified Excavation

Classified excavation will be paid for at the contract unit prices per cubic yard for common or rock excavation.

1.2.2 Piping Trench Excavation

Payment for trench excavation will constitute full payment for excavation and backfilling, except in rock or unstable trench bottoms.

1.2.3 Rock Excavation for Trenches

Payment for rock excavation will be made in addition to the price bid for the trench excavation, and will include all necessary drilling and blasting and all incidentals necessary to excavate and dispose of the rock. Select granular material, used as backfill replacing rock excavation, will not be

paid for separately, but will be included in the unit price for rock excavation.

1.2.4 Unclassified Excavation

Unclassified excavation will be paid for at the contract unit price per cubic yard for unclassified excavation.

1.2.5 Classified Borrow

Classified borrow will be paid for at the contract unit prices per cubic yard for common or rock borrow.

1.2.6 Unclassified Borrow

Unclassified borrow will be paid for at the contract unit price per cubic yard for unclassified borrow.

1.2.7 Authorized Overhaul

The number of station-yards of overhaul to be paid for will be the product of number of cubic yards of overhaul material measured in the original position, multiplied by the overhaul distance measured in stations of 100 feet and will be paid for at the contract unit price per station-yard for overhaul in excess of the free-haul limit as designated in paragraph DEFINITIONS.

1.2.8 Sheeting and Bracing

Sheeting and bracing, when shown or authorized by the Owner's Representative to be left in place, will be paid for as follows:

1.2.8.1 Timber Sheeting

Timber sheeting will be paid for as the number of board feet of lumber below finish grade measured in place prior to backfilling. Include in the measurement sheeting wasted when cut off between the finished grade and 1 foot below the finished grade.

1.2.8.2 Steel Sheeting and Soldier Piles

Steel sheeting, soldier piles, and steel bracing will be paid for according to the number of pounds of steel calculated. Calculate the steel by multiplying the measured in-place length in feet below finish grade by the unit weight of the section in pounds per foot. Obtain unit weight of rolled steel sections from recognized steel manuals.

1.3 CRITERIA FOR BIDDING

Base bids on the following criteria:

a. Surface elevations are as indicated.

b. Pipes or other artificial obstructions, except those indicated, will not be encountered.

c. Ground water elevations indicated by the boring log were those existing at the time subsurface investigations were made and do not necessarily represent ground water elevation at the time of construction.

d. Material character is indicated by the boring logs.

1.4 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 180	(2010) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
AASHTO T 224	(2010) Standard Method of Test for Correction for Coarse Particles in the Soil Compaction Test

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C600	(2010) Installation of Ductile-Iron Water Mains and Their Appurtenances

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2010) Structural Welding Code - Steel

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA C2	(2003) Lumber, Timber, Bridge Ties and Mine Ties - Preservative Treatment by Pressure Processes
AWPA P5	(2009) Standard for Waterborne Preservatives
ASTM INTERNATIONAL (ASTM)	
ASTM A 139/A 139M	(2004; R 2010) Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and over)
ASTM A 252	(2010) Standard Specification for Welded and Seamless Steel Pipe Piles
ASTM C 136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C 33/C 33M	(2008) Standard Specification for Concrete Aggregates
ASTM D 1140	(2000; R 2006) Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve
ASTM D 1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	(2009) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D 1883	(2007e2) CBR (California Bearing Ratio) of Laboratory-Compacted Soils

ASTM D 2167	(2008) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D 2434	(1968; R 2006) Permeability of Granular Soils (Constant Head)
ASTM D 2487	(2010) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 2937	(2010) Density of Soil in Place by the Drive-Cylinder Method
ASTM D 422	(1963; R 2007) Particle-Size Analysis of Soils
ASTM D 4318	(2010) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 6938	(2010) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D 698	(2007e1) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-203 Untreated	(Rev C; Notice 3) Paper, Kraft,

1.5 DEFINITIONS

1.5.1 Satisfactory Materials

Satisfactory materials comprise any materials classified by ASTM D 2487 as SP, SM, SC, SP-SM, CL, ML. Satisfactory materials for grading comprise stones less than 8 inches, except for fill material for pavements and railroads which comprise stones less than 3 inches in any dimension.

1.5.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include man-made fills; trash; refuse; backfills from previous construction; and material classified as satisfactory which contains root and other organic matter or frozen material. Notify the Owner's Representative when encountering any contaminated materials.

1.5.3 Cohesionless and Cohesive Materials

Cohesionless materials include materials classified in ASTM D 2487 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesionless only when the fines are nonplastic. Perform testing, required for classifying materials, in accordance with ASTM D 4318, ASTM C 136, ASTM D 422, and ASTM D 1140.

1.5.4 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D 1557 abbreviated as a percent of laboratory maximum density. Since ASTM D 1557 applies only to soils that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve express the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve as a percentage of the maximum density in accordance with AASHTO T 180 and corrected with AASHTO T 224. To maintain the same percentage of coarse material, use the "remove and replace" procedure as described in NOTE 8 of Paragraph 7.2 in AASHTO T 180.

1.5.5 Overhaul

Overhaul is the authorized transportation of satisfactory excavation or borrow materials in excess of the free-haul limit of 2 stations. Overhaul is the product of the quantity of materials hauled beyond the free-haul limit, and the distance such materials are hauled beyond the free-haul limit, expressed in station yards.

1.5.6 Topsoil

Material suitable for topsoils obtained from offsite areas is defined as: Natural, friable soil representative of productive, well-drained soils in the area, free of subsoil, stumps, rocks larger than one inch diameter, brush, weeds, toxic substances, and other material detrimental to plant growth. Amend topsoil pH range to obtain a pH of 5.5 to 7.

1.5.7 Hard/Unyielding Materials

Hard/Unyielding materials comprise weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" with stones greater than 3.9 inches in any dimension or as defined by the pipe manufacturer, whichever is smaller. These materials usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

1.5.8 Rock

Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 1/2 cubic yard in volume. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

1.5.9 Unstable Material

Unstable materials are too wet to properly support the utility pipe, conduit, or appurtenant structure.

1.5.10 Select Granula r Material

Select granular material consist of materials classified as SP, by ASTM D 2487 where indicated. The liquid limit of such material must not exceed 35 percent when tested in accordance with ASTM D 4318. The plasticity index must not be greater than 12 percent when tested in accordance with ASTM D 4318, and not more than 35 percent by weight may be finer than No. 200 sieve when tested in accordance with ASTM D 1140.

1.6 SYSTEM DESCRIPTION

Subsurface soil boring logs are appended to the SPECIAL CONTRACT REQUIREMENTS. These data represent the best subsurface information available; however, variations may exist in the subsurface between boring locations.

1.6.1 Classification of Excavation

Finish the specified excavation on a classified basis, in accordance with the following designations and classifications.

1.6.1.1 Common Excavation

Include common excavation with the satisfactory removal and disposal of all materials not classified as rock excavation.

1.6.1.2 Rock Excavation

Include rock excavation with blasting, excavating, grading, disposing of material classified as rock, and the satisfactory removal and disposal of boulders 1/2 cubic yard or more in volume; solid rock; rock material that is in ledges, bedded deposits, and unstratified masses, which cannot be removed without systematic drilling and blasting; firmly cemented conglomerate deposits possessing the characteristics of solid rock impossible to remove without systematic drilling and blasting; and hard materials (see Definitions). Include the removal of any concrete or masonry structures, except pavements, exceeding 1/2 cubic yard in volume that may be encountered in the work in this classification. If at any time during excavation, including excavation from borrow areas, the Contractor encounters material that may be classified as rock excavation, uncover such material and notify the Owner's Representative. Do not proceed with the excavation of this material until the Owner's Representative has classified the materials as common excavation or rock excavation and has taken cross sections as required. Failure on the part of the Contractor to uncover such material, notify the Owner's Representative, and allow ample time for classification and cross sectioning of the undisturbed surface of such material will cause the forfeiture of the Contractor's right of claim to any classification or volume of material to be paid for other than that allowed by the Owner's Representative for the areas of work in which such deposits occur.

1.7 SUBMITTALS

Owner or Owner's Representative approval is required for all submittals. Submit the following in accordance with Section 00910 SUBMITTALS:

SD-01 Preconstruction Submittals

Shoring Submit 15 days prior to starting work.

SD-03 Product Data

Utilization of Excavated Materials

Procedure and location for disposal of unused satisfactory material.
Proposed source of borrow material.
Notification of encountering rock in the project.
Advance notice on the opening of excavation or borrow areas.

SD-06 Test Reports

Testing

Within 24 hours of conclusion of physical tests, 2 copies of test results, including calibration curves and results of calibration tests.
Results of testing at the borrow site.

SD-07 Certificates

Testing

Qualifications of the Contractor's validated testing facilities.

PART 2 PRODUCTS

2.1 BURIED WARNING AND IDENTIFICATION TAPE

Provide polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inches minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Provide permanent color and printing, unaffected by moisture or soil.

Warning Tape Color Codes

Red:	Electric
Yellow:	Gas, Oil; Dangerous Materials
Orange:	Telephone and Other Communications
Blue:	Water Systems
Green:	Sewer Systems
White:	Steam Systems
Gray:	Compressed Air

2.1.1 Warning Tape for Metallic Piping

Provide acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.003 inch and a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.

2.1.2 Detectable Warning Tape for Non-Metallic Piping

Provide polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.004 inch, and a minimum strength of 1500 psi lengthwise and 1250 psi crosswise. Manufacture tape with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 3 feet deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

2.2 DETECTION WIRE FOR NON-METALLIC PIPING

Insulate a single strand, solid copper detection wire with a minimum of 12 AWG.

PART 3 EXECUTION

3.1 STRIPPING OF TOPSOIL

Where indicated or directed, strip topsoil to a depth of 4 inches. Spread topsoil on areas already graded and prepared for topsoil, or transported and deposited in stockpiles convenient to areas that are to receive application of the topsoil later, or at locations indicated or specified. Keep topsoil separate from other excavated materials, brush, litter, objectionable weeds, roots, stones larger than 2 inches in diameter, and other materials that would interfere with planting and maintenance operations. Stockpile in locations indicated remove from the site any surplus of topsoil from excavations and gradings.

3.2 GENERAL EXCAVATION

Perform excavation of every type of material encountered within the limits of the project to the lines, grades, and elevations indicated and as specified. Perform the grading in accordance with the typical sections shown and the tolerances specified in paragraph FINISHING. Transport satisfactory excavated materials and place in fill or embankment within the limits of the work. Excavate unsatisfactory materials encountered within the limits of the work below grade and replace with satisfactory materials as directed. Include such excavated material and the satisfactory material ordered as replacement in excavation. Dispose surplus satisfactory excavated material not required for fill or embankment in areas approved for surplus material storage or designated waste areas. Dispose unsatisfactory excavated material in designated waste or spoil areas. During

construction, perform excavation and fill in a manner and sequence that will provide proper drainage at all times. Excavate material required for fill or embankment in excess of that produced by excavation within the grading limits from the borrow areas indicated or from other approved areas selected by the Contractor as specified.

3.2.1 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Completely drain construction site during periods of construction to keep soil materials sufficiently dry. Throughout construction grade the construction area to provide positive surface water runoff away from the construction activity or provide temporary ditches, swales, and other drainage features and equipment as required to maintain dry soils. When unsuitable working platforms for equipment operation and unsuitable soil support for subsequent construction features develop, remove unsuitable material and provide new soil material as specified herein. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed.

3.2.2 Dewatering

Control groundwater flowing toward or into excavations to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. Do not permit French drains, sumps, ditches or trenches within 3 feet of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Take control measures by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, maintain the water level continuously, at least 2 feet below the working level. Operate dewatering system continuously until construction work below existing water levels is complete. Submit performance records weekly.

3.2.3 Trench Excavation Requirements

Excavate the trench as recommended by the manufacturer of the pipe to be installed. Slope trench walls below the top of the pipe, or make vertical, and of such width as recommended in the manufacturer's printed installation manual. Provide vertical trench walls where no manufacturer's printed installation manual is available. Shore trench walls more than 5 feet high, cut back to a stable slope, or provide with equivalent means of protection for employees who may be exposed to moving ground or cave

in. Shore vertical trench walls more than 4 feet high. Excavate trench walls which are cut back to at least the angle of repose of the soil. Give special attention to slopes which may be adversely affected by weather or moisture content. Do not exceed the trench width below the pipe top of 24 inches plus pipe outside diameter (O.D.) for pipes of less than 24 inches inside diameter, and do not exceed 36 inches plus pipe outside diameter for sizes larger than 24 inches inside diameter. Where recommended trench widths are exceeded, provide redesign, stronger pipe, or special installation procedures by the Contractor. The Contractor is responsible for the cost of redesign, stronger pipe, or special installation procedures without any additional cost to the Owner or Owner's Representative.

3.2.3.1 Bottom Preparation

Grade the bottoms of trenches accurately to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Excavate bell holes to the necessary size at each joint or coupling to eliminate point bearing. Remove stones of 3 inch or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, to avoid point bearing.

3.2.3.2 Removal of Unyielding Material

Where [overdepth is not indicated and] unyielding material is encountered in the bottom of the trench, remove such material 4 inch below the required grade and replaced with suitable materials as provided in paragraph BACKFILLING AND COMPACTION.

3.2.3.3 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, remove such material to the depth directed and replace it to the proper grade with select granular material as provided in paragraph BACKFILLING AND COMPACTION. When removal of unstable material is required due to the Contractor's fault or neglect in performing the work, the Contractor is responsible for excavating the resulting material and replacing it without additional cost to the Owner or Owner's Representative.

3.2.3.4 Excavation for Appurtenances

Provide excavation for manholes, catch-basins, inlets, or similar structures 12 inches of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Clean rock or loose debris and cut to a firm surface either level, stepped, or serrated, as shown or as

directed. Remove loose disintegrated rock and thin strata. Specify removal of unstable material. When concrete or masonry is to be placed in an excavated area, take special care not to disturb the bottom of the excavation. Do not excavate to the final grade level until just before the concrete or masonry is to be placed.

3.2.4 Underground Utilities

The Contractor is responsible for movement of construction machinery and equipment over pipes and utilities during construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted by the Owner's Representative. Report damage to utility lines or subsurface construction immediately to the Owner's Representative.

3.3 SELECTION OF BORROW MATERIAL

Select borrow material to meet the requirements and conditions of the particular fill or embankment for which it is to be used. Obtain borrow material from the borrow areas within the limits of the project site, selected by the Contractor or from approved private sources. Unless otherwise provided in the contract, the Contractor is responsible for obtaining the right to procure material, pay royalties and other charges involved, and bear the expense of developing the sources, including rights-of-way for hauling from the owners. Unless specifically provided, do not obtain borrow within the limits of the project site without prior written approval. Consider necessary clearing, grubbing, and satisfactory drainage of borrow pits and the disposal of debris thereon related operations to the borrow excavation.

3.4 OPENING AND DRAINAGE OF EXCAVATION AND BORROW PITS

Notify the Owner's Representative sufficiently in advance of the opening of any excavation or borrow pit to permit elevations and measurements of the undisturbed ground surface to be taken. Except as otherwise permitted, excavate borrow pits and other excavation areas providing adequate drainage. Transport overburden and other spoil material to designated spoil areas or otherwise dispose of as directed. Provide neatly trimmed and drained borrow pits after the excavation is completed. Ensure that excavation of any area, operation of borrow pits, or dumping of spoil material results in minimum detrimental effects on natural environmental conditions.

3.5 SHORING

Submit a Shoring and Sheeting plan for approval 15 days prior to starting work. Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheeting of excavations. Finish shoring, including sheet piling, and install as necessary to protect workmen, banks, adjacent paving, structures, and utilities. Remove shoring, bracing, and sheeting as excavations are backfilled, in a manner to prevent caving.

3.6 FINAL GRADE OF SURFACES TO SUPPORT CONCRETE

Do not excavate to final grade until just before concrete is to be placed. Only use excavation methods that will leave the foundation rock in a solid and unshattered condition. Roughen the level surfaces, and cut the sloped surfaces, as indicated, into rough steps or benches to provide a satisfactory bond. Protect shales from slaking and all surfaces from erosion resulting from ponding or water flow.

3.7 GROUND SURFACE PREPARATION

3.7.1 General Requirements

Remove and replace unsatisfactory material with satisfactory materials, as directed by the Owner's Representative, in surfaces to receive fill or excavated areas. Scarify the surface to a depth of 6 inches before the fill is started. Plow, step, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so that the fill material will bond with the existing material. When subgrades are less than the specified density, break up the ground surface to a minimum depth of 6 inches, pulverizing, and compacting to the specified density. When the subgrade is part fill and part excavation or natural ground, scarify the excavated or natural ground portion to a depth of 12 inches and compact it as specified for the adjacent fill.

3.7.2 Frozen Material

Do not place material on surfaces that are muddy, frozen, or contain frost. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Moisten material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used.

3.8 UTILIZATION OF EXCAVATED MATERIALS

Dispose unsatisfactory materials removing from excavations into designated waste disposal or spoil areas. Use satisfactory material removed from

excavations, insofar as practicable, in the construction of fills, embankments, subgrades, shoulders, bedding (as backfill), and for similar purposes. Do not waste any satisfactory excavated material without specific written authorization. Dispose of satisfactory material, authorized to be wasted, in designated areas approved for surplus material storage or designated waste areas as directed. Stockpile and use coarse rock from excavations for constructing slopes or embankments adjacent to streams, or sides and bottoms of channels and for protecting against erosion. Do not dispose excavated material to obstruct the flow of any stream, endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way.

3.9 BURIED TAPE AND DETECTION WIRE

3.9.1 Buried Warning and Identification Tape

Provide buried utility lines with utility identification tape. Bury tape 12 inches below finished grade; under pavements and slabs, bury tape 6 inches below top of subgrade.

3.9.2 Buried Detection Wire

Bury detection wire directly above non-metallic piping at a distance not to exceed 12 inches above the top of pipe. Extend the wire continuously and unbroken, from manhole to manhole. Terminate the ends of the wire inside the manholes at each end of the pipe, with a minimum of 3 feet of wire, coiled, remaining accessible in each manhole. Furnish insulated wire over its entire length. Install wires at manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal. For force mains, terminate the wire in the valve pit at the pump station end of the pipe.

3.10 BACKFILLING AND COMPACTION

Place backfill adjacent to any and all types of structures, and compact to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials, to prevent wedging action or eccentric loading upon or against the structure. Prepare ground surface on which backfill is to be placed and provide compaction requirements for backfill materials in conformance with the applicable portions of paragraphs GROUND SURFACE PREPARATION. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

3.10.1 Trench Backfill

Backfill trenches to the grade shown. Backfill the trench to 2 feet

above the top of pipe prior to performing the required pressure tests. Leave the joints and couplings uncovered during the pressure test.

3.10.1.1 Replacement of Unyielding Material

Replace unyielding material removed from the bottom of the trench with select granular material or initial backfill material.

3.10.1.2 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or excavation with select granular material placed in layers not exceeding 6 inches loose thickness.

3.10.1.3 Bedding and Initial Backfill

Provide bedding of the type and thickness shown. Place initial backfill material and compact it with approved tampers to a height of at least one foot above the utility pipe or conduit. Bring up the backfill evenly on both sides of the pipe for the full length of the pipe. Take care to ensure thorough compaction of the fill under the haunches of the pipe. Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600, Type 4, except as specified herein. Compact backfill to top of pipe to 95 percent of ASTM D 698 maximum density. Provide plastic piping with bedding to spring line of pipe. Provide materials as follows:

a. Class I: Angular, 0.25 to 1.5 inch, graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shells.

b. Class II: Coarse sands and gravels with maximum particle size of 1.5 inch, including various graded sands and gravels containing small percentages of fines, generally granular and noncohesive, either wet or dry. Soil Types GW, GP, SW, and SP are included in this class as specified in ASTM D 2487

c. Clean, coarse-grained sand classified as in accordance with of the State Standard or SP by ASTM D 2487 for bedding and backfill.

3.10.1.4 Final Backfill

Fill the remainder of the trench, except for special materials for roadways, railroads and airfields, with satisfactory material. Place backfill material and compact as follows:

a. Roadways and Railroads: Place backfill up to the required elevation as specified. Do not permit water flooding or jetting methods of compaction.

b. Sidewalks, Turfed or Seeded Areas and Miscellaneous Areas: Deposit backfill in layers of a maximum of 12 inches loose thickness, and compact it to 85 percent maximum density for cohesive soils and 90 percent maximum density for cohesionless soils. Apply this requirement to all other areas not specifically designated above.

3.10.2 Back fill for Appurtenances

After the manhole, catchbasin, inlet, or similar structure has been constructed and the concrete has been allowed to cure for 3 days, place backfill in such a manner that the structure is not be damaged by the shock of falling earth. Deposit the backfill material, compact it as specified for final backfill, and bring up the backfill evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.11 SPECIAL REQUIREMENTS

Special requirements for both excavation and backfill relating to the specific utilities are as follows:

3.11.1 Gas Distribution

Excavate trenches to a depth that will provide a minimum 18 inches of cover in rock excavation and a minimum 24 inch of cover in other excavation.

3.11.2 Water Lines

Excavate trenches to a depth that provides a minimum cover of 3 feet from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe.

3.11.3 Heat Distribution S ystem

Free initial backfill material of stones larger than 1/4 inch in any dimension.

3.11.4 Electrical Distribution S ystem

Provide a minimum cover of 24 inches from the finished grade to direct burial cable and conduit or duct line, unless otherwise indicated.

3.12 SUBGRADE PREPARATION

3.12.1 Proof Rolling

Finish proof rolling on an exposed subgrade free of surface water (wet conditions resulting from rainfall) which would promote degradation of an otherwise acceptable subgrade. Operate the roller in a systematic manner to ensure the number of passes over all areas, and at speeds between 2-1/2 to 3-1/2 mph. When proof rolling, provide one-half of the passes made with the roller in a direction perpendicular to the other passes.] Notify the Owner's Representative a minimum of 3 days prior to proof rolling. Perform proof rolling in the presence of the Owner's Representative.

3.12.2 Construction

Shape subgrade to line, grade, and cross section, and compact as specified. Include plowing, disking, and any moistening or aerating required to obtain specified compaction for this operation. Remove soft or otherwise unsatisfactory material and replace with satisfactory excavated material or other approved material as directed. Excavate rock encountered in the cut section to a depth of 6 inches below finished grade for the subgrade. Bring up low areas resulting from removal of unsatisfactory material or excavation of rock to required grade with satisfactory materials, and shape the entire subgrade to line, grade, and cross section and compact as specified. After rolling, the surface of the subgrade for roadways shall not show deviations greater than 1/2 inch when tested with a 12-foot straight edge applied both parallel and at right angles to the centerline of the area

3.12.3 Compaction

Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

3.12.3.1 Subgrade for Pavements

Compact subgrade for pavements to at least 90 percentage laboratory maximum density for the depth below the surface of the pavement shown. When more than one soil classification is present in the subgrade, thoroughly blend, reshape, and compact the top 1 inch of subgrade.

3.13 FINISHING

Finish the surface of excavations, embankments, and subgrades to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. Provide the degree of finish for graded areas within 0.1 foot of the grades and elevations indicated except that the degree of finish for subgrades specified in paragraph SUBGRADE PREPARATION. Finish gutters and ditches in a manner that will result in effective drainage. Finish the surface of areas to be turfed from settlement or washing to a smoothness suitable for the application of turfing materials. Repair graded, topsoiled, or backfilled areas prior to acceptance of the work, and re-established grades to the required elevations and slopes.

3.13.1 Subgrad e and Embankments

During construction, keep embankments and excavations shaped and drained. Maintain ditches and drains along subgrade to drain effectively at all times. Do not disturb the finished subgrade by traffic or other operation. Protect and maintain the finished subgrade in a satisfactory condition until ballast, subbase, base, or pavement is placed. Do not permit the storage or stockpiling of materials on the finished subgrade. Do not lay subbase, base course, ballast, or pavement until the subgrade has been checked and approved, and in no case place subbase, base, surfacing, pavement, or ballast on a muddy, spongy, or frozen subgrade.

3.13.2 Gradin g Around Structures

Construct areas within 5 feet outside of each building and structure line true-to-grade, shape to drain, and maintain free of trash and debris until final inspection has been completed and the work has been accepted.

3.14 PLACING TOPSOIL

On areas to receive topsoil, prepare the compacted subgrade soil to a 2-inch depth for bonding of topsoil with subsoil. Spread topsoil evenly to a thickness of 1 inch and grade to the elevations and slopes shown. Do not spread topsoil when frozen or excessively wet or dry. Obtain material required for topsoil in excess of that produced by excavation within the grading limits from offsite areas.

3.15 TESTING

Perform testing by the Contractor's validated testing facility. If the Contractor elects to establish testing facilities, do not permit work requiring testing until the Contractor's facilities have been inspected, validated and approved by the Owner's Representative. Determine field in-place density in accordance with ASTM D 6938.

When test results indicate, as determined by the Owner's Representative, that compaction is not as specified, remove the material, replace and recompact to meet specification requirements. Perform tests on recompacted areas to determine conformance with specification requirements. Appoint a registered professional civil engineer to certify inspections and test results. These certifications shall state that the tests and observations were performed by or under the direct supervision of the engineer and that the results are representative of the materials or conditions being certified by the tests. The following number of tests, if performed at the appropriate time, will be the minimum acceptable for each type operation.

3.15.1 Fill and Ba ckfill Material Gradation

One test per 5 cubic yards stockpiled or in-place source material. Determine gradation of fill and backfill material in accordance with ASTM D 422.

3.15.2 I n-Place Densities

a. One test per 2,000 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines.

b. One test per 2,000 square feet or fraction thereof, of each lift of fill or backfill areas compacted by hand-operated machines.

3.15.3 Check Tests on In-Place Densities

If ASTM D 6938 is used, check in-place densities by ASTM D 1556 as follows:

a. One check test per lift for each 2,000 square feet, or fraction thereof, of each lift of fill or backfill compacted by other than hand-operated machines.

b. One check test per lift for each 2,000 square feet, of fill or backfill areas compacted by hand-operated machines.

3.15.4 Moisture Contents

In the stockpile, excavation, or borrow areas, perform a minimum of two tests per day per type of material or source of material being placed during stable weather conditions. During unstable weather, perform tests as dictated by local conditions and approved by the Owner's Representative.

3.15.5 Optimum Moisture and L aboratory Maximum Density

Perform tests for each type material or source of material including borrow material to determine the optimum moisture and laboratory maximum density values. One representative test per 5 cubic yards of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density.

3.15.6 Toleranc e Tests for Subgrades

Perform continuous checks on the degree of finish specified in paragraph SUBGRADE PREPARATION during construction of the subgrades.

3.15.7 Displacement of Sew ers

After other required tests have been performed and the trench backfill compacted to feet [the finished grade surface, inspect the pipe to determine whether significant displacement has occurred. Conduct this inspection in the presence of the Owner's Representative. If, in the judgment of the Owner's Representative, the interior of the pipe shows poor alignment or any other defects that would cause improper functioning of the system, replace or repair the defects as directed at no additional cost to the Owner.

3.16 DISPOSITION OF SURPLUS MATERIAL

Provide surplus material or other soil material not required or suitable for filling or backfilling, and brush, refuse, stumps, roots, and timber as indicated.

PART 1 GENERAL

1.1 DESCRIPTION

This work shall cover the composition, mixing, construction upon the prepared subgrade, and the protection of hot asphalt concrete pavement. The hot asphalt concrete pavement shall consist of an aggregate or asphalt base course and asphalt surface course constructed in conformity with the lines, grades, thickness, and cross sections as shown. Each course shall be constructed to the depth, section, or elevation required by the drawings and shall be rolled, finished, and approved before the placement of the next course.

1.2 INSPECTION OF PLANT AND EQUIPMENT

The Resident Engineer shall have access at all times to all parts of the material producing plants for checking the mixing operations and materials and the adequacy of the equipment in use.

1.3 ALIGNMENT AND GRADE CONTROL

The Contractor's Registered Professional Land Surveyor shall establish and control the pavement (aggregate or asphalt base course and asphalt surface course) alignments, grades, elevations, and cross sections as shown on the Drawings.

1.4 SUBMITTALS

Owner or Owner's Representative approval is required for all submittals. Submit the following in accordance with Section 00910 SUBMITTALS:

A. Data and Test Reports:
   1. Aggregate Base Course: Sources, gradation, liquid limit, plasticity index, percentage of wear, and other tests required by State Highway Department.
   2. Asphalt Base/Surface Course: Aggregate source, gradation, soundness loss, percentage of wear, and other tests required by State Highway Department.
   3. Job-mix formula.

C. Certifications:
   1. Asphalt prime and tack coat material certificate of conformance to State Highway Department requirements.
   2. Asphalt cement certificate of conformance to State Highway Department requirements.
   3. Job-mix certification - Submit plant mix certification that mix equals or exceeds the State Highway Specification.

D. One copy of State Highway Department Specifications.
E. Provide MSDS (Material Safety Data Sheets) for all chemicals used on ground.

PART 2 PRODUCTS

2.1 GENERAL

A. Asphaltic base and asphalt concrete materials shall conform to the requirements of the following and other appropriate sections of the latest version of the State Highway Material Specifications, including amendments, addenda and errata. Where the term "Engineer" or "Commission" is referenced in the State Highway Specifications, it shall mean the Owner's Representative.

2.2 AGGREGATES

A. Provide aggregates consisting of crushed stone, gravel, sand, or other sound, durable mineral materials processed and blended, and naturally combined.

B. Subbase aggregate (where required) maximum size: 1-1/2".

C. Base aggregate maximum size:
1. Base course over 6" thick: 1-1/2";
2. Other base courses: 3/4".

D. Asphaltic base course:
1. Maximum particle size not to exceed 1".
2. Where conflicts arise between this specification and the requirements in the latest version of the State Highway Specifications, the State Specifications shall control.

E. Aggregates for asphaltic concrete paving: Provide a mixture of sand, mineral aggregate, and liquid asphalt mixed in such proportions that the percentage by weight will be within:

Sieve Sizes	Percentage Passing
3/4"	100
3/8"	67 to 85
1/4"	50 to 65
No. 8 mesh	37 to 50
No. 30 mesh	15 to 25
No. 200 mesh	3 to 8

plus 50/60 penetration liquid asphalt at 5 percent to 6-1/2 percent of the combined dry aggregates.

2.3 ASPHALTS

A. Comply with provisions of Asphalt Institute Specification SS2:

1.	Asphalt cement:	Penetration grade 50/60
2.	Prime coat:	Cut-back type, grade MC-250
3.	Tack coat:	Uniformly emulsified, grade SS-1H

2.4 SEALER

A. Provide a sealer consisting of suitable fibrated chemical type asphalt base binders and fillers having a container consistency suitable for troweling after thorough stirring, and containing no clay or other deleterious substance.

B. Where conflicts arise between this specification and the requirements in the latest version of the State Highway Specifications, the State Specifications shall control.

PART 3 EXECUTION

3.1 GENERAL

The Asphalt Concrete Paving equipment, weather limitations, job-mix formula, mixing, construction methods, compaction, finishing, tolerance, and protection shall conform to the requirements of the appropriate sections of the State Highway Specifications for the type of material specified.

3.2 MIXING ASPHALTIC CONCRETE MATERIALS

A. Provide hot plant-mixed asphaltic concrete paving materials.
   1. Temperature leaving the plant: 290 degrees F minimum, 320 degrees F maximum.
   2. Temperature at time of placing: 280 degrees F minimum.

3.3 SUBGRADE

A. Shape to line and grade and compact with self-propelled rollers.

B. All depressions that develop under rolling shall be filled with acceptable material and the area re-rolled.

C. Soft areas shall be removed and filled with acceptable materials and the area re-rolled.

D. Should the subgrade become rutted or displaced prior to the placing of the subbase, it shall be reworked to bring to line and grade.

E. Proof-roll the subgrade with maximum 50 ton gross weight dump truck as directed by Owner's Representative. If pumping, pushing, or other movement is observed, rework the area to provide a stable and compacted subgrade.

3.4 BASE COURSES

A. Subbase (when required)
1. Spread and compact to the thickness shown on the drawings.
2. Rolling shall begin at the sides and continue toward the center and shall continue until there is no movement ahead of the roller.
3. After completion of the subbase rolling there shall be no hauling over the subbase other than the delivery of material for the top course.

B. Base
1. Spread and compact to the thickness shown on the drawings.
2. Rolling shall begin at the sides and continue toward the center and shall continue until there is no movement ahead of the roller.
3. After completion of the base rolling there shall be no hauling over the base other than the delivery of material for the top course.

C. Thickness tolerance: Provide the compacted thicknesses shown on the Drawings within a tolerance of minus 0.0" to plus 0.5".

D. Smoothness tolerance: Provide the lines and grades shown on the Drawings within a tolerance of 3/16 inch in ten feet.

E. Moisture content: Use only the amount of moisture needed to achieve the specified compaction.

3.5 PLACEMENT OF ASPHALTIC CONCRETE PAVING

A. Remove all loose materials from the compacted base.

B. Apply the specified prime coat, and tack coat where required, and allow to dry in accordance with the manufacturer's recommendations as approved by the Owner or Owner's Representative.

C. Receipt of asphaltic concrete materials:
   1. Do not accept material unless it is covered with a tarpaulin until unloaded, and unless the material has a temperature of not less than 280 degrees F.
   2. Do not commence placement of asphaltic concrete materials when the atmospheric temperature is below 50 degrees F, not during fog, rain, or other unsuitable conditions.

D. Spreading:
   1. Spread material in a manner that requires the least handling.
   2. Where thickness of finished paving will be 3" or less, spread in one layer.

E. Rolling:
   1. After the material has been spread to the proper depth, roll until the surface is hard, smooth, unyielding, and true to the thickness and elevations shown own the drawings.
   2. Roll in at least two directions until no roller marks are visible.
   3. Finished paving smoothness tolerance:
      a. No depressions which will retain standing water.
      b. No deviation greater than 1/8" in six feet.

3.6 APPLICATION OF SEAL COAT

A. Prepare the surfaces, mix the seal coat material, and apply in accordance with the manufacturer's recommendations as approved by the Owner or Owner's Representative.

B. Apply one coat of the specified sealer.

C. Achieve a finished surface seal which, when dry and thoroughly set, is smooth, tough, resilient, of uniform black color, and free from coarse textured areas, lap marks, ridges, and other surface irregularities.

3.7 PROTECTION

Protect the asphaltic concrete paved areas from traffic until the sealer is set and cured and does not pick up under foot or wheeled traffic.

3.8 FINAL CLEAN-UP

Remove all debris, rubbish, and excess material from the work area.

PART 1 GENERAL

1.1 REFERENCES

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AMERICAN WELDING SOCIETY (AWS)

ASME INTERNATIONAL (ASME)

ASTM INTERNATIONAL (ASTM)

FLUID SEALING ASSOCIATION (FSA)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

UNDERWRITERS LABORATORIES (UL)

1.2 GENERAL REQUIREMENTS

Include with Equipment Foundation Data for piping systems all plan dimensions of foundations and relative elevations, equipment weight and operating loads, horizontal and vertical loads, horizontal and vertical clearances for installation, and size and location of anchor bolts.

Include with Listing of Product Installations for piping systems identification of at least 5 units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. Include in the list purchaser, address of installation, service organization, and date of installation.

1.3 SUBMITTALS

Owner or Owner's Representative approval is required for all submittals. Submit the following in accordance with Section 00910 SUBMITTALS:

S-01 Preconstruction Submittals

Submit Material, Equipment, and Fixture Lists for construction equipment to be used.

S-02 Shop Drawings

Submit the following for pipes, valves and specialties showing conformance with the referenced standards contained within this section.

Record Drawings
Connection Diagrams
Coordination Drawings
Fabrication Drawings

Submit Installation Drawings for pipes, valves and specialties in accordance with the paragraph entitled, "Pipe Installation," of this section.

S-03 Product Data

Submit equipment and performance data for the following items consisting of corrosion resistance, life expectancy, gauge tolerances, and grade line analysis.

Submit Manufacturer's catalog data for the following items:

Pipe and Fittings
Piping Specialties
Valves
Miscellaneous Materials
Supporting Elements

Equipment Foundation Data shall be in accordance with paragraph entitled, "General Requirements," of this section.

S-04 Test Reports

Submit test reports on the following tests in accordance with paragraph entitled, "Piping Installation," of this section.

Hydrostatic Tests
Air Tests
Valve-Operating Tests
Drainage Tests
Pneumatic Tests
Non-Destructive Electric Tests
System Operation Tests

S-05 Certificates

Submit Listing of Product Installations for piping systems verifying proper qualifications.

Submit Records of Existing Conditions by the Contractor prior to start.

Submit Certificates for the following in accordance with paragraph entitled, "Pipe Installation," of this section.

Surface Resistance
Shear and Tensile Strengths
Temperature Ratings
Bending Tests
Flattening Tests
Transverse Guided Weld Bend Tests

S-06 Operation and Maintenance Data

Submit Operation and Maintenance Manuals in accordance with paragraph entitled, "Operation and Maintenance," of this section.

1.4 QUALITY ASSURANCE

1.4.1 Material and Equipment Qualifications

Provide materials and equipment that are standard products of manufacturers regularly engaged in the manufacture of such products, which are of a similar material, design and workmanship. Standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period.

1.4.2 Alternative Qualifications

Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

1.4.3 Service Support

The equipment items shall be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations shall be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.4.4 Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.5 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Owner or Owner's Representative. Replace damaged or defective items.

1.6 ELECTRICAL INSTALLATION REQUIREMENTS

Electrical installations shall conform to IEEE C2, NFPA 70, and requirements specified herein.

1.6.1 New Work

Provide electrical components of mechanical equipment, such as motors, motor starters, control or push-button stations, float or pressure switches, solenoid valves, integral disconnects, and other devices functioning to control mechanical equipment, as well as control wiring and conduit for circuits rated 100 volts or less, to conform with the requirements of the section covering the mechanical equipment. Extended voltage range motors are not permitted. The interconnecting power wiring and conduit, control wiring rated 120 volts (nominal) and conduit, and the electrical power circuits shall be provided under Division 16, except internal wiring for components of package equipment shall be provided as an integral part of the equipment. When motors and equipment furnished are larger than sizes indicated, provide any required changes to the electrical service as may be necessary and related work as a part of the work for the section specifying that motor or equipment.

1.6.2 High Efficiency Motors

1.6.2.1 High Efficiency Polyphase Motors

Unless otherwise specified, select polyphase motors based on high efficiency characteristics relative to the applications as listed in NEMA MG 10. Additionally, polyphase squirrel-cage medium induction motors with continuous

ratings shall meet or exceed energy efficient ratings in accordance with Table 12-6C of NEMA MG 1.

1.6.3 Three-Phase Motor Protection

Provide controllers for motors rated one one horsepower and larger with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage. Provide protection for motors from immediate restart by a time adjustable restart relay.

PART 2 PRODUCTS

2.1 ELECTRICAL HEAT TRACING

Heat trace systems for pipes, valves, and fittings shall be in accordance with IEEE 515 and be UL listed. System shall include all necessary components, including heaters and controls to prevent freezing.

Provide self-regulating heaters consisting of two 16 AWG tinned-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature along its length. Heater shall be able to be crossed over itself without overheating and be approved before used directly on plastic pipe. Heater shall be covered by a radiation cross-linked modified polyolefin dielectric jacket in accordance with ASTM D 2308.

Provide heater with self-regulating factor of at least 90 percent, in order to provide energy conservation and to prevent overheating.

Heater shall operate on line voltages of 220 volts without the use of transformers.

Size Heater according to the following table:

Pipe Size (Inch, Diameter)	Minus 10 degrees F	Minus 20 degrees F
4 inch	5 wpf	8 wpf
6 inch	8 wpf	8 wpf
8 inch	2 strips/5 wpf	2 strips/8 wpf

System shall be controlled by an ambient sensing thermostat set at 40 degrees F either directly or through an appropriate contactor.

2.2 PIPE AND FITTINGS

2.2.1 Type BCS, Black Carbon Steel

Pipe 1/8 through 10 inches shall be Schedule 40 electric-resistance welded black carbon steel, conforming to ASTM A 53/A 53M, Type E, Grade B electric-resistance welded. Grade A should be used for permissible field bending, in both cases.

Fittings 2-1/2 inches and over shall be Steel butt weld, conforming to ASTM A 234/A 234M and ASME B16.9 to match pipe wall thickness.

Flanges 2-1/2 inches and over shall be 150-pound forged-steel conforming to ASME B16.5, welding neck to match pipe wall thickness.

2.3 VALVES

2.3.1 Ball and Butterfly Valves

Ball valves shall conform to MSS SP-72 for a 1 piece body, vertically split body, top entry, and three piece body and shall be rated for service at not less than 175 psig at 200 degrees F. Valve bodies in sizes 2-1/2 inches and larger shall be flanged-end connection type, constructed of carbon steel material. Balls of valves 6 inches and larger may be Class D with 900 Brinell hard chrome plating. Valves shall be suitable for flow from either direction and shall seal equally tight in either direction. Valves with ball seals held in place by spring washers are not acceptable. All valves shall have adjustable packing glands. Seats and seals shall be tetrafluoroethylene.

2.4 SUPPORTING ELEMENTS

Provide all necessary piping systems and equipment supporting elements, including but not limited to: building structure attachments; supplementary steel; hanger rods, stanchions, and fixtures; vertical pipe attachments; horizontal pipe attachments; anchors; guides; and spring-cushion, variable, or constant supports. All supporting elements shall be suitable for stresses imposed by systems pressures and temperatures and natural and other external forces normal to this facility without damage to supporting element system or to work being supported.

Supporting elements shall conform to requirements of ASME B31.3, MSS SP-58, and MSS SP-69 except as noted.

Attachments welded to pipe shall be made of materials identical to that of pipe or materials accepted as permissible raw materials by referenced code or standard specification.

Supporting elements exposed to weather shall be hot-dip galvanized or stainless steel. Materials shall be of such a nature that their apparent and latent-strength characteristics are not reduced due to galvanizing process. Supporting elements in contact with copper tubing shall be electroplated with copper.

Type designations specified herein are based on MSS SP-58 and MSS SP-69. Masonry anchor group-, type-, and style-combination designations shall be in accordance with CID A-A-1922, CID A-A-1923, CID A-A-1924, CID A-A-1925, CID A-A-55614, and CID A-A-55615. Support elements, except for supplementary steel, shall be cataloged, load rated, commercially manufactured products.

PART 3 EXECUTION

3.1 PIPE INSTALLATION

Submit certificates for pipes, valves and specialties showing conformance with test requirements as contained in the reference standards contained in this section. Certificates shall verify Surface Resistance, Shear and Tensile Strengths, Temperature Ratings, Bending Tests, Flattening Tests and Transverse Guided Weld Bend Tests.

Test reports for Hydrostatic Tests, Air Tests, Valve-Operating Tests, Drainage Tests, Pneumatic Tests, Non-Destructive Electric Tests and System Operation Tests shall be provided by the Contractor, in compliance with referenced standards contained within this section.

Fabricate and install piping systems in accordance with ASME B31.3, MSS SP-69, and AWS WHB-2.9.

Submit Installation Drawings for pipes, valves and specialties. Drawings shall include the manufacturer's design and construction calculations, forces required to obtain rated axial, lateral, or angular movements, installation criteria, anchor and guide requirements for equipment, and equipment room layout and design. Drawings shall specifically advise on procedures to be followed and provisions required to protect expansion joints during specified hydrostatic testing operations.

Make final connections to equipment with flanges provided every 100 feet of straight run. Provide unions in the line downstream of screwed- and welded-end valves.

Ream all pipe ends before joint connections are made.

Screwed joints shall be made up with specified joint compound and not more than three threads shall show after joint is made up.

Apply joint compounds to the male thread only and exercise care to prevent compound from reaching the unthreaded interior of the pipe.

Provide screwed unions, welded unions, or bolted flanges wherever required to permit convenient removal of equipment, valves, and piping accessories from the piping system for maintenance.

Securely support piping systems with due allowance for thrust forces, thermal expansion and contraction, and shall not be subjected to mechanical, chemical, vibrational or other damage as specified in ASME B31.3.

Field welded joints shall conform to the requirements of the AWS WHB-2.9, ASME B31.3, and ASME BPVC SEC IX.

Make piping systems butt weld joints with backing rings. Backing ring materials shall be compatible with materials being joined. Joint configuration shall conform to ASME B16.25.

3.2 VALVES

Provide valves in piping mains and all branches and at equipment where indicated and as specified.

Provide valves to permit isolation of branch piping and each equipment item from the balance of the system.

Riser and downcomer drains above piping shutoff valves in piping 2-1/2 inches and larger shall be provided. Tap and fit shutoff valve body with a 1/2-inch plugged globe valve.

Valves unavoidably located in furred or other normally inaccessible places shall be provided with access panels adequately sized for the location and located so that concealed items may be serviced, maintained, or replaced.

3.3 SUPPORTING ELEMENTS INSTALLATION

Provide supporting elements in accordance with the referenced codes and standards.

Support piping from building structure. No piping shall be supported from roof deck or from other pipe.

Piping shall run parallel with the lines of the building. Space and install piping and components so that a threaded pipe fitting may be removed between adjacent pipes and so that there shall be no less than 1/2 inch of clear space between the finished surface and other work and between the finished surface of parallel adjacent piping. Hangers on different adjacent service lines running parallel with each other shall be arranged to be in line with each other and parallel to the lines of the building.

Install piping support elements at intervals specified hereinafter, at locations not more than 3 feet from the ends of each runout, and not over 1 foot from each change in direction of piping.

Load rating for all pipe-hanger supports shall be based on insulated weight of lines filled with water and forces imposed. Deflection per span shall not exceed slope gradient of pipe. Supports shall be in accordance with the following minimum rod size and maximum allowable hanger spacing for specified pipe. For concentrated loads such as valves, the allowable span must be reduced proportionately:

PIPE SIZE INCHES	ROD SIZE INCHES	STEEL PIPE FEET	COPPER PIPE FEET
4 to 5	5/8	16	14
6	3/4	16	16
8 to 12	7/8	20	20

Provide vibration isolation supports where needed.

Vertical risers shall be supported independently of connected horizontal piping, whenever practicable, with fixed or spring supports at the base and at intervals to accommodate system range of thermal conditions. Risers shall be guided for lateral stability. For risers subject to expansion, provide only one rigid support at a point approximately one-third down from the top. Place clamps under fittings unless otherwise specified. Support carbon-steel pipe at each floor and at not more than 15-foot intervals for pipe 2 inches and smaller and at not more than 20-footintervals for pipe 2-1/2 inches and larger.

3.4 PENETRATIONS

Effective sound stopping and adequate operating clearance shall be provided to prevent structure contact where piping penetrates walls, floors, or ceilings into occupied spaces adjacent to equipment rooms; where similar penetrations occur between occupied spaces; and where penetrations occur from pipe chases into occupied spaces.

Occupied spaces shall include space above ceilings where no special acoustic treatment of ceiling is provided. Penetrations shall be finished to be compatible with surface being penetrated.

Sound stopping and vapor-barrier sealing of pipe shafts and large floor and wall openings shall be accomplished by packing to high density with properly supported fibrous-glass insulation or, where ambient or surface temperatures do not exceed 120 degrees F, by foaming-in-place with self-extinguishing, 2-pound density

polyurethane foam to a depth not less than 6 inches. Foam shall be finished with a rasp. Vapor barrier shall be not less than 1/8-inch thick vinyl coating applied to visible and accessible surfaces. Where high temperatures and fire stopping are a consideration, only mineral wool shall be used and openings must also be covered with 16- gauge sheet metal.

3.5 SLEEVES

Provide sleeves where piping passes through roofs, masonry, concrete walls and floors.

Sleeves passing through steel decks shall be continuously welded to the deck.

Sleeves that extend through floors, roofs, load bearing walls, and fire barriers shall be continuous and fabricated from Schedule 40 steel pipe, with welded anchor lugs. All other sleeves shall be formed by molded linear polyethylene liners or similar materials that are removable. Diameter of sleeves shall be large enough to accommodate pipe, insulation, and jacketing without touching the sleeve and shall provide a minimum 3/8-inch clearance. Sleeve size must accommodate mechanical and thermal motion of pipe to preclude transmission of vibration to walls and the generation of noise.

Space between a pipe, bare or insulated, and the inside of a pipe sleeve or a construction surface penetration shall be packed solid with a mineral fiber conforming to ASTM C 553 Type V (flexible blanket), to 1,000 degrees F. Provide this packing wherever the piping passes through firewalls, equipment room walls, floors, and ceilings connected to occupied spaces, and other locations where sleeves or construction-surface penetrations occur between occupied spaces. Where sleeves or construction surface penetrations occur between conditioned and unconditioned spaces, the space between a pipe, bare or insulated, and the inside of a pipe sleeve or construction surface penetration shall be filled with an elastomer caulk to a depth of 1/2 inch. All surfaces to be caulked shall be oil-and grease-free.

Through-Penetration fire stop materials and methods shall be in accordance with ASTM E 814 and UL 1479.

Exterior wall sleeves shall be caulked watertight with lead and oakum or mechanically expandable chloroprene inserts with mastic-sealed metal components.

Sleeve height above roof surface shall be a minimum of 12 and a maximum of 18 inches.

3.9 HEAT TRACE CABLE INSTALLATION

Heater tape shall be field applied and cut to fit as necessary, linearly along the length of pipe after piping has been pressure tested and approved by the Owner or Owner's

Representative. Secure the heater to piping with cable ties. Thermal insulation shall be labeled on the outside, "Electrical Heat Trace."

Power connection, end seals, splice kits and tee kit components shall be installed in accordance with IEEE 515 to provide a complete workable system. Connection to the thermostat and ends of the heat tape shall be terminated in a junction box. Cable and conduit connections shall be raintight.

3.11 HEAT TRACE CABLE TESTS

Test heat trace cable system in accordance with IEEE 515 after installation and before and after installation of the thermal insulation. Test heater cable using a 1000 vdc megger. Minimum insulation resistance shall be 20 to 1000 megohms regardless of cable length.

3.12 OPERATION AND MAINTENANCE

Operation and Maintenance Manuals shall be consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures and safety precautions. Test data shall be clear and readily legible.

PART 1 GENERAL

1.1 UNIT PRICES

Measurement and payment will be based on completed work performed in accordance with the drawings, specifications, and the contract payment schedules.

1.1.1 Measurement

The length of pipe lines to be paid for will be determined by measuring along the centerline of the various sizes of pipe furnished and installed. Pipe will be measured from center of fitting to center of fitting and from connection to connection to wells or treatment units. No deduction will be made for the space occupied by valves or fittings.

1.1.2 Payment

Payment will be made for piping at the contract unit price per linear foot for the various types and sizes of piping, and will be full compensation for pipes, joints, specials, and fittings, complete in place. Payment for valves, valve boxes, and standard valve manholes will be made at the respective contract unit price each for such items completed in place. Payment will include the furnishing of testing, plant, labor, and material and incidentals necessary to complete the work, as specified and as shown.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN GAS ASSOCIATION (AGA)

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ASME INTERNATIONAL (ASME)

ASTM INTERNATIONAL (ASTM)

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

PLASTICS PIPE INSTITUTE (PPI)

1.3 SYSTEM DESCRIPTION

The piping system shall consist of above ground pipe, pipe supports, fittings, equipment and accessories.

1.4 SUBMITTALS

Owner or Owner's Representative approval is required for all submittals. Submit the following in accordance with Section 00910 SUBMITTALS:

SD-02 Shop Drawings

Gas Piping System

SD-03 Product Data

Material Safety Data Sheet
Material safety data sheet in conformance with ANSI Z400.1/Z129.1 for solvents, solvent cements, or glues used in pipe connections.
Statement of Satisfactory Installation

SD-06 Test Reports

Bubble Tests
Pressure Testing
Leakage Testing
Vacuum Testing
Hanger Acceptance Testing

SD-07 Certificates

PVC Pipes

1.5 QUALITY ASSURANCE

1.5.1 Contractor Qualifications

Contractor shall have had a minimum of 2 years of experience in the construction of piping systems for sour gas, condensable gas, off-gas or vapor.

1.5.2 Single Source Supplier

Assign to a single supplier full responsibility for the furnishing of the off-gas piping system. The designated single supplier, however, need not manufacture the system but shall coordinate the selection, assembly, installation, and testing of the entire system as specified herein.

1.5.3 Welding

Qualifications of welding procedures, welders, and welding operators shall be in accordance with welding and nondestructive testing procedures for pressure piping.

1.5.4 Jointing Plastic Pipe

Use manufacturer's prequalified joining procedures. Joints shall be inspected by an inspector qualified in the joining procedures being used and in accordance with AGA XR0603.

1.6 DELIVERY, STORAGE, AND HANDLING

1.6.1 Packaging

Plastic pipe shall be packed, packaged and marked in accordance with ASTM D 3892.

1.6.2 Cleaners, Solvents and Glues

A material safety data sheet in conformance with ANSI Z400.1/Z129.1shall accompany each chemical delivered for use in pipe installation. Handling shall be in accordance with ASTM F 402.

1.6.3 Storage

Classify and mark storage facilities in accordance with NFPA 704. Store materials with protection from puncture, dirt, grease, moisture, mechanical abrasions, excessive heat, ultraviolet (UV) damage, or other damage. Pipe and fittings shall be handled and stored in accordance with the manufacturer's recommendations. Piping bundles shall be stored on a prepared surface and should not be stacked more than two bundles high.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment that are new and unused, except for testing equipment. Components that serve the same function and are the same size shall be identical products of the same manufacturer. Piping material and appurtenances shall be as specified and as shown on the drawings, and shall be suitable for the service intended.

2.1.1 Standard Products

Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Pipe, valves, fittings and appurtenances shall be supported by a service organization that is, in the opinion of the Owner or Owner's Representative, reasonably convenient to the site.

2.1.2 Identification

Each piece of pipe shall bear the ASTM designation and the ASTM markings required for that designation. Each valve shall be marked in accordance with MSS SP-25 to identify the manufacturer, size, pressure rating, body disc, and seat material. Securely attach a tag with the manufacturer's name, catalog number and valve identification.

2.2 DESIGN STRENGTH

Design strength of piping shall be suitable for the operating pressure and temperature ranges indicated and/or shown.

2.3 POLYVINYL CHLORIDE (PVC) PIPING

Design and fabrication of below grade components of the off-gas piping system shall be in accordance with ASTM D 2513 except as modified herein.

2.3.1 PVC Pipe

NOTE: CPVC in accordance with ASTM F 422 provides a heat protection factor that is important near blowers but is not generally necessary for buried piping.

ASTM D 3915 should be used unless aggressive chemical conditions dictate that D 1784 be used.

Pipe shall be in accordance with ASTM D 2241, SDR 35. Materials shall conform to ASTM D 3915. The maximum eccentricity of the inside and outside circumferences of the pipe walls shall be 12 percent. Pipe shall be provided which does not fail, balloon, burst, or weep as defined in ASTM D 1598.

2.3.2 PVC Joints

Joints shall be pressure rated solvent cemented bell joints in accordance with ASTM D 2672 except where flanged or threaded fittings are required at expansion joints, valves, flowmeter, equipment connections or otherwise shown. Flanges shall be joined to pipe by solvent cementing. Primer shall conform to ASTM F 656. Solvent cement shall conform to ASTM D 2564.

2.3.3 PVC Fittings

Fittings shall be in accordance with ASTM D 2466.

2.4 FLANGED CONNECTIONS

2.4.1 Flanges

Flanges shall be Class 150, socket weld, flat face in accordance with ASME B16.5. Drilling and dimensions of flanges, bolts, nuts, and bolt patterns shall be in accordance with ASME B16.5, Class 150. Bolts and nuts shall be 304 stainless steel.

2.4.2 Gaskets

Gaskets shall be full face, non-asbestos compressed material compatible with the expected condensates in accordance with ASME B16.21, 1/8 inch minimum thickness, full face or self-centering flat ring type. Gaskets shall be EPDM suitable for 212 degrees F service.

2.4.3 Sealants

Sealants shall conform to ASTM C 920.

2.5 EQUIPMENT AND APPURTENANCES

2.5.1 Manually Operated Valves

Ball valves shall be in accordance with MSS SP-72. Gate, plug, ball, and check valves shall be in accordance with API Spec 6D.

2.5.2 Vacuum Breakers

Vacuum breakers shall be provided to protect blowers and vacuum pumps from damage due to excessive vacuum surges.

2.5.3 Meters

Gas meters shall conform to AGA ANSI B109.2.

2.5.4 Supports for Aboveground Piping

Furnish pipe hangers and supports complete with necessary inserts, bolts, nuts, rods, washers, and accessories. Design and construction shall be in accordance with MSS SP-58. Specific application shall be in accordance with MSS SP-69. Hanger and supports shall be capable of adjustment after placement of piping. Hangers and supports shall be the product of one manufacturer. Hangers, supports and accessories shall be hot dip galvanized in accordance with ASTM A 123/A 123M unless copper or plastic coated. Restrained joints and thrust protection shall be provided. Concrete and metal cradles, collars, floor stands, supports, kickers, and block shall be provided as recommended by manufacturer. Pipe cradle cushion material shall be elastomer sheet strapped to pipe to prevent chafing at pipe support. Elastomer sheet shall be utilized around top of pipe to prevent chafing of pipe strap.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Owner or Owner's Representative of any discrepancy before performing the work.

3.2 MANUFACTURER'S REPRESENTATIVE

Provide the services of a manufacturer's field service representative who is experienced in the installation of the materials and equipment furnished and who has complete knowledge of the proper operation and maintenance of the system.

3.3 CONDENSATE CONTROL

Slope off-gas piping uniformly between control elevations to enhance the removal of liquids. Make provisions to collect and drain liquids from condensation in each pipe run. Liquid removal sumps and traps shall be located in the piping systems.

3.4 PRESSURE REGULATOR AND METER INSTALLATION

Install a valve on each side of each meter or regulator for isolating the regulator for calibration, maintenance and removal. An insulating joint constructed to prevent flow of electrical current shall be installed between metallic pipe and the meter or regulator.

3.4.1 Pressure Regulators

NOTE: Delete inapplicable requirements. Remove reference to bypasses around pressure regulators unless continuity is imperative and the bypass is regulated to prevent possible over pressure of downstream lines.

Install pressure regulators where shown. Provide a 3/8 inch tapped fitting equipped with a plug on both sides of the regulator for installation of pressure gauges for adjusting the regulator.

3.4.2 Meters

Install meters in accordance with ASME B31.8.

3.4.3 Vents

Locate discharge stacks, vents, or outlet ports of devices where gas can be discharged into the atmosphere without undue hazard. Vents shall terminate in the outside air in rain and insect resistant fittings.

3.5 INSTALLING PIPE ABOVEGROUND

Install vertical pipe plumb in all directions. Perpendicular piping shall be installed parallel to building walls. Piping at angles and 45 degree runs across corners will not be accepted unless specifically shown. Install small diameter piping generally as shown when specific locations and elevations are not indicated. Piping shall be located to avoid ducts, equipment, and beams. Piping shall be installed to avoid

obstructing corridors, walkways, work areas, and like spaces. Provide a minimum headroom clearance of 7 feet under piping, unless otherwise indicated. Temporary caps or plugs shall be provided at pipe openings at the end of each day's work. Run piping in groups where practicable. Minimum clearance shall be1 inch between pipe and other work.

3.5.1 Hangers and Supports

Install pipe hangers and supports in accordance with MSS SP-58andMSS SP-69 at locations where pipe changes direction. Hanger rods shall be installed straight and vertical. Chain, wire, strap or perforated bar hangers will not be permitted. Hangers shall not be suspended from piping. Where proper hanger or support spacing does not correspond with joist or rib spacing, suspend pipe from structural steel channels attached to joists or ribs. Maximum support spacing, shall be as follows:

Pipe Size	Spacing
Less than 2 in	6 feet
2 to 3 in	10 feet
> 3 in	12 feet

3.6 JOINTING PIPE

Join non-metallic piping by performance qualified joiners using qualified procedures in accordance with AGA XR0603. Joints shall be inspected by an inspector qualified in the joining procedures being used and in accordance with AGA XR0603.

3.6.1 O-Ring Joints

Clean jointing surfaces and adjacent areas before making joint. Gaskets and "O"-rings shall be lubricated and adjusted in accordance with manufacturer's recommendations. Check each gasket for proper position around full circumference of the joint after "O"-rings are compressed and before pipe is brought fully home. Jointing pipe shall be done in accordance with ASTM D 3139 and manufacturer's recommendations.

3.6.2 Mechanical Joints

The plain end shall be centered and pushed into the bell. The gasket shall be firmly pressed evenly into the bell. The gland shall be slipped to the bell for bolting. The bolt threads shall be oiled. Bolts shall be tightened alternately 180 degrees opposite to each other to seat the gasket evenly. Apply bituminous coating to ferrous bolts and nuts before assembly.

3.7 CONNECTIONS

3.7.1 Transitions Between Types of Pipe

Provide necessary adapters, specials and connector pieces when connecting different types and sizes of pipe or pipe furnished by different manufacturers. Connections between piping and equipment, where required, shall be made using proper fittings to suit the actual conditions.

3.7.2 Connections to Gas Source and Discharge Points

Connect the off-gas pipelines to the source and discharge locations. Notify the Owner or Owner's Representative, in writing, 10 days before final connections and activation of the system.

3.7.3 Connection to Equipment

Provide connections to the equipment in accordance with approved procedures. Isolation of equipment shall only be done at the valve location shown on the drawings.

3.8 PRESSURE AND LEAKAGE TESTS

Perform tests on the system as a whole. Labor, materials and equipment for conducting the tests shall be furnished by the Contractor and shall be subject to inspection during the tests. The Contractor shall be responsible for the cost of repair, replacement, and retesting required because of failure to meet testing requirements. Prior to testing the system, the interior shall be blown out, cleaned and cleared of foreign materials. Meters, regulators, and controls shall be removed before blowing out and cleaning and reinstalled after clearing of foreign materials. Maintain safety precautions for pressure testing during the tests. Notify Owner or Owner's Representative 48 hours in advance of pressure, leakage and/or vacuum testing. Conduct tests in the presence of the Owner or Owner's Representative unless otherwise directed. During the test, the entire system shall be completely isolated from compressors and other sources of pressure. Perform testing with due regard for the safety of employees during the test. Persons not working on the test operations shall be kept out of the testing area while testing is proceeding. Leakage test shall be conducted only after satisfactory completion of pressure test.

3.8.1 Bubble Tests

Test each joint in accordance with ASTM E 515prior to concealing any work.

3.8.2 Pressure Testing

Section to be tested shall be slowly filled with air, and air shall be expelled. Test pressure shall be applied for one hour and gauge pressure shall be observed. Leaks shall be continuously checked while test pressure is being maintained. The piping system shall be tested after construction and before being placed in service using air as the test medium. The pressure test shall continue for at least 48 hours from the time of the initial readings to the final readings of pressure and temperature. The initial test readings of the instrument shall not be made for at

least 1 hour after the pipe has been subjected to the full test pressure, and neither the initial nor final readings shall be made at times of rapid changes in atmospheric conditions. The temperatures shall be representative of the actual trench conditions. Lines which fail to hold specified test pressure or which exceed the allowable leakage rate shall be repaired and retested.

3.8.3 Leakage Testing

Allow pipe to stand full of water at least 12 hours prior to starting leakage test. Exposed pipe, joints, fittings and valves shall be examined. Visible leakage shall be stopped, and the defective pipe, fitting or valve shall be replaced. The line under test shall be refilled to reach the required test pressure. The amount of water permitted as leakage shall be placed in a container attached to the supply side of the test pump. Container shall be sealed. No other source of supply to the pump or line under test shall be attached. Water remaining in the container and the amount used during the test shall be measured and recorded on the test report. Test shall be considered as failed upon exhaustion of supply and/or inability to maintain the required pressure.

3.8.4 Vacuum Testing

Test shall be performed on the entire system as approved by the Owner or Owner's Representative. Openings shall be sealed in system or section to be tested. Vacuum 2 psig shall be pulled for one hour (isolating system from vacuum by closing valves). System shall be allowed to normalize and then the initial vacuum readings shall be recorded. The vacuum shall be recorded at intervals of 15 minutes for the duration of the 8 hour test. Measurable leakage (loss of vacuum) after corrections have been made for changes in atmospheric conditions in conformity with the relationship $T(1)P(2)=T(2)P(1)$, in which T and P denote absolute temperature and total pressure, respectively, and the numbers denote initial and final readings, shall be repaired and retested.

3.8.5 Hanger Acceptance Testing

Pipe systems shall be brought up to operating pressures and temperatures. Systems shall be recycled to duplicate operating conditions.

3.8.6 Demonstration

Upon completion of the work, submit a Statement of Satisfactory Installation as specified in the Submittals paragraph and, at a time designated by the Owner or Owner's Representative, the services of a qualified engineer shall be provided for a period of not less than 8 hours to instruct the Owner or Owner's Representative in the contents of the operation and maintenance manuals for the equipment furnished under this Section. The field instructions shall cover the items contained in the bound instructions.

PART 1 GENERAL.

All work shall conform to the latest APWA Standard Specifications pertaining thereto. Excavations shall be protected at all times. Cuts in roadways shall be plated or temporarily filled and capped with cold mix asphalt when work is not being performed.

PART 2 PRODUCTS.

2.1 Bedding.

Bedding shall be as specified in the earthwork section.

2.2 Backfill

Backfill shall not be placed in water or mud. Clean graded rock or frozen material shall not be used as backfill. Backfill material shall be as specified in the earthwork section.

PART 3 EXECUTION.

3.1 Roadway Surfacing

Pavement surface shall be the same as the surrounding existing pavement. Any unsupported pavement shall be removed prior to pavement patching. All cuts shall be rectangular, with dimensions parallel and perpendicular to the direction of traffic. The finished surface shall be flush with all adjoining surfaces.

Portland Cement Concrete Surface. As indicated in Detail 1 of the attached figure, if the street cut is within 3 feet of an existing joint or cut, the pavement shall be removed to the existing cut or joint. All existing expansion joints, dowels, and reinforcing steel shall be replaced. Concrete shall be broom finished parallel to traffic flow and cured in accordance with Section 2208.2 of APWA Standard Specifications. The surface shall be protected from damage or defacement.

Asphalt Surface. As indicated in Detail 2 of the attached figure, if the street cut is within 18 inches of an existing joint or cut, it shall be extended to that joint or cut. The asphalt surface shall be tack coated to the base, Section 2204 of APWA Standard Specifications. Surface shall be placed and compacted, Section 2205.3 of APWA Standard Specifications.

Other Surfaces.

A. All others shall be replaced as directed by the Owner.

3.2 Sidewalks and Curbs

Any section that is cut shall be removed to the nearest joint (Section 2209.3A and 2301.3A of APWA Standard Specifications). The replacement shall match the existing surface material and comply with the appropriate standards.

3.3 Removing and Restoring Street Pavement and Other Surfaced Areas

The Contractor shall remove and restore all street or roadway pavement, surfaced parking areas, and other surfaced or graveled areas wherever encountered in the laying of pipe, fittings, valves, hydrants, backing blocks, and other appurtenances.

All pavement cuts in parking lots, streets, etc., shall be made with a concrete saw or with tools designed for cutting the pavement with a minimum of damage to the surrounding area. The edges of all cuts shall be smooth and straight.

Streets, highways, and roads, must be temporarily opened at the earliest possible time to traffic, and the pavement restored immediately after the pipe and fittings are tested.

All graveled areas, or areas otherwise surfaced for parking or for any other reason, which are cut or damaged in the construction, shall be returned to a condition equal or better to that which existed before the construction. All materials used shall be of equal or better quality to the materials used in the original construction of the surface.

3.4 Street Surface Restoration

Wherever street surfacing is cut or damaged, the Contractor shall remove and restore all street or roadway pavement, furnishing all necessary labor and materials. Care and caution shall be observed when cutting the existing pavement for the installation of the water or sewer mains. The opening shall be made with tools designed for cutting the pavement with a minimum of damage to the surrounding area.

Concrete pavement, asphaltic surface course, macadam pavement, and any other type of pavement or surface course which is cut or damaged shall be replaced to conform to the lines and grades of the original pavement and shall be of equal quality, thickness, and appearance to that removed.

End of Section.

PART 1 GENERAL

1.1 SCOPE

This section covers all cast-in-place concrete, including reinforcing steel, forms, finishing, curing, and appurtenant work. All concrete shall be air-entrained.

1.2 GENERAL

All cast-in-place concrete shall be accurately formed and properly placed and finished, as indicated on the drawings and specified herein.

The Contractor shall inform the Owner or Owner's Representative at least 24 hours in advance of the times and places at which he intends to place concrete.

1.3 PRELIMINARY REVIEW

The source and quality of concrete materials and the concrete proportions proposed for the work shall be submitted to the Owner or Owner's Representative for review before concrete is placed.

1.4 SUBMITTALS

Owner or Owner's Representative approval is required for all submittals. Submit the following in accordance with Section 00910 SUBMITTALS:

SD-03 Product Data

Portland Cement
Ready-Mixed Concrete
Vapor Barrier
Latex Bonding Agent
Floor Hardener
Chemical Admixtures

SD-04 Samples

Surface Retarder

SD-05 Design Data

Mixture Properties

SD-06 Test Reports

Testing and Inspection for QC

SD-07 Certificates

Qualifications

1.5 STORAGE OF MATERIALS

Cement shall be stored in suitable moistureproof enclosures. Cement which has become caked or lumpy shall not be used.

Aggregates shall be stored so that segregation and the inclusion of foreign materials are prevented. The bottom 6 inches of aggregate piles in contact with the ground shall not be used.

Reinforcing steel shall be carefully handled and shall be stored on supports which will keep the steel from contact with the ground.

PART 2 – PRODUCTS

2.1 FORMS

Forms for pavement, curbs, or gutters shall be made of steel and shall be supported on thoroughly compacted earth. The top face of pavement forms shall not vary from a true plane more than 1/4 inch in 10 feet.

Forms shall be thoroughly cleaned and oiled before concrete is placed.

Where concrete is placed against gravel or crushed rock which does not contain at least 25 percent material passing a No. 4 sieve, such surfaces shall be covered with polyethylene film to protect the concrete from loss of water. Joints in the film shall be lapped at least 4 inches.

2.2 MATERIALS.

Cement	ASTM C150, Type I or II.
Fine Aggregate	Clean natural sand, ASTM C33. Artificial or manufactured sand will not be acceptable.
Coarse Aggregate	Crushed rock, washed gravel, or other inert granular material conforming to ASTM C33, except that clay and shale particles shall not exceed one percent.
Water	Clean and free from deleterious substances.

Admixtures	
Water-Reducing	ASTM C494, Type A or D.
Air-Entraining	ASTM C260.
Reinforcing Steel Bars	ASTM A615, Grade 60, deformed.
Welded Wire Fabric	ASTM A185 or A497.
Bar Supports	CRSI Class 1, plastic protected, or Class 2, stainless steel protected.
Mechanical Connections	Erico "Cadweld T-Series" or "Lenton", or Richmond "Dowel Bar Splice System".
Plywood	Product Standard PS1, waterproof, resin-bonded, exterior type, Douglas fir.
Lumber	Straight, uniform width and thickness, and free from knots, offsets, holes, dents, and other surface defects.
Form Oil	Light-colored paraffin oil or other acceptable nonstaining material.
Polyethylene Film	Product Standard PS17, 6 mils or thicker.
Membrane Curing Compound	Fed Spec TT-C-800, Type I, and Floor Sealer Class 1, minimum 18 percent solids, nonyellowing, unit moisture loss 0.039 g/cm^2 maximum; Cormix "Sealco 800", L&M Chemical "Dress & Seal", Prokrete "Cure-N-Seal 30", ProSoCo "Kure and Seal", or Sonneborn "Kure-N-Seal 0800".

2.3 LIMITING REQUIREMENTS

Unless otherwise specified, concrete shall be controlled within the following limiting requirements.

2.3.1 Minimum Cement Factors

The quantity of portland cement, expressed in pounds per cubic yard, shall be not less than that indicated in the following table:

Concrete Slump	Coarse Aggregate Size from No. 4 Sieve to 3/8"	1/2"	3/4"	1"
2 inches	601	573	545	517
3 inches	629	592	564	536
4 inches	639	611	583	555

2.3.2 Ratio of Fine to Total Aggregates

The ratio of fine to total aggregates based on solid volumes (not weights) shall be:

Coarse Aggregate Size	Minimum Ratio	Maximum Ratio
3/8 inch	0.45	0.60
1/2 inch	0.40	0.55
3/4 inch	0.35	0.50
1 inch	0.30	0.46

2.3.3 Total Water Content

Total water content of concrete shall not exceed 5.4 gallons of water per hundred pounds of cement in the mix.

2.3.4 Slump

Concrete slump shall be kept as low as possible consistent with proper handling and thorough compaction. Unless otherwise authorized by the Engineer, slump shall not exceed 4 inches.

2.3.5 Total Air Content

The total volumetric air content of concrete after placement shall be 6 percent plus or minus one percent.

2.3.6 Admixtures

The admixture content, batching method, and time of introduction to the mix shall be in accordance with the manufacturer's recommendations. A water-reducing admixture and an air-entraining admixture shall be included in all concrete. No calcium chloride or admixture containing chloride from other than impurities from admixture ingredients will be acceptable.

2.3.7 Strength

The minimum acceptable compressive strengths, as determined by ASTM C39, shall be:

Age	Minimum Compressive Strength
7 days	3,000 psi
28 days	4,000 psi

2.3.8 BATCHING AND MIXING

Concrete shall be furnished by an acceptable ready-mixed concrete supplier and shall conform to ASTM C94.

2.3.8.1 Consistency

The consistency of concrete shall be suitable for the placement conditions. Aggregates shall float uniformly throughout the mass, and the concrete shall flow sluggishly when vibrated or spaded. The slump shall be kept uniform.

2.3.8.2 Delivery Tickets

A delivery ticket shall be prepared for each load of ready-mixed concrete. A copy of each ticket shall be handed to the Owner or Owner's Representative by the truck operator at the time of delivery. Tickets shall show the quantity delivered, the amount of each material in the batch, the outdoor temperature in the shade, the time at which the cement was added, and the numerical sequence of the delivery.

2.3.9. TESTING.

2.3.9.1 Air Content

An air content test shall be made from each batch of concrete from which concrete compression test cylinders are made. The Contractor shall provide all equipment and supplies necessary for the testing. Air content shall be determined in accordance with ASTM C231.

2.3.9.2 Slump

A slump test shall be made from each batch of concrete from which concrete compression test cylinders are made. Slump shall

be determined in accordance with ASTM C143.

2.3.9.3 Test Cylinders

Compression test specimens shall be made, cured, stored, and delivered to the laboratory in accordance with ASTM C31 and C39.

One set of concrete test cylinders shall be cast for each concrete pour. A set of test cylinders shall consist of four cylinders, two to be broken and to have compressive strengths averaged at 7 days, and two to be broken and to have compressive strengths averaged at 28 days. All concrete required for testing shall be furnished by the Contractor. No additional compensation will be paid to the Contractor for concrete so used.

Testing of the cured cylinders shall be performed by an independent testing laboratory at the expense of the Contractor.

PART 3 EXECUTION

3.1 FORMS.

3.1.1 Form Ties

Form ties shall be of the removable end, permanently embedded body type, and shall have sufficient strength and rigidity to support and maintain the form in proper position and alignment without the use of auxiliary spreaders.

3.1.2 Edges and Corners

Chamfer strips shall be placed in forms to bevel all salient edges and corners, except the top edges of walls and slabs which are to be tooled and edges which are to be buried. Unless otherwise noted, bevels shall be 3/4 inch wide.

3.1.3 Form Removal

Forms shall not be removed or disturbed until the concrete has attained sufficient strength to safely support all dead, live, and construction loads. Care shall be taken in form removal to avoid surface gouging, corner or edge breakage, and other damage to the concrete.

3.2 REINFORCEMENT

Reinforcement shall be accurately formed and positioned, and shall be maintained in proper position while the concrete is being placed and compacted. Unless otherwise indicated on the drawings, the details of fabrication shall conform to ACI 315 and 318. In case of conflict, ACI 318 shall govern. Reinforcement shall be free from dirt, loose rust, scale, and contaminants. Mechanical connections shall be used only as indicated on the drawings.

3.3 PLACEMENT

Concrete shall be conveyed to the point of final deposit and placed by methods which will prevent segregation or loss of ingredients. During and immediately after placement, concrete shall be thoroughly compacted and worked around all reinforcement and embedments and into the corners of the forms. Concrete shall be compacted by immersion-type vibrators, vibrating screeds, or other suitable mechanical compaction equipment. The use of jitterbug tampers to compact concrete flatwork will not be permitted.

3.4 CURING

Concrete shall be protected from loss of moisture by water saturation or by membrane curing for at least 7 days after placement.

Water saturation of concrete surfaces shall begin as quickly as possible after initial set of the concrete. Unformed surfaces shall be covered with polyethylene film, tarpaulins, or sand to retain the water. Water shall be applied as often as necessary to keep the concrete saturated for the entire curing period.

Membrane curing compound may be used in lieu of water curing on concrete which will not be covered later with mortar or additional concrete. Membrane curing compound shall be spray applied at a coverage of not more than 300 square feet per gallon. Unformed surfaces shall be covered with curing compound within 30 minutes after final finishing. If forms are removed before the end of the specified curing period, curing compound shall be immediately applied to the formed surfaces before they dry out. Curing compound shall be suitably protected against abrasion during the curing period.

Concrete shall be protected against freezing for at least 7 days after placement.

3.5 FINISHING

Recesses from form ties shall be filled flush with mortar. Fins and other surface projections shall be removed from all formed surfaces, except exterior surfaces that will be in contact with earth backfill.

Unless otherwise specified, unformed surfaces shall be screeded and given an initial float finish as soon as the concrete has stiffened sufficiently for proper

working. Any piece of coarse aggregate which is disturbed by the float or which causes a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance, with no unnecessary working of the surface.

Initial floating shall be followed by a second floating at the time of initial set. The second floating shall produce a finish of uniform texture and color. The completed finish for unformed surfaces shall be the finish produced by the second floating.

3.6 REPAIRING DEFECTIVE CONCRETE

Defects in concrete surfaces shall be repaired to the satisfaction of the Engineer. All concrete which is honeycombed or otherwise defective shall be cut out and removed to sound concrete, with edges square cut to avoid feathering.

Concrete repair work shall conform to Chapter 9 of ACI 301 and shall be performed in a manner that will not interfere with thorough curing of surrounding concrete. Repair work shall be adequately cured.

3.7 DATA AND DRAWINGS

All submittals of data and drawings shall be in accordance with the submittals section, except as noted herein.

End of Section

PART 1 GENERAL

1.1 DESCRIPTION

A. SVE Blower unit including integral components specified herein.

B. Definitions: SVE Blower: A factory fabricated assembly consisting of the blower, the transfer pump, and knock out tank, including relief valves and auto drain. Design capacities shall be as scheduled on drawings.

1.2 SUBMITTALS:

A. The contractor shall, in accordance with Section 009010 SUBMITTALS, furnish a complete submission for the unit covered in the project. The submission shall include all information listed below.

B. Manufacturer's Literature and Data

C. Maintenance and operating manuals.

PART 2 PRODUCTS

2.1 SVE BLOWER UNIT

A. General:

1. Units shall be a Sutorbilt 7LP or equal regenerative blower with 15 horsepower explosion proof motor as shown on Drawing C103.
2. The contractor and the unit manufacturer shall be responsible for insuring that the unit meets the requirements shown on the drawings.

PART 3 EXECUTION

3.1 INSTALLATION

Install the unit as shown on Drawing C103

3.2 STARTUP SERVICES

A. A factory-trained service representative of the manufacturer shall supervise the unit startup and application specific calibration of control components.

B. After the units are installed and tested, provide startup and operating instructions to Owner's Representative personnel.

END OF SECTION

PART 1 GENERAL

1.1 DESCRIPTION

A. Storage Tank units including integral components specified herein.

B. Definitions: Storage Tank: A factory fabricated assembly consisting of a tank with cathodic protection and secondary containment, including leak detection, protective coatings, gauges, level alarm, and wiring. Design capacities shall be as scheduled on drawings.

1.2 SUBMITTALS:

A. The contractor shall, in accordance with Section 009010 SUBMITTALS, furnish a complete submission for all roof top units covered in the project. The submission shall include all information listed below.

B. Manufacturer's Literature and Data

C. Maintenance and operating manuals.

PART 2 PRODUCTS

2.1 STORAGE TANK UNITS

A. General:

1. Units shall be 1,000 gallon above ground storage tank with secondary containment as shown on Drawing C103.
2. The contractor and the unit manufacturer shall be responsible for insuring that the unit meets the requirements shown on the drawings.

PART 3 EXECUTION

3.1 INSTALLATION

Install the two TANKS with secondary containment as shown on Drawing C103

3.2 STARTUP SERVICES

A. A factory-trained service representative of the manufacturer shall supervise the unit startup and application specific calibration of control components.

B. After the units are installed and tested, provide startup and operating instructions to Owner's Representative personnel.

END OF SECTION

PART 1 GENERAL

A. Thermal Oxidizer unit including integral components specified herein.

B. Definitions: Thermal Oxidizer: A factory fabricated assembly consisting of the air treatment components and discharge stack. Design capacities shall be as scheduled on drawings.

1.1 SUBMITTALS:

A. The contractor shall, in accordance with Section 009010 SUBMITTALS, furnish a complete submission for the unit covered in the project. The submission shall include all information listed below.

B. Manufacturer's Literature and Data

C. Maintenance and operating manuals.

PART 2 PRODUCTS

2.1 SVE BLOWER UNIT

A. General:

1. Units shall be a Anguil Model 50 or equal with stack as shown on Drawing C103.
2. The contractor and the unit manufacturer shall be responsible for insuring that the unit meets the requirements shown on the drawings.

PART 3 EXECUTION

3.1 INSTALLATION

Install the unit as shown on Drawing C103

3.2 STARTUP SERVICES

A. A factory-trained service representative of the manufacturer shall supervise the unit startup and application specific calibration of control components.

B. After the units are installed and tested, provide startup and operating instructions to Owner's Representative personnel.

END OF SECTION

PART 1 GENERAL

1.1 DESCRIPTION

A. Heater units including integral components specified herein.

B. Definitions: Heater Unit: A factory fabricated assembly consisting of fan, coils, filters, and other necessary equipment to circulate, clean, heat, humidify, dehumidify, and mix air. Design capacities shall be as scheduled on drawings.

1.2 SUBMITTALS:

A. The contractor shall, in accordance with Section 009010 SUBMITTALS, furnish a complete submission for all roof top units covered in the project. The submission shall include all information listed below.

B. Manufacturer's Literature and Data

C. Maintenance and operating manuals.

PART 2 PRODUCTS

2.1 HEATER UNITS

A. General:

1. Unit shall be a 3.5 ton heat pump unit with air handling equipment as shown on Drawing C103.
2. The contractor and the unit manufacturer will be shall be responsible for insuring that the unit meet the requirements shown on the drawings.

PART 3 EXECUTION

3.1 INSTALLATION

Install a 3.5 ton heat pump unit with air handling equipment as shown on Drawing C103

3.2 STARTUP SERVICES

A. A factory-trained service representative of the manufacturer shall supervise the unit startup and application specific calibration of control components.

B. After the units are installed and tested, provide startup and operating instructions to Owner's Representative personnel.

END OF SECTION

PART 1 GENERAL

1.1 DESCRIPTION

A. Cooling air handling units including integral components specified herein.

B. Definitions: Cooling Air Handling Unit: A factory fabricated assembly consisting of fan, coils, filters, and other necessary equipment to circulate, clean, cool, and mix air. Design capacities shall be as scheduled on drawings.

1.2 SUBMITTALS:

A. The contractor shall, in accordance with Section 009010 SUBMITTALS, furnish a complete submission for all roof top units covered in the project. The submission shall include all information listed below.

B. Manufacturer's Literature and Data

C. Maintenance and operating manuals.

PART 2 PRODUCTS

2.1 COOLING AIR HANDLING UNITS

A. General:

1. Units shall be thermostat controlled and motorized air handling vents to vent the building as shown on Drawing C103.
2. The contractor and the unit manufacturer shall be responsible for insuring that the unit meet the requirements shown on the drawings.

PART 3 EXECUTION

3.1 INSTALLATION

Install the two motorized air handling vents that are thermostat controlled as shown on Drawing C103

3.2 STARTUP SERVICES

A. A factory-trained service representative of the manufacturer will be allowed to supervise the unit startup and application specific calibration of control components, if necessary.

B. After the units are installed and tested, provide startup and operating instructions to Owner's Representative personnel.

END OF SECTION

PART 1 GENERAL.

1.1 REFERENCES

ASTM INTERNATIONAL (ASTM)

ASTM D 709 (2001; R 2007) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2007; TIA 2007-1; TIA 2007-2; TIA 2007-3; TIA 2007-4; TIA 2007-5; Errata 2006-1; Errata 2007-2; Errata 2009-3) National Electrical Safety Code
IEEE C57.12.28	(2005) Standard for Pad-Mounted Equipment - Enclosure Integrity

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011) National Electrical Code

1.2 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.
b. The technical sections referred to herein are those specification sections that describe products, installation procedures, and equipment operations and that refer to this section for detailed description of submittal types.
c. The technical paragraphs referred to herein are those paragraphs in PART 2 - PRODUCTS and PART 3 - EXECUTION of the technical sections that describe products, systems, installation procedures, equipment, and test methods.

1.2 ELECTRICAL CHARACTERISTICS

Electrical characteristics for this project shall be [ ] kV primary, three phase, four wire, 60 Hz, and [ ] volts secondary, three phase, four wire. Final connections to the power distribution system at the existing substation shall be made by the Contractor as directed by the Owner's Representative.

1.3 ADDITIONAL SUBMITTALS INFORMATION

Submittals required in other sections that refer to this section must conform to the following additional requirements as applicable.

1.3.1 Shop Drawings (SD-02)

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

1.3.2 Product Data (SD-03)

Submittal shall include performance and characteristic curves.

1.4 QUALITY ASSURANCE

1.4.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.4.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in the technical section.

1.5 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.6 POSTED OPERATING INSTRUCTIONS

Provide for each system and principal item of equipment as specified in the technical sections for use by operation and maintenance personnel. The operating instructions shall include the following:

a. Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.
b. Start up, proper adjustment, operating, lubrication, and shutdown procedures.
c. Safety precautions.
d. The procedure in the event of equipment failure.
e. Other items of instruction as recommended by the manufacturer of each system or item of equipment.

Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. For operating instructions exposed to the weather, provide weather-resistant materials or weatherproof enclosures. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

1.7 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not Be acceptable.

1.8 FIELD FABRICATED NAMEPLATES

ASTM D 709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified in the technical sections or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic 0.125 inch thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inch high normal block style.

1.9 WARNING SIGNS

Provide warning signs for the enclosures of electrical equipment including substations, pad-mounted transformers, pad-mounted switches, generators, and switchgear having a nominal rating exceeding 600 volts.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.28 or IEEE C57.12.29 , such as for pad-mounted transformers[and pad-mounted SF6 switches], provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Sign shall be a decal and shall have nominal dimensions of 7 by 10 inches with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 2 inch high letters. The word "DANGER" shall be in white letters on a red background and

the words "HIGH VOLTAGE" shall be in black letters on a white background. Decal shall be Panduit No. PPSO710D72 or approved equal.

b. When such equipment is guarded by a fence, mount signs on the fence. Provide metal signs having nominal dimensions of 14 by 10 inches with the legend "DANGER HIGH VOLTAGE KEEP OUT" printed in three lines of nominal 3 inch high white letters on a red and black field.

1.10 ELECTRICAL REQUIREMENTS

Electrical installations shall conform to IEEE C2 , NFPA 70 , and requirements specified herein.

PART 2 PRODUCTS.

2.1 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test [and the additional requirements specified in the technical sections].

PART 3 EXECUTION.

3.1 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria.

3.2 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.3 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of 30 feet apart.

PART 1 GENERAL.

1.1 SCOPE

A. The purpose of this document is to provide a specification for the purchase including design, fabrication, inspection, testing and shipment of 2300 to 14,400 volt AC three-phase input, [50, 60] Hertz, adjustable speed drives (ASDs) for [induction, synchronous] motors that will result in a long design life with very low maintenance requirements.

1.2 PRODUCT INSTALLED AND NOT INCLUDED

A. This document is for the procurement of only one component of the system and does not include requirements for the overall system design. Factors such as fault levels, torsional analysis, motor design, voltage drop, etc., also need to be included in the overall system design, but are outside the scope of this Specification. This Specification does not include the requirements for the motor. When a coordinated package is required, the Buyer shall also include an additional motor specification. More consideration will be given to a bidder that manufactures and guarantees both the motor and ASD.

1.3 REFERENCES

Applicable requirements in the latest edition of the following industry standards and industry practices shall be considered an integral part of this Specification. Short titles will be used herein when appropriate.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 519	Guide for Harmonic Control and Reactive Compensation of Static Power Converters
IEEE 1100	Powering and Grounding Sensitive Electronic Equipment

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	Industrial Control and Systems Enclosures
NEMA ICS 7	Industrial Control Systems Adjustable Speed Drives

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	National Electrical Code (NEC)

UNDERWRITERS LABORATORIES (UL)

UL 347A	Medium Voltage Power Conversion Equipment

1.4 DEFINITIONS

A. For the purpose of this Specification, the following definitions apply:

1. **ASD Adjustable Speed Drive:** Also called variable speed drive (VSD), variable frequency drive (VFD), or adjustable frequency drive (AFD) is a device used to vary the speed of a motor.
2. **NPC Neutral Point Clamp** is an ASD topology that has the advantage of reducing the high line to neutral voltage that can occur in other traditional drive designs that can reach 2.7 to 3.3 times normal levels.
3. **PWM:** Pulse Width Modulation is a method of controlling power devices to convert voltage levels. PWM is a popular method of control for converting DC voltage to AC voltage.
4. **IGBT:** Insulated Gate Bipolar Transistor is a high speed electrical switching power device. It is very efficient requiring very low power for control circuits.
5. **HCT:** Hall effect Current Transformer is used for current detection of DC to high frequency without direct contact or shunts.
6. **CPT:** Control Power Transformer is typically used to power control circuits and relays for the ASD.
7. **LCD:** Liquid Crystal Display is a device used for display of alpha-numeric or graphical characters. It is used in the operator interface of the ASD.

1.5 SYSTEM DESCRIPTIONS

A. For the purpose of this Specification, the following definitions apply:
1. Incoming Disconnect (when specified on Data Sheet)
2. Multi-secondary Isolation Transformer with Rectifier
3. Frequency Converter/Inverter
4. Electronic Motor Protection with selection of Class 10/20/30 protection
5. Output filter or reactor (only if /as required to minimize reflected voltage)
6. Output Disconnect(s) or bypass (when specified on Data Sheet)
7. Diagnostics and Control Circuits.

B. If specified on the data sheet, the ASD assembly shall be designed and constructed to Underwriters Laboratory (UL) standards.

C. The ASD inverter shall be of the pulse width modulated (PWM) Neutral Point Clamp (NPC) type. The output devices shall be Insulated Gate Bipolar Transistors (IGBTs) with a voltage rating of at least 3300V. Use of lower rated devices is unacceptable due to the quantity of devices required in the design.

D. This specification covers an ASD driving a single motor. When parallel operation of motors is specified, additional motor rating information shall be included on a separate attachment.

E. All components and material shall be new and of the latest field-proven design and in current production. Obsolete components or components scheduled for immediate discontinuation shall not be used.

F. The equipment shall be completely factory-built, assembled, wired, and tested. When it is necessary to disassemble the units for ease of transportation, adequate materials and instructions shall be provided for easy field reassembling.

1.6 SUBMITTALS

A. The Supplier shall furnish two (2) copies of the following documents with the quotation:

1. Descriptive bulletins to include ratings, protection, controls, diagnostics, and operation.
2. A system harmonic statement assuring compliance with IEEE 519 at the drive terminals.
3. Heat loss data for each typical unit
4. Drive system efficiency, including the effects of transformers, fans and other devices.
5. Outline drawings with weights and dimensions for all components required to meet the specification.
6. Warranty details.

B. The Manufacturer shall submit drawings and data of the type and quantity shown in the table below.

As Built	DESCRIPTION
X	Bill of Material
X	Outline drawings showing all dimensions, weights; and the final assembled configuration.
X	Single-line, 3-line, and control schematic diagrams with connection diagrams for all electrical equipment supplied.
X	Harmonic statement
X	Installation, Operation, Programming, and Maintenance Manual(s)
X	Certified Test Reports
X	Recommended priced spare parts list

1.7 INSPECTION AND TESTING

A. Manufacturer's standard tests shall be performed. Minimum testing shall include:

1. Power semiconductors shall be thermally cycled prior to final assembly into the ASD.

2. Printed circuit boards shall be tested prior to assembly into the ASD. The printed circuit boards shall go through a burn-in at 60° C for a minimum of 24 hours.

3. Individual power cells shall undergo a visual inspection, an electrical inspection, and a complete full load test prior to final assembly into the ASD.

4. Mechanical operation tests shall be performed for each ASD to verify satisfactory operation. These tests shall include checking operating mechanisms and interlock devices.

5. Electrical function tests shall be performed to ensure proper operation of all devices and components including operation of the ASD at full load conditions. Instrumentation, software, and monitoring tests shall be included.

6. The final assembly including transformer shall be tested at full load and voltage by a power back method that returns drive output power to the power line. An unloaded full voltage motor shall also be used during testing.

7. A test record for each ASD shall be furnished as part of the final data requirements.

1.8 RELIABILITY

A. The ASD shall be designed with a Mean Time Between Failure of at least 16 years.

B. The ASD shall be designed to have a Mean Time to Repair of 15 Minutes after the capacitors have discharged to a safe value.

1.9 WARRANTY

A. Seller shall warrant the equipment for a period of 5 years from date of shipment for equipment to be installed and operated in North America. For North American installations, warranty shall cover both parts and labor for required repairs.

B For equipment to be installed and operated in other areas of the world, warranty shall extend for a minimum of 12 months after startup, 18 months after shipment. Inclusion of labor for repairs may vary depending on location.

C. Seller must state clearly the details of warranty offered with his equipment.

1.10 SYSTEM STARTUP AND COMMISSIONING

A. Commissioning and Startup Services must be available from the supplier's local field engineering service group. A field service engineer shall be available 24 hours per day, 365 days per year.

B. The Supplier shall provide a software tool with operational, maintenance and diagnostic features. Using a Buyer supplied IBM compatible PC, this software shall permit the programming of parameters, display block diagrams, show bar graphs, report adjustment data, display trends, provide troubleshooting using first fault data/trace back data/trouble record, and contain links to system documentation and to system help. In addition, the software tool shall have the following features:

1. Ethernet interface with drive
2. Animated function block diagrams with real time variables
3. Commissioning wizards
4. Integrated trending window.

C. After commissioning is completed, the ASD supplier shall have a remote diagnostic center available for troubleshooting. This center shall have the capability of having connectivity to the ASD through a Buyer supplied modem. This diagnostic center shall be staffed by a qualified engineer 24 hours per day, 365 days per year. If specified on the data sheet, the costs associated with this support are to be included.

PART 2 PRODUCTS.

2.1 Acceptable Manufactures

A. The adjustable frequency drives shall be TMGE Automation Dura-Bilt5i MV or equal.

B. The VFD supplier shall have a minimum of 15 years experience in supplying medium voltage adjustable frequency drives.

2.2 PRODUCT DESCRIPTION

A. MECHANICAL

1. ENCLOSURE CONSTRUCTION

a. The ASD enclosure shall be suitable for installation in an indoor, unclassified area.

b. All enclosure openings exceeding 0.25 inch width shall be provided with screens to prevent the entrance of snakes, rodents,

etc. The maximum screen mesh opening width shall be 0.25 inch.

c. A "loss of cooling" fault shall be furnished. In the event of clogged filters or fan failure, the drive will produce an alarm and then in a predetermined time shutdown safely without electronic component failure. If specified on the data sheet, optional redundant fans, shall be available in the drive design as backup in the event of fan failure.

d. Air filters shall be of a reusable type that can be easily cleaned. All doors or front panels will be fully gasketed. Air exhaust from cooling fans will be at the top of the enclosure away from personnel in front of the equipment.

e. Fan motors shall be protected by an input circuit breaker. Metal squirrel cage ball bearing 460V three phase fan motors with 10-year design life are to be used in the drive design. Plastic muffin fans are not acceptable. Fan power will be obtained from [a remote 460V three-phase power, from a tap on the main power] transformer.

f. The maximum noise level of the unit shall not exceed 78 dBA at a distance of 40 inches from the unit and at a height of 5 feet from the floor.

g. The drive, including incoming disconnect and integral transformer should not be greater than the dimensions shown in the table at the end of this specification.

h. Use Manufacturer's standard finish unless otherwise shown on the Data Sheet.

2. ENCLOSURE AUXILIARY COMPONENTS

a. If specified on the Data Sheet, enclosure space heaters shall be supplied. Space heater elements shall be rated 240 VAC and operated at 120 VAC, single-phase.

b. The space heater circuit shall turn on when the drive is not operating. Thermostatic control cannot determine the dew point.

c. A fused switch or circuit breaker for the space heater circuit shall be provided for overload protection and as a disconnecting means.

3. ENCLOSURE NAMEPLATES

a. When specified by the data sheet, engraved, laminated plastic nameplates with characters 1/2 inch high, or larger, shall be provided for each ASD to identify the load it serves.

b. Nameplates shall have black letters on a white background, unless otherwise specified on the Data Sheet.

c. Meters, relays, switches, and other devices within the ASD shall be permanently identified using the same name as those appearing on the schematic diagrams.

B. ELECTRICAL

1. POWER REQUIREMENTS

a. The ASD shall be capable of providing rated output for continuous input voltage deviations of ±10% from the nominal rating with transformer taps adjusted accordingly for continuous operation matching the average system voltage.

b. The ASD shall be able to ride through voltage dips down to 70% of nominal, such as those experienced during motor starting.

c. The ASD shall be able to return to normal operation following an incoming power disturbance that falls within the range determined by Figure 3-2 in IEEE 1100.

d. The ASD one-minute overload current rating shall be 115% of rated current for variable torque applications when indicated on the Data Sheet.

e. The ASD one-minute overload current rating shall be 150% of rated current for constant torque applications when indicated on the Data Sheet.

f. The ASD output voltage shall not cause insulation stress to the motor or exceed the peak voltage insulation level of the motor. Output filters, if required, shall be integral to the drive cabinet. Any capacitors supplied shall be oil filled.

g. The ASD shall comply with the latest revision of IEEE 519 for total harmonic current and voltage distortion measurement and calculation. Voltage distortion shall not exceed 5% and current distortion shall not exceed 3% to the utility line. Individual current harmonics shall not exceed the requirements of IEEE 519.

2. POWER DISCONNECT DEVICES

a. When the Buyer does not have a suitable disconnect available, the ASD Manufacturer shall include an integral main disconnect device with an interlocked and padlockable handle mechanism. The disconnecting device shall be a medium voltage vacuum contactor with a bolted pressure disconnect switch whose blades are externally visible from outside the enclosure. The disconnect

device and associated fuses shall have a minimum rating of 350 MVA.

b. The incoming line shall have distribution class lightning arrestors to protect from transient voltages. The transformer and rectifier shall be an integral part of the ASD assembly.

c. When multiple inverter enclosure doors are supplied, all doors shall be electrically interlocked with the disconnect device. The interlocks shall include a provision to manually override for test and repair.

d. If specified on the Data Sheet, the ASD shall include an output disconnect.

e. If specified on the Data Sheet, the ASD shall include a bypass feature. A "maintenance bypass" shall allow servicing of the ASD components while the motor is operating at fixed speed.

3. INPUT POWER TRANSFORMER AND RECTIFIER

a. The ASD shall contain an incoming dry type isolation transformer whose primary voltage shall be as specified on the Data Sheet.

b. The transformer shall contain three-phase secondary windings that provide the proper phase shifting to feed a minimum of a 24-pulse rectification to reduce harmonic currents and voltages reflected to the primary power system. Any ASD proposed with a converter designed for less than 24 pulse shall include a harmonic study with the proposal. Additional testing at the user site to verify the study results will be required at no additional cost to Buyer.

c. The transformer shall be copper wound and shall have a 430°F insulation system to operate at 240° F rise at full load conditions.

d. The transformer shall have an electrostatic shield for protection from voltage transients.

e. The rectifiers shall be protected by fuses with blown fuse indication.

f. Soft charge of the DC bus capacitors shall be accomplished by use of an input reactor on the primary of the input transformer. A vacuum contactor rated for drive full load amps will short the reactor after charge is accomplished.

g. The DC power supply shall be filtered by long lasting liquid filled capacitors. Electrolytic capacitors are not permitted in the

main energy storage power circuit.

4. POWER BUS

   a. All power bus bars, when part of the standard design, and other high current carrying parts shall be tin-plated copper for corrosion resistance. Power bus bar joints shall be plated.

   b. Bus bars shall be braced to withstand short circuit currents with a minimum of 50KAIC.

   c. Input and output connections shall be either top or bottom access in the standard design.

5. INVERTER SECTION

   a. The ASD inverter section shall consist of three modular assemblies fed from series DC power supplies. Each DC supply shall be derived from a phase-shifted secondary of the input transformer that cancels reflected harmonics back to the power line.

   b. The IGBTs are designed in a bridge connection such that when used in combination with the other bridges, a multi-level output motor voltage waveform is constructed. Each cell has a minimum rating of 3300V.

   c. The IGBTs shall be cooled using a sealed cooling system utilizing modern heat plate technology.

   d. Each cell shall communicate to the controller through optical communications. No other isolation method is permitted.

   e. A high resistance ground detection circuit at the neutral point shall be included for alarm or warning in the event the load develops a ground leakage current or fault.

   f. The output of the inverter shall produce harmonic current of not more than 3% over a speed range of 10% to 100% regardless of load.

6. WIRING AND TERMINATIONS

   a. Bus bar with standard NEMA four-hole pattern shall be supplied for input and output connection of external wiring and shall be conveniently located, clearly numbered, and identified.

   b. Control wire terminal blocks for external wiring terminations shall be compression screw type, designed to accommodate stripped insulation bare wire ends, and shall accept a minimum of two No. 14 AWG wires.

c. Connection points for inputs and outputs of different voltage levels shall be segregated to reduce possibility of electrical noise.

d. Where wiring is run through sheet metal or any barrier, bushings, grommets or other mechanical protection around the sheet or barrier opening shall be provided.

e. All internal wiring shall be terminated with no more than two (2) conductors per terminal point.

f. The ASD shall have an internal mechanical ground connection suitable for terminating a stranded copper ground conductor of the same size as the incoming phase conductors. Ground connections shall be near the incoming and outgoing power cable termination points and control wiring connections.

g. Enclosures shall be designed to accommodate power cable entry from either top or bottom.

h. Minimum wire bending space shall meet or exceed the value shown in NEC Table 430-10(b) for termination of the power cable.

C. CONTROL

1. CONFIGURATION

a. The ASD Supplier shall supply a software tool, called toolbox herein, to configure, monitor and troubleshoot the drive. The toolbox shall have a path to a modem for remote diagnostics. The monitor feature shall have a trending feature where the ASD signals can be displayed in real time.

b. The toolbox shall have a multilevel privilege feature for configuration parameter settings.

2. OPERATOR PANEL, INSTRUMENTS, DISPLAYS, AND INDICATING LIGHTS

a. A door-mounted drive backlit LCD keypad will be standard for operator interface.

b. The operator keypad display shall:

1) have configurable bar charts and intuitive icons
2) contain LED's to indicate "Ready", "Run", and "Alarm/Fault"
3) have drive control functions and allow local operation of the motor from the keypad
4) have full access to all parameters and variables.

c. The operator keypad shall be used to read and write parameter data, to present operational information, to produce first fault and device indication, to show alarms, and to allow metering of parameters, and provide Ethernet connectivity to the drive software programming tool on the Buyer's PC.

d. The operator keypad shall include a level of security.

e. The operator keypad shall have seven analog test points. Two points shall be for Current A and B, and the other five shall be configurable.

f. Additional metering and indication shall be supplied in accordance with the Data Sheet.

g. Meters, displays, and keypads shall be accessible and visible from the front without opening the enclosure.

3. OPERATIONAL CONTROLS

a. The ASD shall include the following basic operating adjustments:

1) Acceleration Time
2) Deceleration time
3) Current Limit
4) Minimum frequency or speed
5) Maximum frequency or speed
6) Selectable skip frequencies
7) Sensor-less Vector parameter settings
8) Local/Remote selection

b. The door mounted keypad shall have a button, which when activated, shall check each IGBT and display any errors in this self diagnostic test.

c. The ASD shall include necessary components to protect the ASD and motor against motor overload, internal faults in either the motor or ASD and disturbances in the incoming AC line. The overload protection shall have a multiple motor thermal curve function that allows tailoring the drive overload for different applications. The failure shall be annunciated on the operator panel's LCD display. The ASD to be shut down with the output voltage reduced to zero for the following conditions:

1) Short circuit on the output of the ASD
2) Instantaneous overcurrent
3) Motor overload
4) Undervoltage or overvoltage on the incoming AC line
5) Single-phasing of the AC incoming line

6) Overtemperature of the ASD electronics from a component or ventilation failure
7) Gate driver power supply or control power supply undervoltage
8) ASD output open circuit during operation
9) Overvoltage or ground fault of the ASD output
10) Cause of individual power cell fault isolated to failed device.

d. If specified on the Data Sheet, the ASD shall return the motor to operating speed upon restoration of power following a voltage interruption on the AC incoming line.

e. If specified on the Data Sheet, the ASD shall be able to reaccelerate a rotating motor. If this feature is not specified, the Manufacturer shall ensure the ASD will not restart until the motor has slowed sufficiently.

f. If specified on the Data Sheet, the ASD shall have the ability to smoothly transfer the motor to and from the power line. When multiple motors are specified, this feature allows the acceleration and synchronization of a motor to line voltage and speed and then allows another motor to be run at adjustable speed.

g. If specified on the Data Sheet, the ASD shall have the ability provide electronic braking to slow the motor down.

h. The ASD shall be equipped with an auto tune-up wizard that includes a motor simulation feature. This function will allow the drive to be tuned up without the motor being connected.

4. CONTROL POWER TRANSFORMERS (CPT)

a. A control power transformer (CPT) shall be provided within the enclosure. Depending on the end user's needs and specified on the data sheet, the CPT primary can be furnished from a separate source of 460VAC or take power from the drive main power.

b. The KVA rating of the CPT shall be determined by the Manufacturer and shall have a minimum of 25% spare capacity.

c. The CPT secondary voltage shall be 120 VAC.

d. The CPT primary shall be fused with current limiting fuses with an interrupting rating no less than 100,000 amperes.

e. The CPT secondary shall be fused and have one terminal grounded.

5. INPUT AND OUTPUT CONTROLS

a. Interface to external controls and signals from the Buyer shall be furnished by the Manufacturer as specified on the Data Sheet.

b. The ASD shall provide, as a minimum, two analog inputs at ± 10vdc or 4-20 mA.

c. Three configurable analog output voltage signals shall be supplied. Two outputs shall be isolated and rated 4-20 mA and the other output shall be rated ± 10vdc.

d. The ASD shall include, as a minimum, two 24vdc – 120vac discrete inputs.

e. The ASD shall include, as a minimum, six 24vdc inputs.

f. The ASD shall include, as a minimum, five relays with 2 NO and 2 NC contacts rated 115 VAC, at 5 amps.

g. The ASD source voltage for external "Start - Stop" circuit logic shall be 120 VAC, derived from either the CPT or another remote source.

h. If specified, a communication network to the Buyer's network shall be [DeviceNet, Profibus, ISBus, TOSLINE-S20].

6. FAULTS AND ALARMS

a. The latest 8 faults and alarms are logged in trace memory with 64 analog channels. The trace for each alarm is started 50 ms before the fault and ends 100 ms after the fault. This trace data can be uploaded to the toolbox for display/analysis in the trend window.

b. The ASD shall provide one normally open contact to indicate motor run status. Contacts shall be rated 5A at 230 VAC and 24 VDC.

c. The ASD shall include an alarm contact that will be closed during normal operation and will open on ASD fault conditions. Contacts shall be rated 5A at 230 VAC and 24 VDC. If specified on the Data Sheet, additional diagnostic contacts shall be provided. The contacts can alarm the following conditions:

1) Input Contactor Failure
2) Ventilation Fan Malfunction
3) Control Power Loss
4) CPU Failure
5) DC Bus Overvoltage or Undervoltage
6) Open Cabinet Door

7) Gate Power Loss
8) Drive Cooling Fan Failure
9) Motor Overtemperture
10) Transformer Overtemperature
11) Motor Overspeed
12) PCB Failure
13) Data Network Failure
14) Individual Cell Fault.
15) Under-load / loss of load

d. The ASD shall have the ability to be connected via a modem in a user supplied PC to a remote diagnostic center. The diagnostic center shall be manned 24 hours per day, 365 days per year.

2.3 PRODUCT DESCRIPTION

A. EFFICIENCY

1. The efficiency of the ASD including the transformer and fans shall be greater than 96.5% at 60 hertz output frequency.

B. POWER FACTOR

1. The power factor of the ASD including the transformer shall be greater than 95% at loads greater than 50%.

C. SPEED CONTROL

1. Sensor-less vector control shall be supplied when required speed regulation is less than 0.5%.

2. Vector control with a tachometer or encoder shall be supplied when required speed regulation is between 0.5% and 0.01%.

3. The response of the speed regulator shall be at least 60 rad/sec.

D. TORQUE CONTROL

1. The ASD shall have less than 1% torque ripple over a 20 to 1 speed range on the motor.

2. The accuracy of the torque regulator shall be ± 3% FS with a motor temperature sensor or ± 30% without a motor temperature sensor.

3. The response of the torque regulator shall be at least 500 rad/sec.

PART 3 EXECUTION

3.1 SITE PREPARATION

A. The ASD shall be placed in an indoor, unclassified area. The maximum temperature shall not exceed the maximum ambient listed on the data sheet.

3.2 SHIPPING

A. Unless specified otherwise, preparation for shipment shall be in accordance with Manufacturer's standards.

B. Loose equipment shall be appropriately packaged and secured for shipment inside the enclosure or shipping container. These items shall be properly tagged for easy identification.

C. Export packaging shall be available when indicated on the data sheet.

PART 1 GENERAL

1.1 REFERENCES

ASTM INTERNATIONAL (ASTM)

ASTM A 1008/A 1008M (2010) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardened
ASTM A 123/A 123M (2009) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 368 (1995a; R 2009) Standard Specification for Stainless Steel Wire Strand
ASTM A 467/A 467M (2007) Standard Specification for Machine Coil Chain
ASTM A 47/A 47M (1999; R 2009) St andard Specification for Ferritic Malleable Iron Castings ASTM A 580/A 580M (2008) Standard Specification for Stainless Steel Wire
ASTM A 641/A 641M (2009a) Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A 653/A 653M (2009a) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B 164 (2003; R 2008) Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire
ASTM B 26/B 26M (2009) Standard Specification for Aluminum-Alloy Sand Castings
ASTM B 633 (2007) Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
ASTM E 2129 (2005) Standard Practice for Data Collection for Sustainability Assessment of Building Products

ILLUMINATING ENGINEERING SOCIETY OF NORTH AMERICA (IESNA)

IESNA HB-9 (2000; Errata 2004; Errata 2005; Errata 2006) IES Lighting Handbook

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100 (2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2 (2007; TIA 2007-1; TIA 2007-2; TIA 2007-3; TIA 2007-4; TIA 2007-5; Errata 2006-1; Errata 2007-2; Errata 2009-3) National Electrical Safety Code
IEEE C62.41.1 (2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2 (2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI ANSLG C78.41 (2006) For Electric Lamps--Guidelines for Low-Pressure Sodium Lamps ANSI ANSLG C78.42 (2009) For Electric Lamps: High-Pressure Sodium Lamps
ANSI C78.1381 (1998) American National Standard for Electric Lamps - 250-Watt, 70 Watt, M85 Metal-Halide Lamps
ANSI C82.1 (2004) American National Standard for Electric Lamp Ballasts - Line Frequency Fluorescent Lamp Ballasts
ANSI C82.11 (2002) American National Standard for High-Frequency Fluorescent Lamp Ballasts--Supplements
ANSI C82.2 (2002) American National Standard for Lamp Ballasts--Methods of Measurement of Fluorescent Lamp Ballasts
ANSI C82.4 (2002) American National Standard for Ballasts for High-Intensity-Discharge and Low-Pressure Sodium (LPS) Lamps (Multiple-Supply Type)
ANSI/ANSLG C78.43 (2007) American National Standard for Electric Lamps - Single-Ended Metal-Halide Lamps
ANSI/IEC C78.81 (2010) American National Standard for Electric Lamps--Double-Capped Fluorescent Lamps--Dimensional and Electrical Characteristics
ANSI/IEC C78.901 (2005) American National Standard for Electric Lamps - Single Base Fluorescent Lamps--Dimensional and Electrical Characteristics
ANSI/NEMA C78.LL 1256 (2003) Procedures for Fluorescent Lamp Sample Preparation and the Toxicity Characteristic Leaching Procedure (TCLP)
NEMA 250 (2008) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2011) National Electrical Code
NFPA 90A (2009; Errata 09-1) Standard for the Installation of Air Conditioning and Ventilating Systems

UNDERWRITERS LABORATORIES (UL)

UL 1029 (1994; Reprint Jun 2010) High-Intensity-Discharge Lamp Ballasts
UL 1598 (2008; Reprint Jan 2010) Luminaires
UL 595 (1985) Marine-Type Electric Lighting Fixtures
UL 844 (2006; Reprint Nov2008) Standard for Luminaires for Use in Hazardous (Classified) Locations
UL 935 (2001; Reprint Jun 2010) Standard for Fluorescent-Lamp Ballasts

1.1 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE 100 .
b. Average life is the time after which 50 percent has failed and 50 percent has survived under normal conditions.
c. Total harmonic distortion (THD) is the root mean square (RMS) of all the harmonic components divided by the total fundamental current.

1.2 SUBMITTALS

Submittals require Owner's Representative approval. Submit the following in accordance with Section 00910 SUBMITTALS:

SD-02 Shop Drawings

Submit Fabrication Drawings for the following items consisting of fabrication and assembly details
to be performed in the factory.

Commercial Incandescent Lighting Fixtures
Industrial Incandescent Lighting Fixtures
Enclosed and Gasketed Vapor-Tight Fixtures
Incandescent Lamps
Lowering Devices

SD-03 Product Data

Fluorescent lighting fixtures
Fluorescent electronic ballasts
Fluorescent electromagnetic ballasts
Fluorescent lamps
High-intensity-discharge (HID) lighting fixtures
HID ballasts
High-pressure sodium (HPS) lamps
Low-pressure sodium lamps
Metal-halide lamps
Incandescent lighting fixtures
Incandescent lamps
Power hook fixture hangers
Electronic dimming ballast
Dimming ballast controls
Light Level Sensor

Submit Manufacturer's catalog data for the following items:

Commercial Incandescent Lighting Fixtures
Industrial Incandescent Lighting Fixtures
Enclosed and Gasketed Vapor-Tight Fixtures
Incandescent Lamps
Lowering Devices

SD-06 Test Reports

Operating test
Submit test results as stated in paragraph entitled "Field Quality Control."
Submit Test reports for Operational Tests on incandescent lighting fixtures in accordance with the paragraph entitled, "Field Testing," of this section.

1.3 QUALITY ASSURANCE

1.3.1 Fluorescent Electronic Ballasts

Submit ballast catalog data as required in the paragraph entitled "Fluorescent Lamp Electronic Ballasts" contained herein. As an option, submit the fluorescent fixture manufacturer's electronic ballast specification information in lieu of the actual ballast manufacturer's catalog data. Include published specifications and sketches, which cover the information required by the paragraph entitled "Fluorescent Lamp Electronic Ballasts" herein. This information may be supplemented by catalog data if required, containing a list of vendors with vendor part numbers.

1.3.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Owner's Representative. Provide equipment, materials, installation, and workmanship in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.3.3 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship,which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period includes applications of equipment and materials under similar circumstances and of similar size, on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4 WARRANTY

Support the equipment items with service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.4.1 Electronic Ballast Warranty

Furnish the electronic ballast manufacturer's warranty, for not less than 5 years from the date of manufacture of the electronic ballast. Ballast assembly in the lighting fixture, transportation, and on-site storage is not to exceed 12 months, thereby permitting 4 years of the ballast 5 year warranty to be in service and energized. State in the warranty that the manufacturer agrees to exchange a malfunctioning ballast and promptly ship the replacement to the using

Government facility,said replacement ballast being identical to, or an improvement upon, the original design of the malfunctioning ballast.

PART 2 PRODUCTS

2.1 PRODUCT STANDARDS

Provide incandescent lighting fixtures conforming to UL 1598. Provide fixtures in hazardous areas conforming to UL 844.

Furnish lighting fixtures completely assembled with wiring and mounting devices and ready for installation at the locations noted. Design and equip recessed fixtures in suspended ceilings for installation in the type of ceiling in which the fixture is to be installed. Design fixtures to be supported independent of the ceiling. Equip fixtures with the lamps required.

2.2 FLUORESCENT LIGHTING FIXTURES

Provide fluorescent fixtures, conforming to UL 1598 with electronic ballasts.

2.2.1 Fluorescent Lamp Electronic Ballasts

Provide electronic ballasts, meeting as a minimum, the following characteristics:

a. Provide ballasts complying with UL 935 , ANSI C82.11 , NFPA 70 , and CEC Title 24 unless specified otherwise. Provide 100 percent electronic high frequency type ballasts with no magnetic core and coil components, which provide transient immunity as recommended by IEEE C62.41.1 and IEEE C62.41.2 . Design ballast for the wattage of the lamps used in the indicated application. Design ballasts to operate on the voltage system to which they are connected.
b. A power factor of 0.95 (minimum).
c. Operates at a frequency of 20,000 Hertz (minimum), and is compatible with and not cause interference with the operation of occupancy sensors or other infrared control systems. Provide ballasts operating at or above 40,000 Hertz where available.
d. Light regulation of plus or minus 10 percent lumen output with a plus or minus 10 percent input voltage regulation. Ensure ballasts have 10 percent flicker (maximum) using any compatible lamp.
e. A ballast factor between 0.85 (minimum) and 1.00 (maximum). Current crest factor - 1.7 (maximum).
f. UL listed Class P with a sound rating of "A."
g. Include circuit diagrams and lamp connections displayed on the ballast.
h. Provide instant start ballasts unless otherwise indicated, with programmed start where indicated.
i. Provide programmed start ballasts for compact fluorescent fixtures.
j. Provide ballasts capable of starting and maintaining operation at a minimum of 0 degrees F unless otherwise indicated.

k. Provide electronic ballasts with a full replacement warranty of 5 years from date of manufacture as specified in paragraph entitled "Electronic Ballast Warranty" herein.

2.2.1.1 T-8 Lamp Ballast

a. Total harmonic distortion (THD): 20 percent.
b. Input wattage.
   1. 32 watts (maximum) when operating one F32T8 lamp]
   2. 62 watts (maximum) when operating two F32T8 lamps]
c. Ballast efficacy factor.
   1. 2.54 (minimum) when operating one F32T8 lamp]
   2. 1.44 (minimum) when operating two F32T8 lamps]
d. Provide three lamp fixtures with two ballasts per fixture where multilevel switching is indicated.]
e. A single ballast may be used to serve multiple fixtures if they are continuously mounted and factory manufactured for that installation with an integral wireway.

2.2.1.2 F17T8 Lamp Ballast

Provide F17T8 ballasts with:

a. Total harmonic distortion (THD): 25 percent (maximum).
b. Input wattage: 34 watts (maximum) when operating two F17T8 lamps.

2.2.1.3 F96T8 Lamp Ballast

a. Total harmonic distortion (THD): No greater than 30 percent when operating one lamp and 20 percent when operating two lamps.
b. Input wattage:
   1. 56 watts (maximum) when operating one F96T8 lamps
   2. 102 watts (maximum) when operating two F96T8 lamps
c. A single ballast may be used to serve multiple fixtures if they are continuously mounted and factory manufactured for that installation with an integral wireway.

2.2.3 Light Level Sensor

UL listed. Provide light level sensor capable of detecting changes in ambient lighting levels, and providing a dimming range of 20 percent to 100 percent, minimum, designed for use with dimming ballast and voltage system to which they are connected. Ensure sensor is capable of controlling 40 electronic dimming ballast, minimum. Provide adjustable light level sensor with a set level range from 10 to 100 foot candles, minimum. Provide sensor with a bypass function to electrically override sensor control.

2.2.4 Fluorescent Lamps

Low mercury lamps must be specified on projects that use 4-foot lamps and are located in the continental United States.

a. Provide T-8 rapid start lamps rated 32 watts (maximum), 2800 initial lumens (minimum), CRI of 75 (minimum), color temperature of 3500 K, with an average rated life of 20,000 hours.
b. Provide T-8 rapid start lamp, 17 watt (maximum), nominal length of 24 inches, 1300 initial lumens, CRI of 75 (minimum), color temperature of 3500 K, and an average rated life of 20,000 hours.

Average rated life is based on 3 hours operating per start.

2.2.5 Open-Tube Fluorescent Fixtures

Provide with self-locking sockets, or lamp retainers (two per lamp).

2.2.6 Air Handling Fixtures

Provide fixtures used as air handling registers conforming to the requirements of NFPA 90A .

2.3 HIGH-INTENSITY-DISCHARGE (HID) LIGHTING FIXTURES

UL 1598 . Provide HID fixtures with tempered glass lenses when using metal-halide lamps.

2.3.1 HID Ballasts

Provide HID ballasts conforming to UL 1029 and ANSI C82.4 , with constant wattage autotransformer (CWA) or regulator, high power factor type (minimum 90 percent). Provide single-lamp ballasts which have a minimum starting temperature of minus minus 22 degrees F. Provide ballasts:

a. Designed to operate on the voltage system to which they are connected.
b. Designed for installation in a normal ambient temperature of 105 degrees F.
c. Constructed so that open circuit operation will not reduce the average life.

Provide high-pressure sodium (HPS) ballasts with a solid-state igniter/starter with an average life in the pulsing mode of 3500 hours at the intended ambient temperature. Igniter case temperature is not to exceed 195 degrees F in any mode.

2.3.2 High-Pressure Sodium (HPS) Lamps

ANSI ANSLG C78.42 wattage as indicated. 150 watt lamps, if required, are 55 volt type.

2.3.2.2 Luminaire Efficiency Rating (LER)

a. Upward efficiency of 0 percent
   1. 150-399 watts: Minimum 58 LER for closed fixture; minimum 68 for open fixture
   2. 400-999 watts: Minimum 63 LER for closed fixture; minimum 84 for open fixture

b. Upward efficiency of 1 percent-10 percent
   1. 150-399 watts: Minimum 64 LER for closed fixture; minimum 63 for open fixture
   2. 400-999 watts: Minimum 82 LER for closed fixture; minimum 89 for open fixture
   3. 1000 plus watts: Minimum 109 LER for open fixture]

2.3.3 Low-Pressure Sodium Lamps

ANSI ANSLG C78.41 .

2.4 INCANDESCENT LIGHTING FIXTURES

Use of incandescent lamps and fixtures is prohibited, unless specifically indicated otherwise. UL 1598 .

2.4.1 Incandescent Lamps

Provide the number, type, and wattage indicated.

2.5 RECESS- AND FLUSH-MOUNTED FIXTURES

Provide type that can be relamped from the bottom, with access to ballast from the bottom, with trim for the exposed surface of flush-mounted fixtures as indicated.

2.6 FIXTURES FOR HAZARDOUS LOCATIONS

In addition to requirements stated herein, provide incandescent fixtures for hazardous locations which conform to UL 844 or which have Factory Mutual certification for the class and division indicated.

2.7 POWER HOOK FIXTURE HANGERS

Provide UL listed assembly including through-wired power hook housing, interlocking plug and receptacle, power cord, and fixture support loop. Provide power hook housing of cast aluminum having two 3/4 inch threaded hubs, including support hook with safety screw. Provide fixture support loop of cast aluminum with provisions for accepting 3/4 inch threaded fixture stems. Include with power cord 16 inches of 3 conductor No. 16 Type SO cord. Provide complete assembly rated [120 volts or 277 volts, 15 amperes][480 volts, 20 amperes].

2.9 EQUIPMENT IDENTIFICATION

2.9.1 Manufacturer's Nameplate

Provide each item of equipment with a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.9.2 Labels

Provide labeled luminaires in accordance with UL 1598 requirements. Clearly mark all for operation of specific lamps and ballasts according to proper lamp type.

Provide all markings related to lamp type clear and located to be readily visible to service personnel, but unseen from normal viewing angles when lamps are in place. Provide ballasts with clear markings indicating multi-level outputs and indicate proper terminals for the various outputs.

2.10 FACTORY APPLIED FINISH

Provide electrical equipment with factory-applied painting systems which , as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

2.11 COMMERCIAL INCANDESCENT LIGHTING FIXTURES

Commercial incandescent lighting fixtures include recessed, surface mounted, and pendant-mounted luminaires.

Provide [corrosion-resistant nonferrous metal] [sheet steel with corrosion-resistant finish] metal parts of fixtures. Do not use solder or self-threading sheet metal screws in the construction of the fixture enclosure. Equip fixtures rated up to and including 300 watts with medium screw-base lampholders. Equip fixtures rated in excess of 300 watts but not more than 1,500 watts with mogul screw-base lampholders. Provide screw shells of lampholders which are electrically connected to the metal part of lighting fixtures or equipment grounding-circuit conductor.

2.11.1 Surface-Mounted Fixtures

Design the surface-mounted fixtures to be fastened to wall or ceiling flush-mounted outlet boxes. Do not subject combustible ceiling materials to temperatures in excess of 195 degrees F.

2.12 INDUSTRIAL INCANDESCENT LIGHTING FIXTURES

Provide industrial incandescent lighting fixtures with industrial porcelain-enameled seamless dome reflectors with ventilated necks and hoods tapped for 1/2 inch conduit for swivel suspension pendant mounting. Provide lampholders with medium or mogul bases as applicable, furnished with incandescent lamps having the wattage rating indicated, meeting the requirements of UL 1598 . Provide easily detachable reflectors and sockets as a unit, without the use of tools, but arranged so that they cannot inadvertently come loose.

2.13 INCANDESCENT LAMPS

Provide general-purpose lamps, clear. Provide lamps with wattage ratings up to and including 300 watts with medium brass screw bases. Provide lamps with wattage ratings in excess of 300 watts with mogul brass screw bases.

Special-purpose lamps include PAR and R lamps. Provide PAR lamps with clear, molded, heat-resistant, hard-glass bulbs with parabolic, aluminized, inner-bulb wall reflector for spot- or flood-lighting applications. Provide R lamps with clear, soft, blown-glass bulbs with silver-deposited, inner-bulb wall reflector for spot or floodlighting applications. Design lamps for operation on 120 volts.

PART 3 EXECUTION

3.1 INSTALLATION

Ensure all electrical installations conform to IEEE C2 , NFPA 70 , and to the requirements specified herein.

3.1.1 Lamps

Deliver lamps of the type, wattage, and voltage rating indicated to the project in the original cartons and installed just prior to project completion. Replace lamps installed and used for working light during construction prior to turnover to the Government if more than 15 percent of their rated life has been used. Test the lamps for proper operation prior to turn-over and replace if necessary with new lamps from the original manufacturer. Provide 10 percent spare lamps of each type from the original manufacturer.

3.1.2 Lighting Fixtures

Set lighting fixtures plumb, square, and level with ceiling and walls, in alignment with adjacent lighting fixtures, and secure in accordance with manufacturers' directions and approved drawings, in conformance with the requirements of NFPA 70 . Mounting heights specified or indicated are to the

bottom of fixture for ceiling-mounted fixtures and to center of fixture for wall-mounted fixtures. Obtain approval of the exact mounting for lighting fixtures on the job before commencing installation and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed. Ceiling grid clips are not allowed as an alternative to independently supported light fixtures. Independently support round fixtures smaller in size than the ceiling grid from the building structure by a minimum of four wires per fixture spaced approximately equidistant around the fixture. Do not support fixtures by ceiling acoustical panels. Where fixtures of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support such fixtures independently and provide at least two 3/4 inch metal channels spanning, and secured to, the ceiling tees for centering and aligning the fixture. Provide wires for lighting fixture support in this section.

3.1.4 Ballasts

3.1.4.1 Remote Ballasts

Mount remote type ballasts or transformers, where indicated, in a well ventilated, easily accessible location, within the maximum operating distance from the lamp, as designated by the manufacturer.

3.3 FIELD QUALITY CONTROL

Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Conduct an operating test to show that equipment operates in accordance with requirements of this section.

3.4 FIELD TESTING

Demonstrate that all incandescent lighting fixtures and their accessories, including lowering devices , operate satisfactorily in the presence of the Owner's Representative.

Perform operational tests in accordance with referenced standards in this section.

PART 1 GENERAL

1.1 REFERENCES

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.15 (1990) Solid-State Demand Registers for Electromechanical Watthour Meters
ANSI C39.1 (1981; R 1992) Requirements for Electrical Analog Indicating Instruments

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M (2009) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M (2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 167 (1999; R 2009) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 653/A 653M (2009a) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A 780/A 780M (2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM B 187/B 187M (2006) Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes
ASTM B 317/B 317M (2007) Standard Specification for Aluminum-Alloy Extruded Bar, Rod, Tube, Pipe, and Structural Profiles for Electrical Purposes (Bus Conductor)
ASTM D 149 (2009) Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D 1535 (2008e1) Specifying Color by the Munsell System
ASTM D 709 (2001; R 2007) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100 (2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 81 (1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C12.16 (1991) Solid-State Electricity Meters
IEEE C2 (2007; TIA 2007-1; TIA 2007-2; TIA 2007-3; TIA 2007-4; TIA 2007-5; Errata 2006-1; Errata 2007-2; Errata 2009-3) National Electrical Safety Code
IEEE C37.13 (2008; INT 1 2009) Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.20.1 (2002; INT 1 2005; AMD A 2005; AMD B 2006; R 2007) Standard for Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear

IEEE C37.90.1 (2002; Errata 2003; Errata 2004) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C57.12.01 (2005) General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid-Cast and/or Resin-Encapsulated Windings
IEEE C57.12.28 (2005) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.13 (2008) Standard Requirements for Instrument Transformers

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS (2009) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.1 (2008) Electric Meters Code for Electricity Metering
ANSI C12.4 (1984; R 2002) Registers - Mechanical Demand
NEMA ICS 6 (1993; R 2006) Enclosures
NEMA LI 1 (1998) Industrial Laminating Thermosetting Products
NEMA PB 2 (2006) Deadfront Distribution Switchboards
NEMA PB 2.1 (2007) General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less
NEMA/ANSI C12.10 (2004) Physical Aspects of Watthour Meters - Safety Standards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2011) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1558 (1999; Reprint Apr 2010) Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
UL 198M (2003; Reprint Oct 2007) Standard for Mine-Duty Fuses
UL 467 (2007) Grounding and Bonding Equipment
UL 489 (2009) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 512 (1993; R 1993 thru 2008) Standard for Fuseholders

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, use as defined in IEEE 100 .

1.3 SUBMITTALS

Submittals require Owner's Representative approval. Submit the following in accordance with Section 00910 SUBMITTALS:

SD-02 Shop Drawings

Switchgear Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Indicate within the drawings adequate clearance for operation, maintenance, and replacement of operating equipment devices. Include submittals for the nameplate data, size, and capacity. Also include submittals for applicable federal, military, industry, and technical society publication references.

SD-03 Product Data

Switchgear

SD-06 Test Reports

Switchgear Design Tests
Switchgear Production Tests
Acceptance Checks And Tests

SD-10 Operation and Maintenance Data

Switchgear Operation and Maintenance , Data Package 5

SD-11 Closeout Submittals

Assembled Operation and Maintenance Manuals
Equipment Test Schedule
Request for Settings

1.4 QUALITY ASSURANCE

1.4.1 Switchgear Product Data

Each submittal shall include manufacturer's information for each component, device and accessory provided with the Switchgear including:

a. Circuit breaker type, interrupting rating, and trip devices, including available settings
b. Manufacturer's instruction manuals and published time-current curves (on full size logarithmic paper) of the main secondary breaker and largest secondary feeder device.

1.4.2 Switchgear Drawings

Drawings shall include, but are not limited to the following:

a. One-line diagram including breakers, fuses, and meters
b. Outline drawings including front elevation, section views, footprint, and overall dimensions
c. Bus configuration including dimensions and ampere ratings of bus bars
d. Markings and NEMA nameplate data
e. Circuit breaker type, interrupting rating, and trip devices, including available settings
f. Three-line diagrams and elementary diagrams and wiring diagrams with terminals identified, and indicating prewired interconnections between items of equipment and the interconnection between the items.
g. Provisions for future extension.

1.4.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Owner's Representative . Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.4.4 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.4.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.4.2 Material and Equipment Manufacturing Date

Do not use products manufactured more than 3 years prior to date of delivery to site, unless specified otherwise.

1.5 MAINTENANCE

1.5.1 Switchgear Operation and Maintenance Data

Submit Operation and Maintenance Manuals.

1.5.2 Assembled Operation and Maintenance Manuals

Assemble and bind manuals securely in durable, hard covered, water resistant binders. Assemble and index the manuals in the following order with a table of contents. The contents of the assembled operation and maintenance manuals shall be as follows:

a. Manufacturer's O&M information.
b. Catalog data required by the paragraph entitled, "SD-03, Product Data".
c. Drawings required by the paragraph entitled, "SD-02, Shop Drawings".
d. Prices for spare parts and supply list.
e. Design test reports
f. Production test reports

1.6 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 SWITCHGEAR

IEEE C37.20.1 and UL 1558 .

2.1.1 Ratings

The voltage rating of the Switchgear shall be [480Y/277][208Y/120][125] volts [AC][DC], 4-wire 3 phase. The continuous current rating of the main bus shall be as indicated. The short-circuit current rating shall be as indicated. The Switchgear shall be UL listed and labeled for its intended use.

2.1.2 Construction

The short-circuit current rating assigned to the switchboard shall be in accordance with NEMA PB 2. Switchgear shall consist of vertical sections bolted together to form a rigid assembly and shall be aligned as indicated. All circuit breakers are to be front accessible. Where indicated, "space for future"

or "space" shall mean to include bus, device supports, and connections. Provide insulating barriers in accordance with NEMA LI 1 , Type GPO-3, 0.25 inch minimum thickness. Apply moisture resistant coating to all rough-cut edges of barriers. Switchboard shall be completely factory engineered and assembled, including protective devices and equipment indicated with necessary interconnections, instrumentation, and control wiring.

2.1.2.1 Enclosure

The Switchgear enclosure shall be an outdoor NEMA ICS 6 Type as indicated. Enclosure shall be bolted together with removable bolt-on side and rear covers. Front doors shall be provided with padlockable vault handles with a three point catch. Bases, frames and channels of enclosure shall be corrosion resistant and shall be fabricated of ASTM A 167 type 304 or 304L stainless steel or galvanized steel. Base shall include any part of enclosure that is within 3 inches of concrete pad. Galvanized steel shall be ASTM A 123/A 123M , ASTM A 653/A 653M G90 coating, and ASTM A 153/A 153M , as applicable. Paint enclosure, including bases, ASTM D 1535 light gray No. 61 or No. 49. Paint coating system shall comply with IEEE C57.12.28 for galvanized steel and IEEE C57.12.29 for stainless steel.

2.1.2.2 Bus Bars

Bus bars shall be copper with silver-plated contact surfaces. Plating shall be a minimum of 0.0002 inch thick. Make bus connections and joints with hardened steel bolts. The through-bus shall be rated at the full ampacity of the main throughout the switchboard. Provide minimum one-quarter by 2 inch copper ground bus secured to each vertical section along the entire length of the Switchgear. The neutral bus shall be rated 100 percent of the main bus continuous current rating. Phase bus bars shall be insulated with an epoxy finish coating powder providing a minimum breakdown voltage of 16,000 volts per ASTM D 149 .

2.1.2.3 Main Section

The main section shall consist of main lugs only air power circuit breaker with current-limiting fuses and utility transformer compartment.

2.1.2.4 Distribution Sections

The distribution section[s] shall consist of air power circuit breakers with current-limiting fuses and utility transformer compartments as indicated.

2.1.2.5 Combination Sections

Combination sections shall consist of fusible switches for the main devices as indicated.

2.1.2.6 Auxiliary Sections

Auxiliary sections shall consist of indicated instruments, metering equipment, control equipment, transformer, as indicated.

2.1.2.7 Handles

Handles for individually mounted devices shall be of the same design and method of external operation. Label handles prominently to indicate device ampere rating, color coded for device type. Identify ON-OFF indication by handle position and by prominent marking.

2.1.3 Protective Device

Provide ground fault protection of equipment for solidly grounded wye electrical services of more than 150 volts to ground for each service disconnect rated 1000 amperes or more in accordance with NFPA 70.

Provide main and branch protective devices as indicated.

2.1.3.1 Power Circuit Breaker

IEEE C37.13 . [120 Vac][electrically][manually] operated [unfused][fused], low-voltage power circuit breaker with a short-circuit current rating as indicated at [ ] volts. Breaker frame size shall be as indicated.

2.1.3.2 Fusible Switches

Fusible Switches: Quick-make, quick-break, hinged-door type. Fuses shall be current-limiting cartridge type conforming to [UL 198M , Class J for 0 to 600 amperes and Class L for 601 to 6000 amperes].

Fuseholders: UL 512 .

2.1.3.5 Integral Combination Breaker and Current-Limiting Fuses

UL 489. Provide integral combination molded-case circuit breaker and current-limiting fuses as indicated with a minimum short-circuit-current rating equal to the short-circuit-current rating of the Switchgear in which the circuit breaker will be mounted. Series rated circuit breakers are unacceptable. Coordination of overcurrent devices of the circuit breaker and current-limiting fuses shall be such that on overloads or fault currents of relatively low value, the overcurrent device of the breaker will be operated to clear the fault. For high magnitude short circuits above a predetermined value, the current-limiting fuses shall operate to clear the fault. Housing for the current-limiting fuses shall be an individual molding readily removable from the front and located at

the load side of the circuit breaker. If the fuse housing is removed, a blown fuse shall be readily evident by means of a visible indicator. Removal of fuse housing shall cause the breaker contacts to open, and it shall not be possible to close the breaker contacts with the fuse housing removed. It shall not be possible to insert the fuse housing with a blown fuse or with one fuse missing. The blowing of any of the fuses shall cause the circuit breaker contacts to open.

2.1.4 Electronic Trip Units

Equip breakers as indicated with a solid-state tripping system consisting of three current sensors and a microprocessor-based trip unit that will provide true rms sensing adjustable time-current circuit protection. The ampere rating of the current sensors are to be as indicated. The trip unit ampere rating shall be as indicated. Ground fault protection shall be as indicated.

Provide ground fault protection of equipment for solidly grounded wye electrical services of more than 150 volts to ground for each service disconnect rated 1000 amperes or more in accordance with NFPA 70.

2.1.5 Electronic Trip Unit Central Monitor

Provide a microprocessor-based device designed to monitor and display parameters of the circuit breaker electronic trip units. The central monitor shall have the following features:

a. Alphanumeric display.
b. Indication of circuit breaker status; tripped, open, closed.
c. Cause of circuit breaker trip.
d. Phase, neutral, and ground current for each breaker.
e. Energy parameters for each breaker.
f. Provisions for communicating directly to a remote computer.

2.1.6 Instruments

ANSI C39.1 for electrical indicating switchboard instruments, with 2 percent accuracy. The ac ammeters and voltmeters shall be a minimum of 2 inches square with 250-degree scale. Provide single phase indicating instruments with flush-mounted transfer switches for reading three phases.

2.1.6.1 Ac Ammeters

Self-contained.

2.1.6.2 Ac Voltmeters

Self-contained.

2.1.6.3 Instrument Control Switches

Provide rotary cam-operated type with positive means of indicating contact positions. Switches shall have silver-to-silver contacts enclosed in a protective cover which can be removed to inspect the contacts.

2.1.7 Watthour and Digital Meters

2.1.7.1 Digital Meters

IEEE C37.90.1 for surge withstand. Provide true rms, plus/minus one percent accuracy, programmable, microprocessor-based meter enclosed in sealed cases with a simultaneous three line, twelve value LED display. Meters shall have 0.56 inch, minimum, LEDs. The meters shall accept input from standard 5A secondary instrument transformers and direct voltage monitoring range to [300][600] volts, phase to phase. Programming shall be via a front panel display and a communication interface with a computer. Password secured programming shall be stored in non-volatile EEPROM memory. Digital communications shall be Modbus ASCII protocol via a [RS232C][RS485] serial port. The meter shall calculate and store average max/min demand values for all readings based on a user selectable sliding window averaging period. The meter shall have programmable hi/low set limits with two Form C dry contact relays when exceeding alarm conditions. Meter shall provide Total Harmonic Distortion (THD) measurement to the thirty-first order. Event waveform recording shall be triggered by the rms of 2 cycles of voltage or current exceeding programmable set points. Waveforms shall be stored for all 6 channels of voltage and current for a minimum of 10 cycles prior to the event and 50 cycles past the event.

2.1.7.2 Electronic Watthour Meter

Provide a switchboard style electronic programmable watthour meter, semi-drawout, semi-flush mounted, as indicated. Meter shall either be programmed at the factory or shall be programmed in the field. When field programming is performed, turn field programming device over to the Owner's Representative at completion of project. Meter shall be coordinated to system requirements and conform to IEEE C12.16 .

2.1.8 Current Transformers

Select an ANSI Metering Accuracy Class in accordance with the following table:

CT Ratio	RF	Accuracy Class
200/5	4.0	0.3 thru B-0.1
300/5	3.0	0.3 thru B-0.2
400/5	4.0	0.3 thru B-0.2
600/5	3.0	0.3 thru B-0.5
800/5	2.0	0.3 thru B-0.5

1200/5	1.5	0.3 thru B-0.5
1500/5	1.5	0.3 thru B-0.9
2000/5	1.5	0.3 thru B-1.8

IEEE C57.13 . Transformers shall be single ratio, 60 hertz, [ ] to 5-ampere ratio, [ ] rating factor, with a metering accuracy class of 0.3 through [ ].

2.1.9 Transformer

Provide transformer section in Switchgear in accordance with UL 1558] and as indicated. The transformer and section shall be suitable for the installation.

2.1.10 Meter Fusing

Provide a fuse block mounted in the metering compartment containing one fuse per phase to protect the voltage input to voltage sensing meters. Size fuses as recommended by the meter manufacturer.

2.1.11 Heaters

Provide 120-volt heaters in each Switchgear section. Heaters shall be of sufficient capacity to control moisture condensation in the section, shall be 250 watts minimum, and shall be controlled by a thermostat[and humidistat] located in the section. Thermostat shall be industrial type, high limit, to maintain sections within the range of 60 to 90 degrees F. Humidistat shall have a range of 30 to 60 percent relative humidity. Supply voltage for the heaters shall be obtained from a control power transformer within the Switchgear. If heater voltage is different than switchboard voltage, provide transformer rated to carry 125 percent of heater full load rating. Transformer shall have 220 degrees C insulation system with a temperature rise not exceeding 115 degrees C and shall conform to IEEE C57.12.01 .

2.1.12 Terminal Boards

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Terminal boards associated with current transformers shall be short-circuiting type. Terminate conductors for current transformers with ring-tongue lugs. Terminal board identification shall be identical in similar units. External wiring shall be color coded consistently for similar terminal boards.

2.1.13 Wire Marking

Mark control and metering conductors at each end. Provide factory-installed, white, plastic tubing, heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Each sleeve shall contain a single letter or number, shall be elliptically shaped to securely

grip the wire, and shall be keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Each wire marker shall indicate the device or equipment, including specific terminal number to which the remote end of the wire is attached.

2.2 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable. This nameplate and method of attachment may be the manufacturer's standard if it contains the required information.

2.3 FIELD FABRICATED NAMEPLATES

ASTM D 709 . Provide laminated plastic nameplates for each[switchboard,][switchgear,] equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic 0.125 inch thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inch high normal block style.

2.4 SOURCE QUALITY CONTROL

2.4.1 Equipment Test Schedule

Provide equipment test schedules for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Owner's Representative 30 calendar days before scheduled test date. Notify Owner's Representative 15 calendar days in advance of changes to scheduled date.

2.4.2 Switchgear Design Tests

IEEE C37.20.1 and UL 1558 .

2.4.2.1 Design Tests

Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification.

a. Short-circuit current test
b. Enclosure tests
c. Dielectric test

2.4.2.2 Additional design tests

In addition to normal design tests, perform the following tests on the actual equipment. Furnish reports which include results of design tests performed on the actual equipment.

a. Temperature rise tests
b. Continuous current

2.4.3 Switchgear Production Tests

IEEE C37.20.1 and UL 1558. Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include:

a. 60-hertz dielectric tests
b. Mechanical operation tests
c. Electrical operation and control wiring tests
d. Ground fault sensing equipment test

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to IEEE C2 , NFPA 70 , and to the requirements specified herein.

3.2 GROUNDING

NFPA 70 and IEEE C2 , except that grounds and grounding systems shall have a resistance to solid earth ground not exceeding 5 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Equipment Grounding

Provide bare copper cable not smaller than No. 4/0 AWG not less than 24 inches below grade connecting to the indicated ground rods. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" shall apply.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector.

3.2.4 Grounding and Bonding Equipment

UL 467 , except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect equipment furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Switchboard

NEMA PB 2.1 .

3.3.2 Switchgear

IEEE C37.20.1 .

3.3.3 Meters and Instrument Transformers

ANSI C12.1 .

3.3.4 Field Applied Painting

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3.5 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A 780/A 780M , zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.3.6 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.4.1 Exterior Location

Mount Switchgear on concrete slab. Unless otherwise indicated, the slab shall be at least 8 inches thick, reinforced with a 6 by 6 inch No. 6 mesh placed uniformly 4 inchesfrom the top of the slab. Slab shall be placed on a 6 inch thick, well-compacted gravel base. The top of the concrete slab shall be approximately 4 inches above the finished grade. Edges above grade shall have 1/2 inch chamfer. The slab shall be of adequate size to project at least 8 inches beyond the equipment. Provide conduit turnups and cable entrance space

required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 3 inches above slab surface. Concrete work shall be as specified in Section 03102 CAST-IN-PLACE CONCRETE.

3.4.2 Interior Location

Mount Switchgear on concrete slab. Unless otherwise indicated, the slab shall be at least 4 inches thick. The top of the concrete slab shall be approximately 4 inches above finished floor. Edges above floor shall have 1/2 inch chamfer. The slab shall be of adequate size to project at least 8 inches beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 3 inches above slab surface. Concrete work shall be as specified in Section 03102 CAST-IN-PLACE CONCRETE.

3.5 FIELD QUALITY CONTROL

Contractor shall submit request for settings of breakers to the Owner's Representative after approval of Switchgear and at least 30 days in advance of their requirement.

3.5.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS .

3.5.1.1 Switchboard Assemblies

a. Visual and Mechanical Inspection
   (1) Compare equipment nameplate data with specifications and approved shop drawings.
   (2) Inspect physical, electrical, and mechanical condition.
   (3) Confirm correct application of manufacturer's recommended lubricants.
   (4) Verify appropriate anchorage, required area clearances, and correct alignment.
   (5) Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.
   (6) Verify that[fuse and] circuit breaker sizes and types correspond to approved shop drawings.
   (7) Verify that current transformer ratios correspond to approved shop drawings.
   (8) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter,
   verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(9) Confirm correct operation and sequencing of electrical and mechanical interlock systems.
(10) Clean switchboard.
(11) Inspect insulators for evidence of physical damage or contaminated surfaces.
(12) Verify correct barrier[and shutter] installation[and operation].
(13) Exercise all active components.
(14) Inspect all mechanical indicating devices for correct operation.
(15) Verify that vents are clear.
(16) Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.
(17) Inspect control power transformers.

b. Electrical Tests
(1) Perform insulation-resistance tests on each bus section.
(2) Perform overpotential tests.
(3) Perform insulation-resistance test on control wiring; Do not perform this test on wiring connected to solid-state components.
(4) Perform control wiring performance test.
(5) Perform primary current injection tests on the entire current circuit in each section of assembly.
(6) Perform phasing check on double-ended switchboard to ensure correct bus phasing from each source.
(7) Verify operation of switchboard heaters.

3.5.1.2 Switchgear

a. Visual and Mechanical Inspection
(1) Compare equipment nameplate data with specifications and approved shop drawings.
(2) Inspect physical, electrical, and mechanical condition.
(3) Confirm correct application of manufacturer's recommended lubricants.
(4) Verify appropriate anchorage, required area clearances, and correct alignment.
(5) Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.
(6) Verify that[fuse and] circuit breaker sizes and types correspond to approved shop drawings.
(7) Verify that current transformer ratios correspond to approved shop drawings.
(8) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(9) Confirm correct operation and sequencing of electrical and mechanical interlock systems.
(10) Clean switchgear.
(11) Inspect insulators for evidence of physical damage or contaminated surfaces.
(12) Verify correct barrier[and shutter] installation[and operation].
(13) Exercise all active components.
(14) Inspect all mechanical indicating devices for correct operation.
(15) Verify that vents are clear.
(16) Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.
(17) Inspect control power transformers.

b. Electrical Tests
(1) Perform insulation-resistance tests on each bus section.
(2) Perform overpotential tests.
(3) Perform insulation-resistance test on control wiring; do not perform this test on wiring connected to solid-state components.
(4) Perform control wiring performance test.
(5) Perform primary current injection tests on the entire current circuit in each section of assembly.
(6) Perform phasing check on double-ended switchgear to ensure correct bus phasing from each source.
(7) Verify operation of switchgear heaters.

3.5.1.3 Circuit Breakers - Low Voltage - Power

a. Visual and Mechanical Inspection
(1) Compare nameplate data with specifications and approved shop drawings.
(2) Inspect physical and mechanical condition.
(3) Confirm correct application of manufacturer's recommended lubricants.
(4) Inspect anchorage, alignment, and grounding. Inspect arc chutes. Inspect moving and stationary contacts for condition, wear, and alignment.
(5) Verify that all maintenance devices are available for servicing and operating the breaker.
(6) Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.
(7) Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism.
(8) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated

torque-wrench method, or performing thermographic survey.

(9) Verify cell fit and element alignment.

(10) Verify racking mechanism.

b. Electrical Tests

(1) Perform contact-resistance tests on each breaker.

(2). Perform insulation-resistance tests.

(3) Adjust Breaker(s) for final settings in accordance with Government provided settings.

(4) Determine long-time minimum pickup current by primary current injection.

(5) Determine long-time delay by primary current injection.

(6) Determine short-time pickup and delay by primary current injection.

(7) Determine ground-fault pickup and delay by primary current injection.

(8) Determine instantaneous pickup value by primary current injection.

(9) Activate auxiliary protective devices, such as ground-fault or undervoltage relays, to ensure operation of shunt trip devices; Check the operation of electrically-operated breakers in their cubicle.

(10) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.

(11) Verify operation of charging mechanism.

3.5.1.4 Circuit Breakers

Low Voltage - Insulated-Case][and][Low Voltage Molded Case with Solid State Trips

a. Visual and Mechanical Inspection

(1) Compare nameplate data with specifications and approved shop drawings.

(2) Inspect circuit breaker for correct mounting.

(3) Operate circuit breaker to ensure smooth operation.

(4) Inspect case for cracks or other defects.

(5) Inspect all bolted electrical connections for high resistance using low resistance ohmmeter, verifying tightness of accessible bolted connections and/or cable connections by calibrated torque-wrench method, or performing thermographic survey.

(6) Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests

(1) Perform contact-resistance tests.

(2) Perform insulation-resistance tests.

(3) Perform Breaker adjustments for final settings in accordance with Government provided settings.
(4) Perform long-time delay time-current characteristic tests.
(5) Determine short-time pickup and delay by primary current injection.
(6) Determine ground-fault pickup and time delay by primary current injection.
(7) Determine instantaneous pickup current by primary injection.
(8) Verify correct operation of any auxiliary features such as trip and pickup indicators,
zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.

3.5.1.5 Current Transformers

a. Visual and Mechanical Inspection
(1) Compare equipment nameplate data with specifications and approved shop drawings.
(2) Inspect physical and mechanical condition.
(3) Verify correct connection.
(4) Verify that adequate clearances exist between primary and secondary circuit.
(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.
(6) Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests
(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.
(2) Perform insulation-resistance tests.
(3) Perform polarity tests.
(4) Perform ratio-verification tests.

3.5.1.6 Metering and Instrumentation

a. Visual and Mechanical Inspection
(1) Compare equipment nameplate data with specifications and approved shop drawings.
(2) Inspect physical and mechanical condition.
(3) Verify tightness of electrical connections.

b. Electrical Tests
(1) Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.
(2) Calibrate watthour meters according to manufacturer's published data.

(3) Verify all instrument multipliers.
(4) Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.5.1.7 Grounding System

a. Visual and Mechanical Inspection
(1) Inspect ground system for compliance with contract plans and specifications.

b.Electrical Tests
(1) IEEE 81 . Perform ground-impedance measurements utilizing the fall-of-potential method.

On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

(2) Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.5.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Circuit breakers shall be tripped by operation of each protective device. Test shall require each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, the Owner's Representative shall be given 5 working days advance notice of the dates and times for checks, settings, and tests.

PART 1 GENERAL

1.1 REFERENCES

ASME INTERNATIONAL (ASME)

ASME B1.1 (2003; R 2008) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.20.1 (1983; R 2006) Pipe Threads, General Purpose (Inch)
ASME B1.20.2M (2006) Pipe Threads, 60 Deg. General Purpose (Metric)

ASTM INTERNATIONAL (ASTM)
ASTM B 187/B 187M (2006) Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes
ASTM B 317/B 317M (2007) Standard Specification for Aluminum-Alloy Extruded Bar, Rod, Tube, Pipe, and Structural Profiles for Electrical Purposes (Bus Conductor)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)
IEEE C57.13 (2008) Standard Requirements for Instrument Transformers

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.1 (2008) Electric Meters Code for Electricity Metering
ANSI C12.4 (1984; R 2002) Registers - Mechanical Demand
NEMA ICS 1 (2000; R 2005; R 2008) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2 (2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 4 (2005) Terminal Blocks
NEMA ICS 6 (1993; R 2006) Enclosures
NEMA PB 1 (2006; Errata 2008) Panelboards
NEMA PB 2 (2006) Deadfront Distribution Switchboards
NEMA ST 1 (1988; R 1994; R 1997) Specialty Transformers (Except General Purpose Type)
NEMA ST 20 (1992; R 1997) Standard for Dry-Type Transformers for General Applications
NEMA/ANSI C12.10 (2004) Physical Aspects of Watthour Meters - Safety Standards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2011) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1063 (2006) Machine-Tool Wires and Cables
UL 44 (2010) Thermoset-Insulated Wires and Cables
UL 489 (2009) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures

UL 50 (2007) Enclosures for Electrical Equipment, Non-environmental Considerations
UL 67 (2009; Reprint Sep 2010) Standard for Panelboards
UL 845 (2005; Reprint Aug 2006) Motor Control Centers
UL 891 (2005) Switchboards

1.2 SYSTEM DESCRIPTION

1.2.1 Rules

Provide equipment conforming to the requirements of NFPA 70 unless more stringent requirements are indicated herein or shown. NEMA rated and UL listed equipment has been specified when available. Equipment shall meet NEMA and UL construction and rating requirements as specified. No equivalent will be acceptable. Immediately notify the Owner's Representative of any requirements of the specifications or Contractor proposed materials or assemblies that do not comply with UL or NEMA. International Electrotechnical Commission (IEC) rated equipment will not be considered an acceptable alternative to specified NEMA ratings.

1.2.2 Coordination

The general arrangement of the motor control centers, switchboards and panelboards is shown on the contract drawings. Any modifications of the equipment arrangement or device requirements as shown on the drawings shall be subject to the approval of the Owner's Representative. If any conflicts occur necessitating departures from the drawings, details of and reasons for departures shall be submitted and approved prior to implementing any change. Completely assemble all equipment at the factory. The motor control centers and switchboards may be disassembled into sections, if necessary, for convenience of handling, shipping, and installation.

1.3 SUBMITTALS

Submittals require Owner's Representative approval. Submit the following in accordance with Section 00910 SUBMITTALS:

SD-02 Shop Drawings

Drawings
Shop Drawings

Six (6) copies of outline drawings of all equipment to be furnished under this contract, together with weights and overall dimensions, within 30 calendar days after date of award, for the approval of the Owner's Representative. Drawings shall show the general arrangement and overall dimensions of the motor control centers, switchboards, and panelboards. These drawings shall show space requirements, details of any floor supports to be embedded in concrete and provisions for conduits for external cables.

Motor Control Centers

Switchboards Panelboards

Six (6) copies of electrical equipment drawings, within 30 calendar days after date of award, for the approval of the Owner's Representative. Submit an individual wiring diagram for each motor control center. Provide a single-line diagram, equipment list and nameplate schedule for each switchboard and panelboard.

SD-03 Product Data

Equipment

Six (6) copies of such descriptive cuts and information as are required to demonstrate fully that all parts of the equipment will conform to the requirements and intent of the specifications, within 30alendar days after date of award for approval. Data shall include descriptive data showing typical construction of the types of equipment proposed, including the manufacturer's name, type of molded case circuit breakers or motor circuit protectors, performance capacities and other information pertaining to the equipment.

SD-06 Test Reports

Factory Tests

Six (6) complete reproducible copies of the factory inspection results and six (6) complete reproducible copies of the factory test results in booklet form, including all plotted data curves, all test conditions, a listing of test equipment complete with calibration certifications, and all measurements taken. Report shall be signed and dated by the Contractor's Representatives.

1.4 DELIVERY, STORAGE, AND HANDLING

Ship the equipment as completely assembled and wired as feasible so as to require a minimum of installation work. Each shipping section shall be properly match marked to facilitate reassembly, and shall be provided with removable lifting channels with eye bolts for attachment of crane slings to facilitate lifting and handling. Any relay or other device which cannot withstand the hazards of shipment when mounted in place on the equipment shall be carefully packed and shipped separately. These devices shall be marked with the number of the panel which they are to be mounted on and fully identified. All finished painted surfaces and metal work shall be wrapped suitably or otherwise protected from damage during shipment. All parts shall be prepared for shipment so that slings for handling may be attached readily while the parts are in a railway car or transport truck. All spare parts and accessories shall be carefully packaged and clearly marked.

1.5 MAINTENANCE

1.5.1 Accessories and Tools

Furnish a complete set of accessories and special tools unique to equipment provided and required for erecting, handling, dismantling, testing and maintaining the apparatus.

1.5.2 Extra Materials

a. 2 Fuses of each type and size.
b. 1 Circuit breaker auxiliary switch.
c. 2 Operating coils for each size ac contactor.
d. 1 Operating coil for each size dc contactor.
e. 2 Complete sets of 3-pole stationary and moving contact assemblies for each size ac contactor.
f. 1 Complete set of 2-pole stationary and moving contact assemblies for each size dc contactor.
g. 3 Contactor overload relays of each type and rating, each relay with a complete set of contact blocks.
h. 1 Spare set of heater elements for each heater rating provided.
i. 2 Indicating lamp assemblies of each type.
j. 4 Keys for motor control center door lock.

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment which are standard products of a manufacturer regularly engaged in their manufacture and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening and that conform to the requirements of these specifications. Materials shall be of high quality, free from defects and imperfections, of recent manufacture, and of the classification and grades designated. All materials, supplies, and articles not manufactured by the Contractor shall be the products of other recognized reputable manufacturers. If the Contractor desires for any reason to deviate from the standards designated in these specifications, submit, after award, a statement of the exact nature of the deviation, and complete specifications for the materials proposed for use, for the approval of the Owner's Representative.

2.2 NAMEPLATES

Provide nameplates made of laminated sheet plastic or of anodized aluminum approximately 1/8 inch thick, engraved to provide white letters on a black background. The nameplates shall be fastened to the panels in proper positions with anodized round-head screws. Lettering shall be minimum 1/2 inch high. Nameplate designations shall be in accordance with lists on the drawings, and as a minimum shall be provided for the following equipment:

a. Motor Control Centers
b. Individual items of equipment mounted in the Motor Control Centers
c. Switchboards
d. Panelboards

2.3 CONNECTIONS

All bolts, studs, machine screws, nuts, and tapped holes shall be in accordance with ASME B1.1 . The sizes and threads of all conduit and fittings, tubing and fittings, and connecting equipment shall be in accordance with ASME B1.20.1. All ferrous fasteners shall have rust-resistant finish and all bolts and screws shall be equipped with approved locking devices. Manufacturer's standard threads and construction may be used on small items which, in the opinion of the Owner's Representative, are integrally replaceable, except that threads for external connections to these items shall meet the above requirements.

2.4 WIRING

All control wire shall be stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44 or Type MTW meeting UL 1063 , and shall pass the VW-1 flame tests included in those standards. Hinge wire shall have Class K stranding. Current transformer secondary leads shall be not smaller than No. 10 AWG. The minimum size of control wire shall be No. 14 AWG. Power wiring for 480-volt circuits and below shall be of the same type as control wiring and the minimum size shall be No. 12 AWG. Special attention shall be given to wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.5 TERMINAL BLOCKS

Control circuit terminal blocks for control wiring shall be molded or fabricated type with barriers, rated not less than 600 volts. The terminals shall be removable binding, fillister or washer head screw type, or of the stud type with contact and locking nuts. The terminals shall be not less than No. 10 in size and shall have sufficient length and space for connecting at least two indented terminals for 10 AWG conductors to each terminal. The terminal arrangement shall be subject to the approval of the Owner's Representative and not less than four (4) spare terminals or 10 percent, whichever is greater, shall be provided on each block or group of blocks. Modular, pull apart, terminal blocks will be acceptable provided they are of the channel or rail-mounted type. Submit data showing that the proposed alternate will accommodate the specified number of wires, are of adequate current-carrying capacity, and are constructed to assure positive contact between current-carrying parts.

2.5.1 Types of Terminal Blocks

2.5.1.1 Short-Circuiting Type

Short-circuiting type terminal blocks shall be furnished for all current transformer secondary leads and shall have provision for shorting together all leads from each current transformer without first opening any circuit. Terminal blocks shall meet the requirements of paragraph CONTROL CIRCUIT TERMINAL BLOCKS above.

2.5.1.2 Load Type

Load terminal blocks rated not less than 600 volts and of adequate capacity shall be provided for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits except those for feeder tap units. The terminals shall be of either the stud type with contact nuts and locking nuts or of the removable screw type, having length and space for at least two indented terminals of the size required on the conductors to be terminated. For conductors rated more than 50 amperes, screws shall have hexagonal heads. Conducting parts between connected terminals shall have adequate contact surface and cross-section to operate without overheating. Each connected terminal shall have the circuit designation or wire number placed on or near the terminal in permanent contrasting color.

2.5.2 Marking Strips

White or other light-colored plastic marking strips, fastened by screws to each terminal block, shall be provided for wire designations. The wire numbers shall be made with permanent ink. The marking strips shall be reversible to permit marking both sides, or two marking strips shall be furnished with each block. Marking strips shall accommodate the two sets of wire numbers. Each device to which a connection is made shall be assigned a device designation in accordance with NEMA ICS 1 and each device terminal to which a connection is made shall be marked with a distinct terminal marking corresponding to the wire designation used on the Contractor's schematic and connection diagrams. The wire (terminal point) designations used on the Contractor's wiring diagrams and printed on terminal block marking strips may be according to the Contractor's standard practice; however, additional wire and cable designations for identification of remote (external) circuits shall be provided for the Government's wire designations. Prints of drawings submitted for approval will be so marked and returned to the Contractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

2.6 MOTOR CONTROL CENTERS

Each motor control center shall be designed for operation on 480-volts ac, 3-phase, 60-Hz system, and the equipment shall conform to all the applicable requirements of NEMA ICS 1 , NEMA ICS 2 , NEMA ICS 4 and NEMA ICS 6 . Vertical sections and individual units shall be listed and labeled under UL 845 where ever possible. In lieu of the UL listing, certification from any nationally recognized, adequately equipped, testing agency that the individual units and vertical sections have been tested and conform to the UL requirements of that agency will be acceptable when approved by the Owner's Representative. The motor control center shall be NEMA Class II, [Type B] [Type C], motor control centers in accordance with NEMA ICS 2 .

2.6.1 Enclosures

Each motor control center shall consist of the required number of vertical sections of 90 inches nominal height, bolted together, with steel channel sills

and suitable for mounting against a wall. Vertical section shall be 20 inches deep and buses, control wiring, control transformers, small power transformers, terminal blocks, line terminals, cable supports, and clamps shall be accessible from the front. Enclosure shall be NEMA Type [1 gasketed] [12] [3R]. The control centers shall be fabricated from smooth select steel sheets shaped and reinforced to form rigid free-standing structures. Metal thickness for enclosures shall be not less than specified in NEMA ICS 6 without exception. Vertical edges of sections exposed to view shall be so fabricated and bolted that the joints will not pass a 1/16 inch gage. Each structure shall be designed for addition of future sections required. Individual compartments shall be isolated from adjacent compartments.

2.6.1.1 Unit Compartments

Each operating unit shall contain equipment as shown on the drawings, mounted in an individual cell. The unit assembly, except main circuit breakers, panelboards and auxiliary control devices, shall be drawout type removed from the front, without rear access or disturbing other units in the control center assembly. All drawout type unit assemblies shall have positive guide rail system to ensure alignment of connection to vertical bus. Units shall be mechanically interlocked with the door to prevent removal while in the energized position. Each removable unit shall have provision for padlocking in a position in which it is disconnected from the vertical bus although not removed from the stationary structure. All ventilating openings shall be provided with corrosion-resistant insect-proof screens on the inside. Bus closing plugs shall be provided for all unused openings in vertical bus barriers.

2.6.1.2 Motor Control Center Doors and Covers

Each unit compartment, including blank compartments for future use, shall be provided with either a flange-formed or a rolled-edge door. Each door shall be mounted on fully-concealed or continuous full-length piano-type hinges and shall be provided with positive fasteners. Door sag shall be prevented by proper alignment of hinges made of sufficiently strong material. The door fastenings shall be so interlocked to prevent opening when the equipment is energized. The external operating handle shall clearly indicate whether the equipment is in an "ON", "OFF" or "TRIPPED" position.

2.6.1.3 Horizontal Wireways

Structure shall have a minimum 12 inches high wireway at the top and a 6 inches minimum wireway
at the bottom. Both horizontal wireways shall run the length of the structure. Cover plates shall be provided on the side of the assembly to permit extension of the horizontal bus and wireway when vertical sections are added.

2.6.1.4 Vertical Wireways

Vertical wireways shall be provided in all vertical sections accepting multiple plug-in components. Vertical wireways shall connect with horizontal wireways at the top and bottom and be a minimum 4 inches wide. Barriers shall be provided in sections containing both ac and dc vertical buses. Doors shall be provided on each vertical wireway. The exposed surface of any door shall not deviate more than 1/16 inch from a true plane.

2.7.2 Buses

NEMA ICS 2 allows a 65 degrees Celsius temperature rise on the buses, irrespective of the equipment used. UL 845 allows 65 degrees temperature rise only under certain conditions. In general this means all buses must be plated and devices must be UL labeled for the higher temperatures. If this is not the case, the UL standard for temperature rise is 50 degrees Celsius creating a conflict with NEMA. The designer should be aware of this difference. This specification references the UL standard and bases the rise on the exceptions it permits.

All buses shall be of copper or aluminum. Copper or aluminum] bars and shapes for bus conductors shall conform to the applicable requirements of ASTM B 187/B 187M and ASTM B 317/B 317M . All splices for field assembly shall be bolted with at least two bolts and shall employ the use of "Belleville" washers in the connection. The bus ratings shall be based on a 65 degree Celsius maximum emperature rise in accordance with UL 845 requirements. Bus shall have a short-circuit current rating of not less than [42,000] [65,000] [100,000] RMS symmetrical amperes. All bus work shall be supported on wet process porcelain insulators, glass polyester, or suitable molded material.

2.7.2.1 Horizontal Bus

Each control center assembly shall be provided with a three-phase main horizontal bus, with a continuous current rating not less than [600] [800] [1,000] [1,200] amperes, located across the top of each vertical section. The ends of horizontal buses shall be drilled for future extensions.

2.7.2.2 Vertical Bus

Each vertical section shall be provided with a three-phase vertical bus with a continuous current rating of [300] [600] amperes connected to the horizontal bus by brazing, welding, or bolting. Where the incoming feeder breakers are located at the bottom of a control center, the vertical bus in that section shall be rated the same as the main horizontal bus. Vertical buses shall extend from the horizontal bus to the bottom of the lowest available unit mounting space. The vertical bus shall be isolated from wireways and equipment in compartments.

2.7.3 Combination Starters

Combination motor controller units shall contain motor circuit protectors, auxiliary and pilot devices and a magnetic contactor with thermal overload relays. The ratings of motor circuit protectors, air circuit breakers, contactors, motor controllers and other devices shall be as shown on the drawings. All combination motor controller units shall have short circuit ratings equal to [ ] or greater. Where control push-buttons, indicating lamps, "Hand-Off-Automatic" switches, and similar control devices are associated with a unit, they shall be mounted on the unit compartment door. Door-mounted components shall not interfere with access within the compartments.

2.7.3.1 Magnetic Contactors

Magnetic contactors shall be of the NEMA sizes indicated on the drawings. The rating, performance and service characteristics shall conform to the requirements of NEMA ICS 2 for contactors with continuous current ratings for the duty indicated. Contactors for motor control shall be rated for full-voltage starting (Class A controllers). Contactors shall be suitable for at least 200,000 complete operations under rated load without more than routine maintenance. The interruption arc and flame shall be minimized by suitable arc chutes or other means so that no damage will be done to other portions of the device. The arc chutes, if provided, shall be easily removable without removing or dismantling other parts. The contacts shall be easily removable. All current-carrying contact surfaces shall be silver-surfaced or of other approved material to prevent the formation of high resistance oxides. The contactor shall operate without chatter or perceptible hum while energized. Coils shall be suitable for continuous operation [120-volt ac] [480-volt ac] [125-volt dc] circuits. Alternating-current contactors shall be three-pole, except where otherwise noted, and shall be insulated for 600 volts ac and of the electrically- operated, magnetically-held type. Direct-current contactors shall be two-pole, suitable for controlling circuits operating at 125 volts dc, insulated for 250 volts dc, electrically-operated, magnetically-held type and adequate for full-voltage motor starting service.

2.7.3.2 Auxiliary Contacts

Each controller shall be provided with a minimum of three auxiliary contacts which can be easily changed from normally open to normally closed. Where indicated on the drawings, a fourth auxiliary contact and red and green indicating lights shall be provided.

2.7.3.3 Overload Relays

Except as otherwise indicated, each controller shall be provided three NEMA Class 20 thermal overload relays with external manual reset. Prior to shipment of the control centers, the Owner's Representative will

furnish the ratings of the heater elements to be installed in the relays by the Contractor.

2.7.4 Panelboards for Motor Control Centers

Panelboards shall meet the requirements of paragraph PANELBOARDS.

2.7.5 Distribution Transformers

Dry type transformers for power and lighting loads shall be furnished with voltage and kVA ratings as indicated on the drawings. The transformers shall conform to the requirements for general-purpose transformers in NEMA ST 20. Each transformer shall be protected on the primary side with a molded case circuit breaker as indicated on the drawings. [Transformers shall be drawout type.]

2.7.6 Wiring for Motor Control Centers

All wiring shall meet the requirements of paragraph WIRING above. Provide heavy-duty clamp type terminals for terminating all power cables entering the control centers.

2.7.6.1 Contractor's Wiring

The Contractor's wiring shall be formed into groups, suitably bound together, properly supported and run straight horizontally or vertically. There shall be no splices in the wiring. The manufacturer's standard pressure-type wire terminations for connections to internal devices will be acceptable. Terminal blocks shall be added for wiring to devices having leads instead of terminals. Ring tongue indented terminals shall be used on all wires terminated on control terminal blocks for external or interpanel connections and at shipping splits. All stud terminals shall have contact nuts and either locking nuts or lockwashers.

2.7.6.2 External Connections

Power and control cables will enter the control centers where shown on the drawings.

2.7.6.3 Terminal Blocks

Terminal blocks shall meet the requirements of paragraph TERMINAL BLOCKS above. In no case shall the terminals provided for circuit breakers or contactors accommodate less than the number or size of conductors shown on the drawings. Special attention shall be given to wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.7.7 Control Transformers

Control transformers for several starter units shall be mounted in a separate compartment and its primary windings shall be connected to the main bus through a molded case circuit breaker of suitable rating. The control transformers shall be rated 480-120 volts and shall conform to the requirements for control transformers in NEMA ST 1 . Control transformers shall have adequate volt-ampere capacity for the control functions indicated and an additional 10 percent capacity. Transformers shall be installed without primary fuses. Except as otherwise indicated on the drawings, each unit compartment shall provide a fuse for control power in one secondary lead and shall have the other secondary lead grounded.

2.7.8 Accessories and Control Devices

Control accessories shall be provided, and shall be suitable for mounting on the front of, or inside, the control centers as indicated on the drawings. Control accessories shall meet the applicable requirements of NEMA ICS 2. Relays and other equipment shall be so mounted that mechanical vibration will not cause false operation.

2.7.8.1 Control Stations

Push-button stations and selector switches shall conform to NEMA ICS 2 , shall be of the heavy-duty, oil-tight type, rated 600 volts ac, and have a contact rating designation of A600. Switches shall be provided with escutcheon plates clearly marked to show operating positions.

2.7.8.2 LED Indicating Lights

Red and green LED's shall be furnished where shown on the drawings, indicating contact "open" and "closed" position. The LED's shall be accessible and replaceable from the front of the control center through a finished opening in the compartment door. The LED assemblies shall be of the heavy duty oiltight, watertight, and dusttight type.

2.7.8.3 Control Relays

Control relays shall be of the electrically operated, magnetically held, self-reset, open type, suitable for mounting inside the starter compartments, and shall be [125-volt dc] [120-volt ac]. Contacts shall be as indicated on the drawings and shall have a contact rating designation of A600 or N600, as required, in accordance with NEMA ICS 2.

2.7.8.4 Timing Relays

Timers shall be pneumatic type. They shall be suitable for mounting inside the control center and shall be rated 120 volts ac, 60 Hz.

Instantaneous and time delay contacts shall be provided as indicated on the drawings, and shall have a contact rating designation of A600 or N600, as required, in accordance with NEMA ICS 2 . Means shall be provided for manual adjustment over a range as indicated on the drawings.

2.7.8.5 Alternators

Alternators 120-volt, 60 Hz, single-phase, open type, suitable for mounting inside of control center as indicated. Alternators shall automatically cycle two motor starters in such a manner that No. 1 will lead and No. 2 will lag during the first cycle, and during the second cycle No. 2 will lead and No. 1 will lag, and the third cycle will repeat the first cycle. The duration of a cycle will be determined by an [external device] [adjustable time delay]. Contacts shall have a minimum contact rating designation of A600 or N600, as required, in accordance with NEMA ICS 2 .

2.7.9 Feeder Tap Units

Feeder tap units shall be provided as indicated on the drawings.

2.7.10 Metering Section

Metering section shall be provided with instruments as indicated on the drawings.

2.7.10.1 Instrument Transformers

All transformers used for metering shall meet the requirements of NEMA/ANSI C12.11 and IEEE C57.13 . Voltage transformers shall be protected with removable primary and secondary fuses. Fuses shall be installed in each ungrounded lead and located adjacent to the transformers in an easily accessible place. If cable connections to current transformer primary are required, terminals of an approved solderless type and proper size shall be furnished. If current transformers are connected to buses, proper connections shall be furnished, complete with bolts, nuts, washers and other accessories.

2.7.10.2 Ammeters

Switchboard type ammeter shall be provided where indicated on the drawings. Ammeter, range 0 to [ ] amperes, complete with selector switch having off position and positions to read each phase current. Meters shall be long scale 6.8 inches, semiflush rectangular, indicating type mounted at eye level.

2.7.10.3 Voltmeters

Switchboard type voltmeter shall be provided where indicated on the drawings. Voltmeter, range 0 to 600 volts, complete with selector switch having off position and positions to read each phase to phase voltage. Meters shall be long scale 6.8 inches, semiflush rectangular, indicating type mounted at eye level.

2.7.10.4 Watthour Meters

Watthour meters shall conform to ANSI C12.1 and NEMA/ANSI C12.10 , except numbered terminal wiring sequence and case size may be the manufacturer's standard. Watthour meters shall be of the drawout switchboard type having a 15-minute, cumulative form, demand register meeting ANSI C12.4 and provided with not less than two and one-half stators.

2.7.10.5 Switches

All metering switches shall be of the rotary switchboard type with handles on the front and operating contact mechanisms on the rear of the panels. Control switches shall be suitable for operation on 600-volt AC or 250-volt DC circuits. All such switches shall be capable of satisfactorily withstanding a life test of at least 10,000 operations with rated current flowing in the switch contacts. Selector switches shall be maintained-contact type with the required number of positions, and shall have round notched, or knurled handles. Ammeter switches shall not open the secondary circuits of current transformers at any time. Instrument switches for potential selection shall have oval handles.

2.8 SWITCHBOARDS

The short-circuit current rating assigned to the switchboard shall be in accordance with NEMA PB 2.

The switchboards shall be dead-front switchboards conforming to NEMA PB 2 and labeled under UL 891 . The switchboards shall be completely enclosed self-supporting metal structures with the required number of vertical panel sections, buses, molded-case circuit breakers, as shown on the drawings. Switchboards shall be fully rated for a short-circuit current of [14,000] [22,000] [65,000] symmetrical amperes RMS AC.

2.8.1 Enclosure

Each switchboard enclosure shall be NEMA type [2] [3R], built with selected smooth sheet steel panels of not less than No. 14 gage. Exposed panels on the front and ends shall have bent angle or channel edges with all corner seams welded and ground smooth. The front outside surfaces shall not be drilled or

welded for the purpose of attaching wires or mounting devices if such holes or fastenings will be visible from the front. The front panels shall be made in sections flanged on four sides and attached to the framework by screws and arranged for ready removal for inspection or maintenance. Ventilating openings shall be provided as required and shall preferably be of the grille type. All ventilating openings shall be provided with corrosion-resistant insect-proof screens on the inside. Switchboards shall be mounted as shown on the drawings and mounting materials shall be furnished as indicated. All interior and exterior steel parts shall be treated to inhibit corrosion and shall be painted as specified in paragraph PAINTING.

2.8.2 Bus

All buses shall be of copper or aluminum and all bolted splices and connections between buses and for extensions or taps for equipment] shall be tin or silver-plated. Copper or aluminum bars and shapes for bus conductors shall conform to the applicable requirements of ASTM B 187/B 187M and ASTM B 317/B 317M]. All splices for field assembly shall be bolted with at least two bolts and shall employ the use of "Belleville" washers in the connection. Horizontal and vertical power buses have minimum current ratings as shown on the drawings. The buses shall be insulated for not less than 600 volts. Shop splices and tap connections shall be brazed, pressure-welded or bolted. All splices for field assembly shall be bolted. The buses shall be mounted on insulating supports of wet process porcelain, glass polyester, or suitable molded material, and shall be braced to withstand not less than [14,000] [22,000] [65,000] symmetrical amperes ac.

2.8.3 Grounding Bus

A copper or aluminum ground bus, rated not less than 300 amps, extending the entire length of the assembled structure, shall be mounted near the bottom of enclosure. A full clamp-type solderless copper or copper alloy lug for No. 2/0 AWG stranded copper cable shall be provided at each end of the bus for connection to the station grounding system.

2.9 FACTORY TESTS

Each item of equipment supplied under this contract shall be given the manufacturer's routine factory tests and tests as specified below, to insure successful operation of all parts of the assemblies. All tests required herein shall be witnessed by the Owner's Representative unless waived in writing, and no equipment shall be shipped until it has been approved for shipment by the Owner's Representative. Notify the Owner's Representative a minimum of 14 days prior to the proposed date of the tests so that arrangements can be made for the Owner's Representative to be present at the tests. The factory test equipment and the test methods used shall conform to the applicable NEMA Standards, and shall be subject to the approval of the Owner's Representative. Reports of all witnessed tests shall be signed by witnessing representatives of the Contractor and Owner's Representative. The cost of performing all tests shall be borne by the Contractor and shall be included in the prices bid in the schedule for equipment.

2.9.1 Motor Control Centers Tests

2.9.1.1 Dielectric Tests

Each motor control center shall be completely assembled and given dielectric tests in accordance with NEMA ICS 1.

2.9.1.2 Operational Tests

The correctness of operation of each air circuit breaker [or motor circuit protector] and magnetic contactor and of all control devices, accessories and indicating lamps, shall be checked. These checks shall be made at rated voltage with power supplies to the main buses. All magnetic contactors shall also be checked for proper operation with power at 90 percent of rated voltage.

2.9.1.3 Short Circuit Tests

If the unit is not UL labeled for the specified short circuit, the Contractor may submit design tests demonstrating that satisfactory short-circuit tests, as specified in NEMA ICS 2 , have been made on a motor control center of similar type of construction and having the same available short circuit current at the motor terminals, including any motor contributions, as the motor control centers specified to be furnished under these specifications.

2.10 PAINTING

Interior and exterior steel surfaces of equipment enclosures shall be thoroughly cleaned and then receive a rust-inhibitive phosphatizing or equivalent treatment prior to painting. Exterior surfaces shall be free from holes, seams, dents, weld marks, loose scale or other imperfections. Interior surfaces shall receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice. Exterior surfaces shall be primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish. Equipment located indoors shall be ANSI Light Gray.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations, including weatherproof and hazardous locations and ducts, plenums and other air-handling spaces, shall conform to requirements of NFPA 70 and IEEE C2 and to requirements specified herein.

3.1.2 Overhead Service

Overhead service conductors into buildings shall terminate at service entrance fittings or weatherhead outside building.

3.1.3 Wiring Methods

Provide insulated conductors installed in rigid steel conduit, IMC, rigid nonmetallic conduit, or EMT, except where specifically indicated or specified otherwise or required by FPA 70 to be installed otherwise. Grounding conductor shall be separate from electrical system neutral conductor. Minimum conduit size shall be 1/2 inch in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings shall be made with metal conduit in fire-rated shafts. Metal conduit shall extend through shafts for minimum distance of 6 inches.

3.1.3.1 Pull Wire

Install pull wires in empty conduits. Pull wire shall be plastic having minimum 200-pound force tensile strength. Leave minimum 36 inches of slack at each end of pull wire.

3.1.3.2 Metal Clad Cable

Install in accordance with NFPA 70, Type MC cable.

3.1.3.3 Armored Cable

Install in accordance with NFPA 70, Type AC cable.

3.1.3.4 Flat Conductor Cable

Install in accordance with NFPA 70, Type FCC cable.

3.1.4 Conduit Installation

Unless indicated otherwise, conceal conduit under floor slabs and within finished walls, ceilings, and floors. Keep conduit minimum 6 inches away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project.

3.1.4.1 Restrictions Applicable to Aluminum Conduit

a. Do not install underground or encase in concrete or masonry.
b. Do not use brass or bronze fittings.

3.1.4.2 Conduit Interior to Buildings for 400 Hz Circuits

Aluminum or nonmetallic.

3.1.4.3 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.1.3.4 Conduit Installed Under Floor Slabs

Conduit run under floor slab shall be located a minimum of 12 inches below the vapor barrier. Seal around conduits at penetrations thru vapor barrier.

3.1.4.5 Conduit Through Floor Slabs

Where conduits rise through floor slabs, curved portion of bends shall not be visible above finished slab.

3.1.4.6 Conduit Installed in Concrete Floor Slabs

Locate so as not to adversely affect structural strength of slabs. Install conduit within middle one-third of concrete slab. Space conduits horizontally not closer than three diameters, except at cabinet locations. Curved portions of bends shall not be visible above finish slab. Increase slab thickness as necessary to provide minimum one inch cover over conduit. Where embedded conduits cross building and/or expansion joints, provide suitable watertight expansion/deflection fittings and bonding jumpers. Expansion/deflection fittings shall allow horizontal and vertical movement of raceway. Conduit larger than one inch trade size shall be parallel with or at right angles to main reinforcement; when at right angles to reinforcement, conduit shall be close to one of supports of slab.

3.1.4.7 Stub-Ups

Provide conduits stubbed up through concrete floor for connection to free-standing equipment with adjustable top or coupling threaded inside for plugs, set flush with finished floor. Extend conductors to equipment in rigid steel conduit, except that flexible metal conduit may be used 6 inches above floor. Where no equipment connections are made, install screwdriver-operated threaded flush plugs in conduit end.

3.1.4.8 Conduit Support

Support conduit by pipe straps, wall brackets, hangers, or ceiling trapeze. Fasten by concrete inserts or expansion bolts on concrete or brick and by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Load applied to fasteners shall not exceed one-fourth proof test load. Fill unused holes. Conduit and box systems shall be supported independently of both (a) tie wires supporting ceiling grid system, and (b) ceiling grid system into

which ceiling panels are placed. Supporting means shall not be shared between electrical raceways and mechanical piping or ducts. Installation shall be coordinated with above-ceiling mechanical systems to assure maximum accessibility to all systems. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations. For conduits greater than 2 1/2 inches inside diameter, provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.4.9 Locknuts and Bushings

Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by NFPA 70, where insulated bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, use at least minimum single locknut and bushing. Locknuts shall have sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by NFPA 70.

3.1.5 Busway Installation

Installation shall comply at minimum with NFPA 70. Install busways parallel with or at right angles to ceilings, walls, and structural members. Support busways at 1525 mm 5 foot maximum intervals, and brace to prevent lateral movement. Hinges provided on risers shall be fixed type; spring-type are unacceptable. Provide flanges where busway makes penetrations through walls and floors, and seal to maintain smoke and fire ratings. Provide waterproof curb where busway riser passes through floor. Seal gaps with fire-rated foam and calk. Provide expansion joints, but only where bus duct crosses building expansion joints. Provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.6 Cable Tray Installation

Install and ground in accordance with NFPA 70. For grounding of cable tray system provide No. 2 AWG bare copper wire throughout cable tray system, and bond to each section, except use No. 1/0 aluminum wire if cable tray is aluminum.

Install cable trays parallel with or at right angles to ceilings, walls, and structural members. Support as indicated. Edges, fittings, and hardware shall be finished free from burrs and sharp edges. Provide No. 2 AWG bare copper wire throughout cable tray system, and bond to each section. Use No. 1/0 aluminum wire if cable tray is aluminum.

3.1.7 Boxes, Outlets, and Supports

Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes for metallic raceways shall be cast-metal, hub-type when located in wet locations, when surface mounted on outside of exterior surfaces or when surface mounted on interior walls exposed up to 7 feet above floors and walkways, and when specifically indicated. Boxes in other locations shall be sheet steel, except that aluminum boxes may be used with aluminum conduit, and nonmetallic boxes may be used with nonmetallic conduit system. Each box shall have volume required by NFPA 70 for number of conductors enclosed in box. Boxes for mounting lighting fixtures shall be minimum 4 inches square, or octagonal, except that smaller boxes may be installed as required by fixture configurations, as approved. Fasten boxes and supports with bolts and expansion shields on concrete or brick, and with machine screws or welded studs on steel.

3.1.7.1 Boxes

Boxes for use with raceway systems shall be minimum 1 1/2 inches deep, except where shallower boxes required by structural conditions are approved. Boxes for other than lighting fixture outlets shall be minimum 4 inches square, except that 4 by 2 inch boxes may be used where only one raceway enters outlet. Telecommunications outlets shall be a minimum of 4 inches square by 2 1/8 inches deep.

3.1.7.2 Pull Boxes

Construct of at least minimum size required by NFPA 70 except where cast-metal boxes are required in locations specified herein. Provide boxes with screw-fastened covers. Where several feeders pass through common pull box, tag feeders to indicate clearly electrical characteristics, circuit number, and panel designation.

3.1.8 Mounting Heights

Mount panelboards, motor controller and disconnecting switches so height of operating handle at its highest position is maximum 78 inches above floor. Mount lighting switches 48 inches above finished floor. Mount receptacles18 inches above finished floor.

3.1.9 Conductor Identification

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, color coding shall be by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, color coding shall be by plastic-coated, self-sticking markers; colored nylon cable ties and plates; or heat shrink-type sleeves.

3.1.10 Terminating Aluminum Conductors

3.1.10.1 Termination to Copper Bus

Terminate aluminum conductors to copper bus either by: (a) inline splicing a copper pigtail, of ampacity at least that of aluminum conductor, or (b) utilizing circumferential, compression-type, aluminum-bodied terminal lug UL listed for AL/CU, and steel Belleville cadmium-plated hardened steel spring washers, flat washers, bolts, and nuts. Carefully install Belleville spring washers with crown up toward nut or bolt head, with concave side of Belleville bearing on heavy-duty, wide series flat washer of larger diameter than Belleville. Tighten nuts sufficiently to flatten Belleville, and leave in position. Lubricate hardware with joint compound prior to making connection. Wire brush and apply joint compound to conductor prior to inserting in lug.

3.1.10.2 Termination to Aluminum Bus

Terminate aluminum conductors to aluminum bus by using aluminum nuts, bolts, washers, and compression lugs. Wire brush and apply joint compound to conductor prior to inserting in lug. Lubricate hardware with joint compound prior to making connection. When bus contact surface is unplated, scratch-brush and coat with joint compound, without grit.

3.1.11 Covers and Device Plates

Install with edges in continuous contact with finished wall surfaces without use of mats or similar devices. Plaster fillings are not permitted. Install plates with alignment tolerance of 1/16 inch.

3.1.12 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated walls, partitions, floors, or ceilings.

3.1.13 Grounding and Bonding

Provide In accordance with NFPA 70 and NFPA 780. Ground exposed, non-current-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductor in metallic and nonmetallic raceways, grounding conductor of nonmetallic sheathed cables, and neutral conductor of wiring systems. Make ground connection at main service equipment, and extend grounding conductor to point of entrance of metallic water service. Interconnect all grounding media in or on the structure to provide a common ground potential. Use main size lightning conductors for interconnecting these grounding systems to the lightning protection system. Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection.

3.1.13.1 Ground Rods

Provide cone pointed ground rods. The resistance to ground shall be measured using the fall-of-potential method described in IEEE 81. The maximum resistance of a driven ground shall not exceed 25 ohms under normally dry conditions. If this resistance cannot be obtained with a single rod, [ ] additional rods not less than 6 feet on centers.

3.1.13.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, by exothermic weld or compression connector.

3.1.13.3 Ground Bus

A copper ground bus shall be provided in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of electrical equipment shall be effectively grounded by bonding to the ground bus. The ground bus shall be bonded to both the entrance ground, and to a ground rod or rods as specified above having the upper ends terminating approximately 4 inches above the floor. Connections and splices shall be of the brazed, welded, bolted, or pressure-connector type, except that pressure connectors or bolted connections shall be used for connections to removable equipment.

3.1.13.4 Resistance

Maximum resistance-to-ground of grounding system shall not exceed 5ohms under dry conditions. Where resistance obtained exceeds 5 ohms, contact Owner's Representative for further instructions.

3.1.14 Equipment Connections

Provide power wiring for the connection of motors and control equipment under this section of the specification. Except as otherwise specifically noted or specified, automatic control wiring, control devices, and protective devices within the control circuitry are not included in this section of the specifications but shall be provided under the section specifying the associated equipment.

3.1.15 Watthour Meters

ANSI C12.1.

3.1.16 Surge Protective Devices

Connect the surge protective devices in parallel to the power source, keeping the conductors as short and straight as practically possible.

3.2 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side.

3.3 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria.

3.4 FIELD QUALITY CONTROL

Furnish test equipment and personnel and submit written copies of test results. Give Owner's Representative 5 working days notice prior to test[s].

3.4.1 Devices Subject to Manual Operation

Each device subject to manual operation shall be operated at least five times, demonstrating satisfactory operation each time.

3.4.2 600-Volt Wiring Test

Test wiring rated 600 volt and less to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 500 volts to provide direct reading of resistance. Minimum resistance shall be 250,000 ohms.

3.4.3 Transformer Tests

Perform the standard, not optional, tests in accordance with the Inspection and Test Procedures for transformers, dry type, air-cooled, 600 volt and below; as specified in NETA ATS. Measure primary and secondary voltages for proper tap settings.

3.4.4 Ground-Fault Receptacle Test

Test ground-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed.

3.4.5 Grounding System Test

Test grounding system to ensure continuity, and that resistance to ground is not excessive. Test each ground rod for resistance to ground before making connections to rod; tie grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours

after rainfall. Submit written results of each test to Owner's Representative, and indicate location of rods as well as resistance and soil conditions at time measurements were made.

3.4.6 Watthour Meter

a. Visual and mechanical inspection
   (1) Examine for broken parts, shipping damage, and tightness of connections.
   (2) Verify that meter type, scales, and connections are in accordance with approved shop drawings.

b. Electrical tests
   (1) Determine accuracy of meter.
   (2) Calibrate watthour meters to one-half percent.
   (3) Verify that correct multiplier has been placed on face of meter, where applicable.

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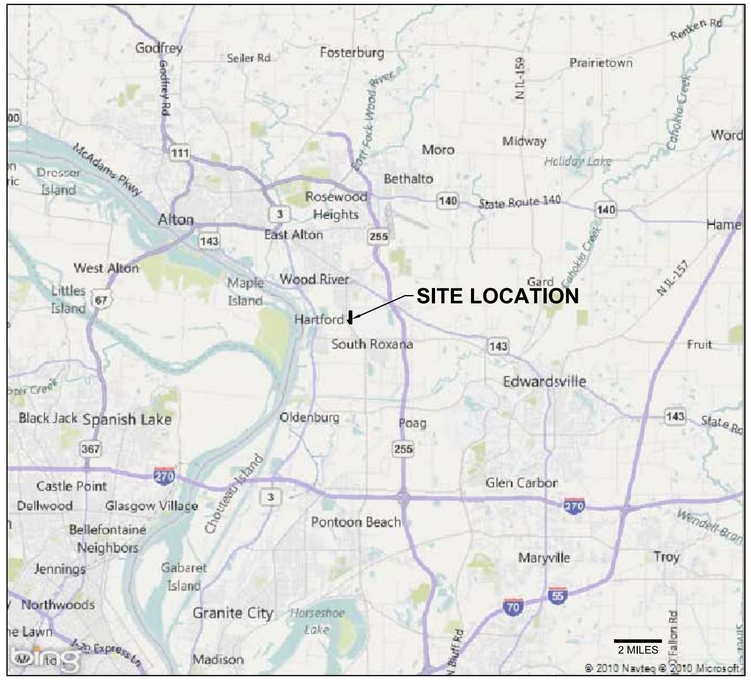
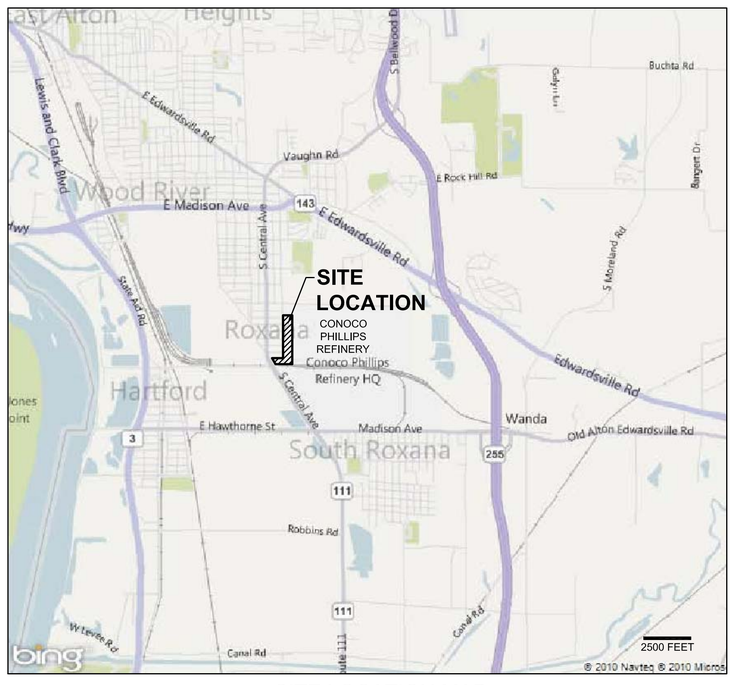
ROXANA, ILLINOIS



VICINITY MAP



SITE LOCATION MAP

SHEET INDEX:

C001 - TITLE SHEET
C101 - EXISTING SITE CONDITIONS
C102 - PROPOSED SOIL VAPOR EXTRACTION (SVE) SYSTEM
C103 - SVE BUILDING LAYOUT
C201 - PIPING AND SVE WELL SCHEMATIC
P101 - SVE PROCESS & INSTRUMENTATION DIAGRAM
E101 - ELECTRICAL CONTROL PANEL LAYOUT
E102 - CONTROL SCHEMATIC

PREPARED FOR:
SHELL OIL PRODUCTS US
17 JUNCTION DRIVE
PMB #399
GLEN CARBON, IL 62034

PREPARED BY:
URS CORP.
8300 COLLEGE BLVD. SUITE 200
OVERLAND PARK, KANSAS 66210

CALL BEFORE YOU DIG:
JULIE, INC.
ILLINOIS ONE CALL SYSTEM
1-800-892-0123
OR 811

DRAFT

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8300 College Blvd., Suite 200
Overland Park, Kansas 66210

CLIENT: SHELL OIL PRODUCTS US

LOCATION: ROXANA, ILLINOIS

TITLE: TITLE SHEET

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CTD	ROH	
PROJECT NO.	DATE	DRAWING NO.
21562593	APR. 2011	C001

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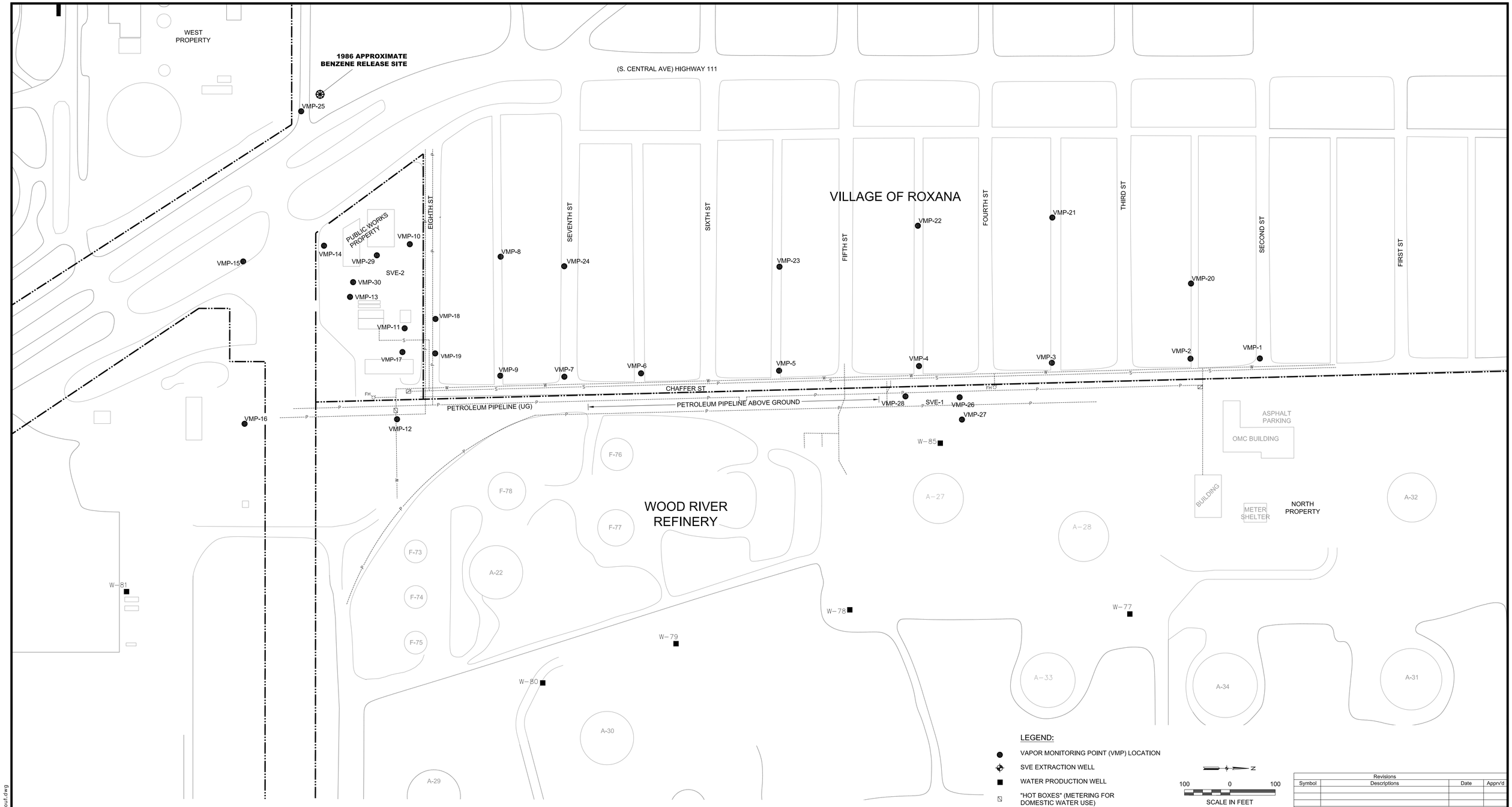

LEGEND:

- VAPOR MONITORING POINT (VMP) LOCATION
- SVE EXTRACTION WELL
- WATER PRODUCTION WELL
- "HOT BOXES" (METERING FOR DOMESTIC WATER USE)
- PROPERTY BOUNDARY
- PETROLEUM PIPELINE
- WATER LINE
- SANITARY SEWER LINE
- FIRE HYDRANT

100 0 100

SCALE IN FEET

NOTE:

1. CONTRACTOR SHALL FIELD VERIFY UTILITY LOCATIONS PRIOR TO CONSTRUCTION.

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CLIENT: SHELL OIL PRODUCTS US

LOCATION: ROXANA, ILLINOIS

TITLE: EXISTING SITE CONDITIONS

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PROJECT NO.	DATE	DRAWING NO.
21562593	APR. 2011	C101

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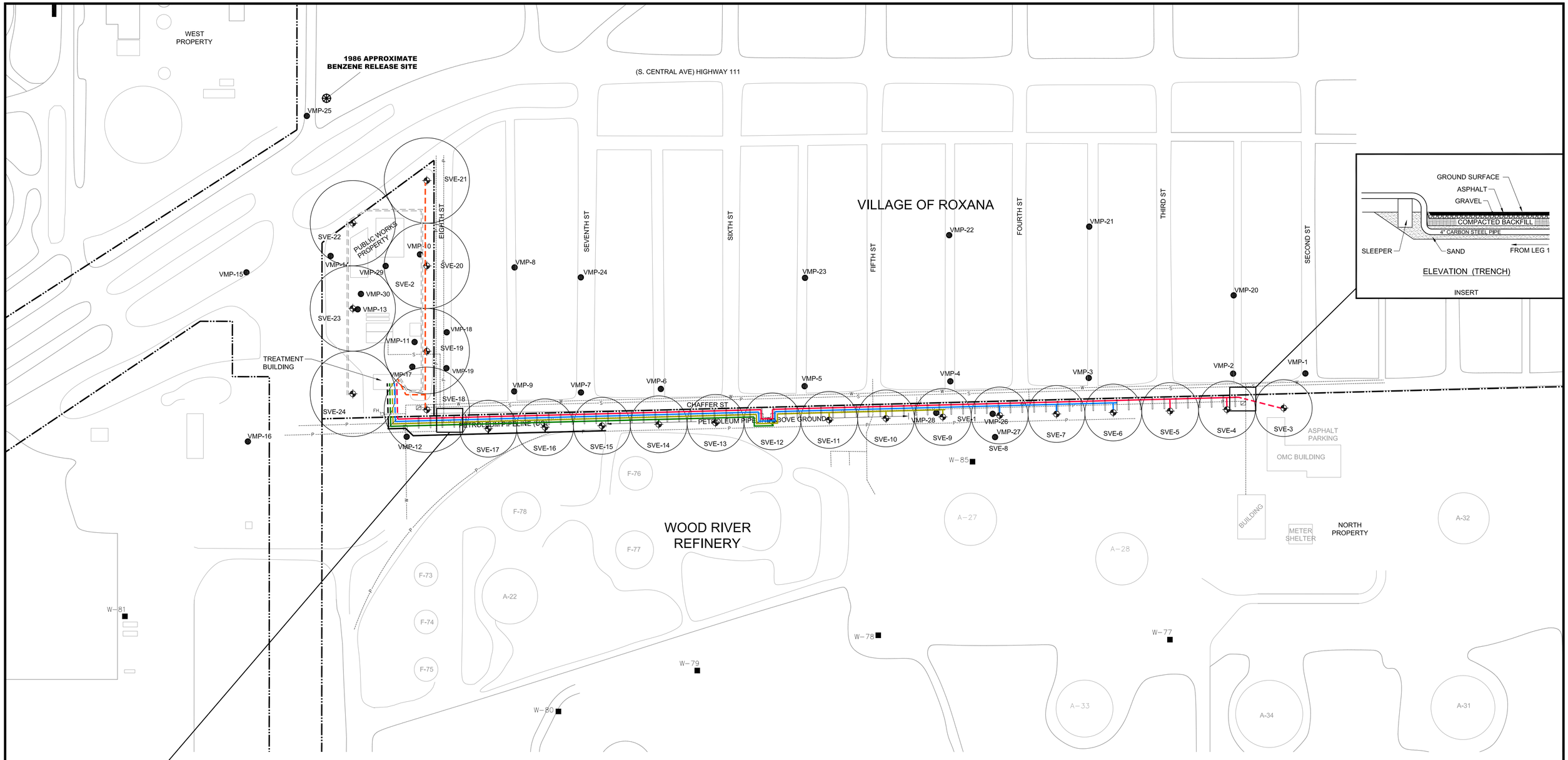

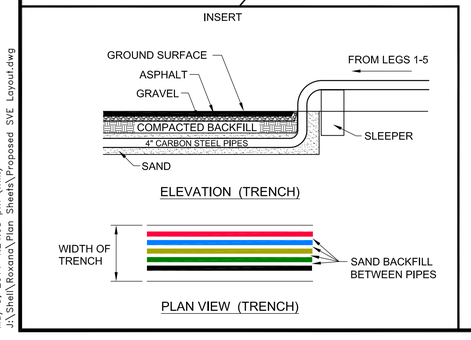

IDENTIFICATION TAPE (FADE RESISTANT / SELF ADHESIVE)

LEG #	SVE WELLS	COLOR
1	SVE-3 THROUGH SVE 5	RED
2	SVE-6 THROUGH SVE-8	BLUE
3	SVE-9 THROUGH SVE-11	YELLOW
4	SVE-12 THROUGH SVE-14	GREEN
5	SVE-15 THROUGH SVE-17	BLACK
6	SVE-18 THROUGH SVE-21	ORANGE
7	SVE-22 THROUGH SVE-24	WHITE

LEGEND:

- VAPOR MONITORING POINT (VMP) LOCATION
- SVE EXTRACTION WELL
- "HOT BOXES" (METERING FOR DOMESTIC WATER USE)
- PIPE SLEEPER
- UNDERGROUND PIPING (DASHED)
- ABOVEGROUND PIPING
- PROPERTY BOUNDARY
- ESTIMATED RADIUS OF INFLUENCE

N

100 0 100

SCALE IN FEET

NOTES:

1. CONTRACTOR SHALL FIELD VERIFY UTILITY LOCATIONS PRIOR TO CONSTRUCTION.
2. WELL LOCATIONS ARE PROPOSED AND WILL BE MOVED AS CLOSE TO THE FENCE LINE AS IS SAFE.

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Revisions			
Symbol	Descriptions	Date	Apprv'd

URS 8300 College Blvd., Suite 200 Overland Park, Kansas 66210

CLIENT: SHELL OIL PRODUCTS US

LOCATION: ROXANA, ILLINOIS

TITLE: PROPOSED SOIL VAPOR EXTRACTION (SVE) SYSTEM

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CTD	ROH	
PROJECT NO.	DATE	DRAWING NO.
21562593	APR. 2011	C102

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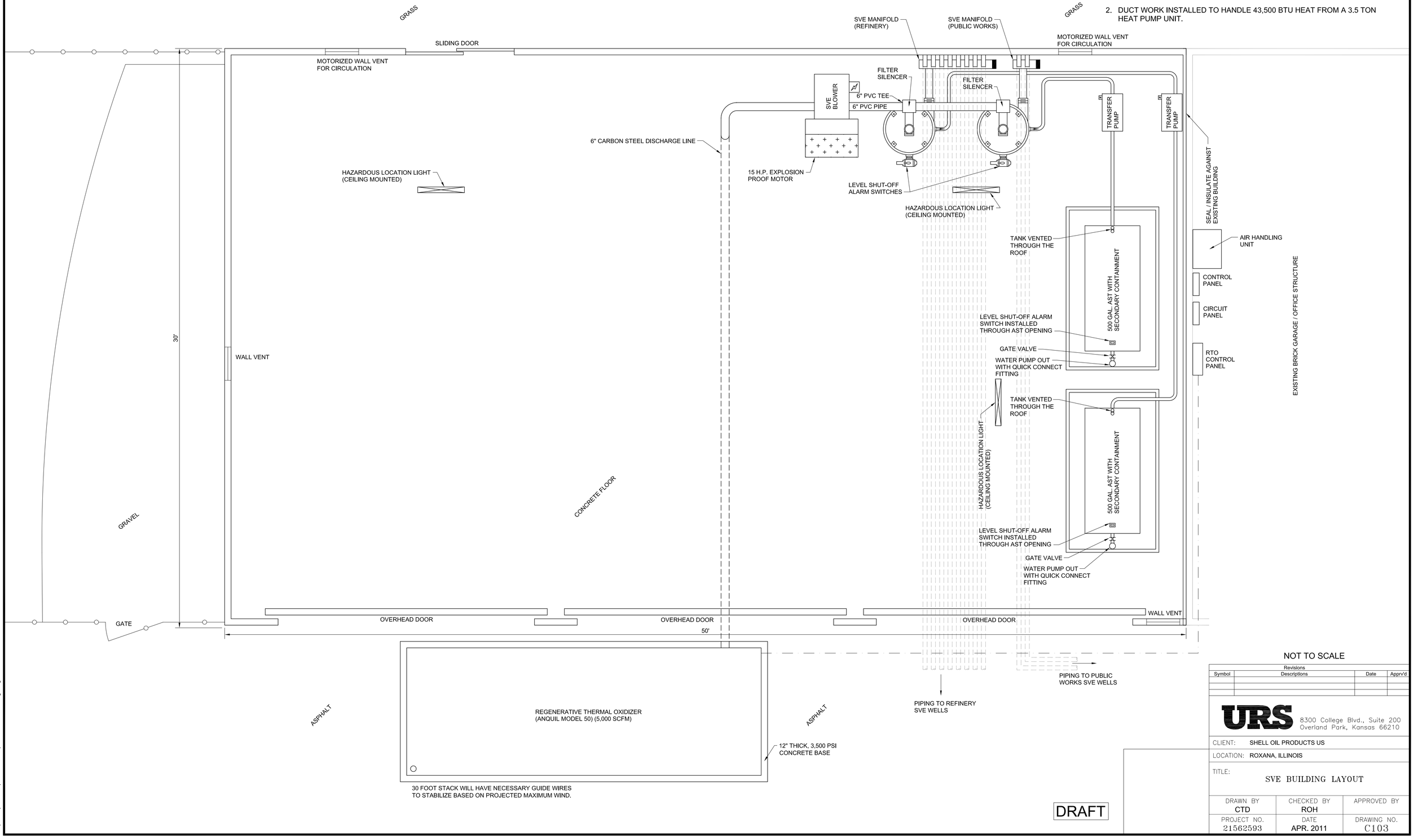
NOTES:

1. ALL BUILDING WALLS INSULATED WITH FIBERGLASS INSULATION WITH BACKING HAVING A R-FACTOR SUFFICIENT FOR ROXANA, ILLINOIS.
2. DUCT WORK INSTALLED TO HANDLE 43,500 BTU HEAT FROM A 3.5 TON HEAT PUMP UNIT.



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URS 8300 College Blvd., Suite 200 Overland Park, Kansas 66210

CLIENT: SHELL OIL PRODUCTS US

LOCATION: ROXANA, ILLINOIS

TITLE: SVE BUILDING LAYOUT

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CTD	ROH	
PROJECT NO.	DATE	DRAWING NO.
21562593	APR. 2011	C103

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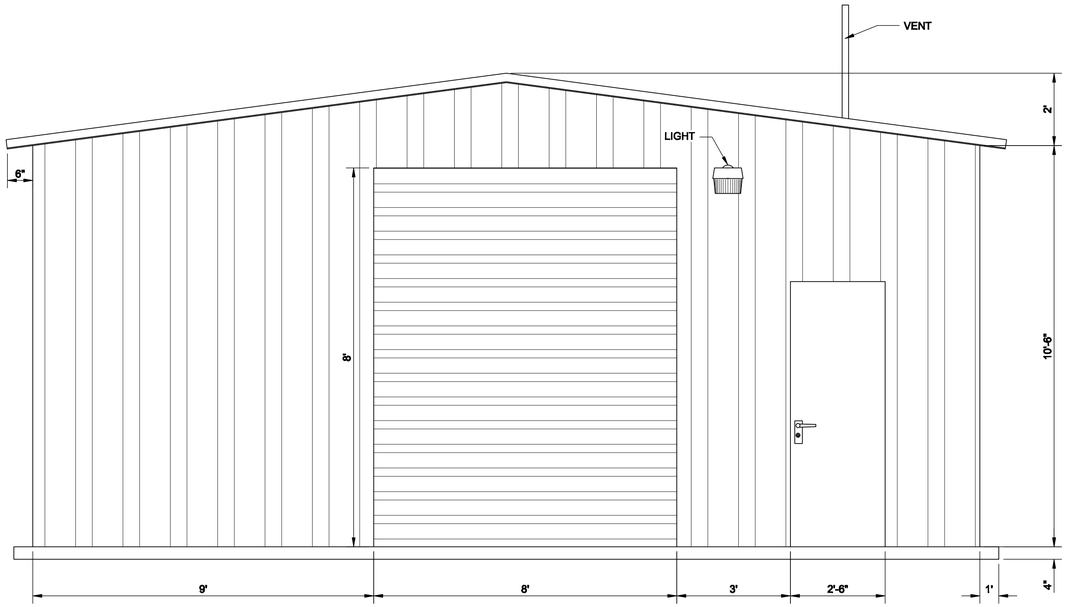

ELEVATION VIEW OF THE EAST WALL
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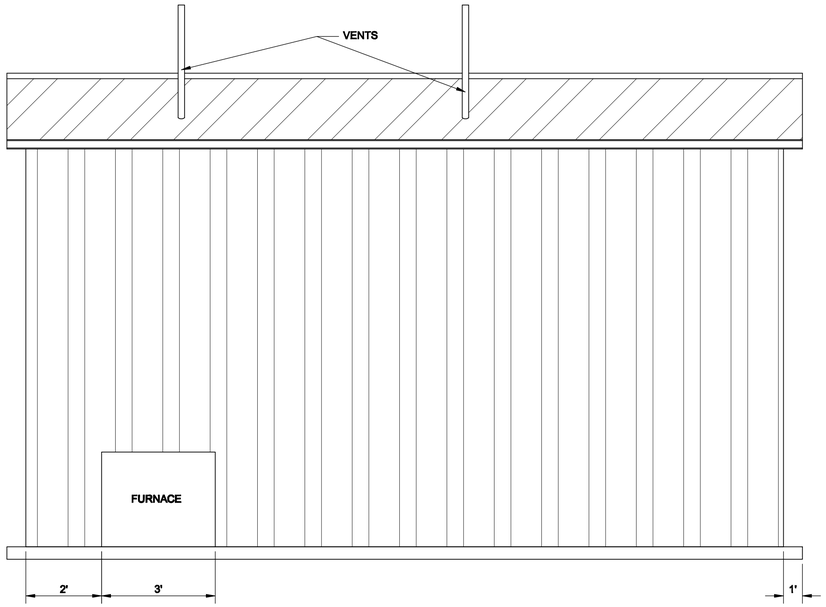

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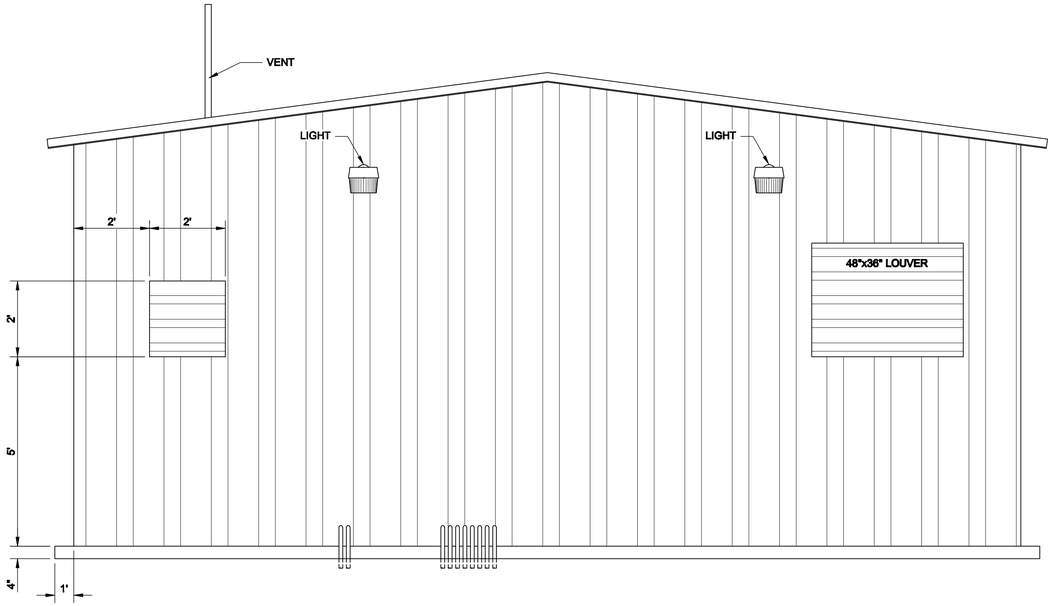

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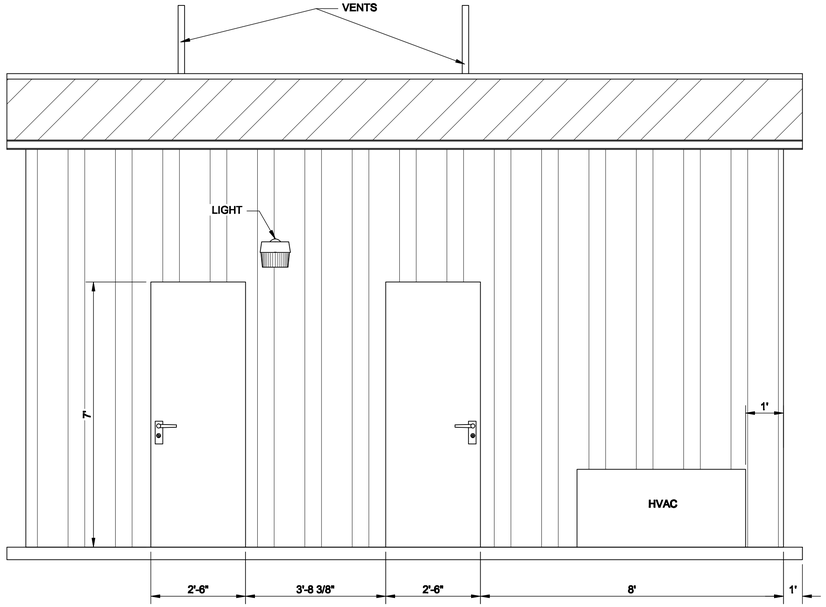

ELEVATION VIEW OF THE SOUTH WALL
NOT TO SCALE

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Symbol	Descriptions	Date	Apprv'd

URS
8300 College Blvd., Suite 200
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CLIENT: SHELL OIL PRODUCTS US

LOCATION: ROXANA, ILLINOIS

TITLE: BUILDING ELEVATION VIEWS

LICENSED PROFESSIONAL ENGINEER
LESLIE B. VOSS
062.063455
STATE OF ILLINOIS

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CTD	ROH	
PROJECT NO.	DATE	DRAWING NO.
21562593	JUNE 2011	C104

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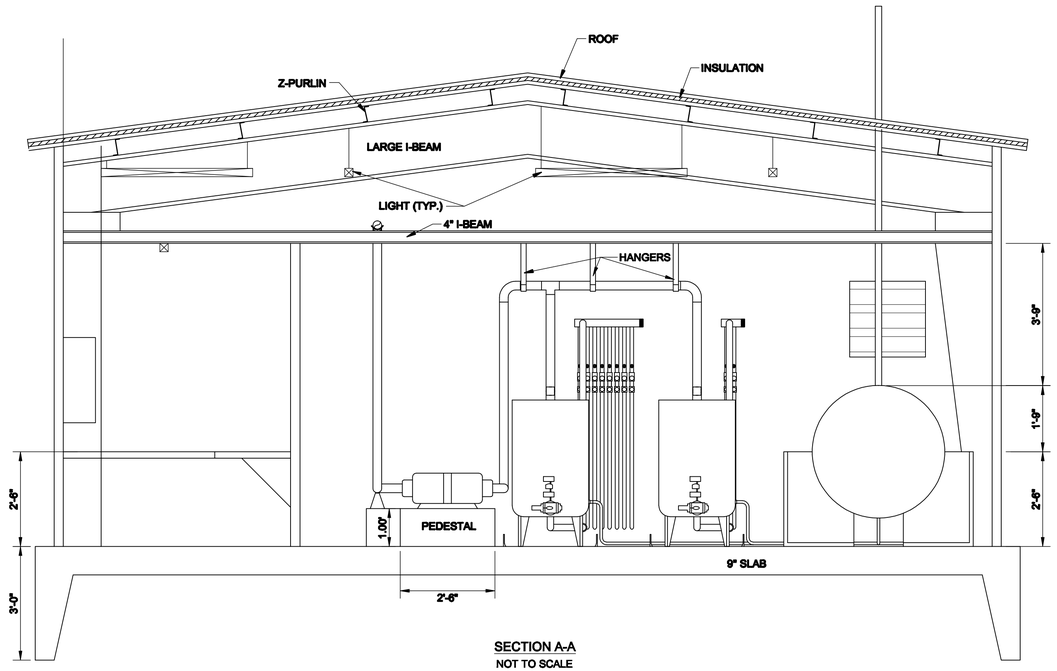

SECTION A-A
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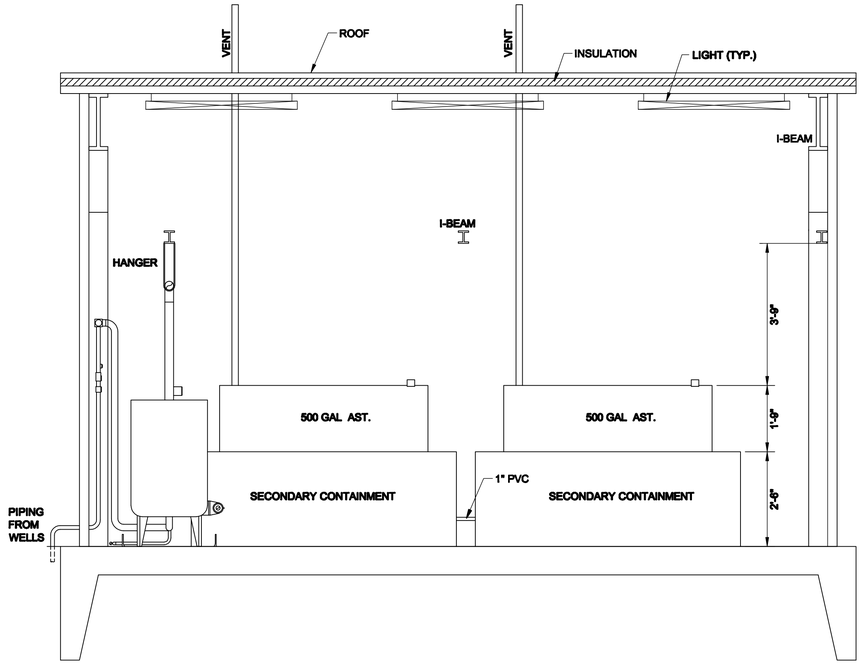

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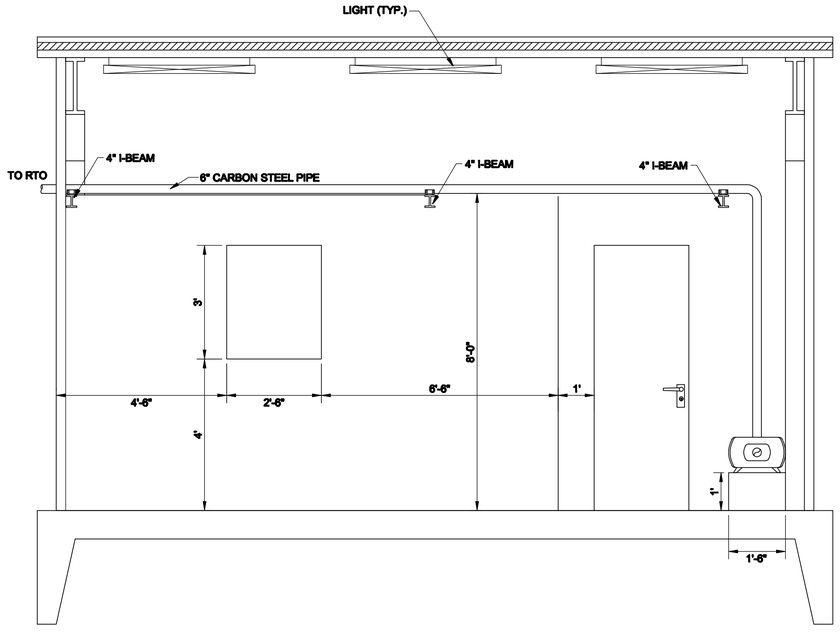

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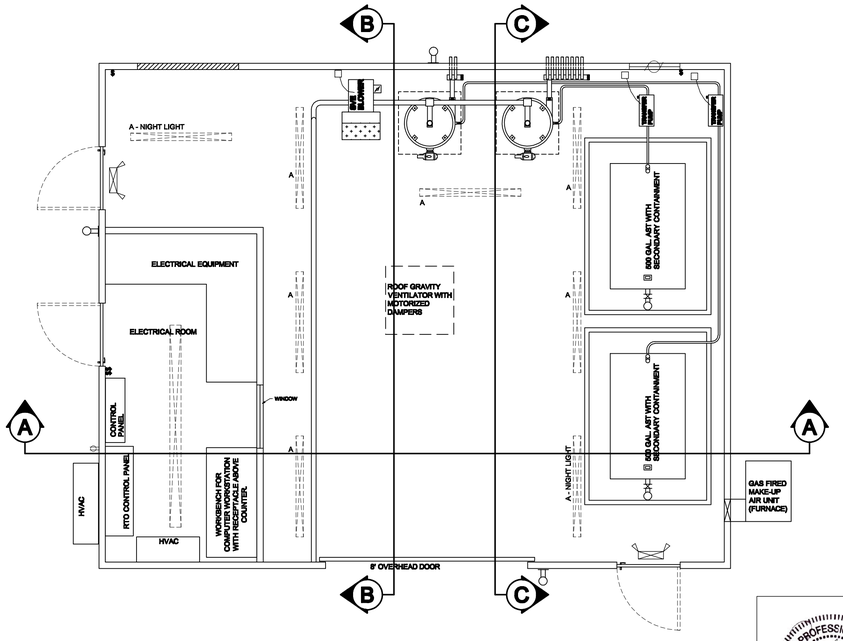

SECTION KEY
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CLIENT: SHELL OIL PRODUCTS US

LOCATION: ROXANA, ILLINOIS

TITLE: BUILDING CROSS SECTION VIEWS

LICENSED PROFESSIONAL ENGINEER
LESLIE B. VOSS
062.063455
STATE OF ILLINOIS

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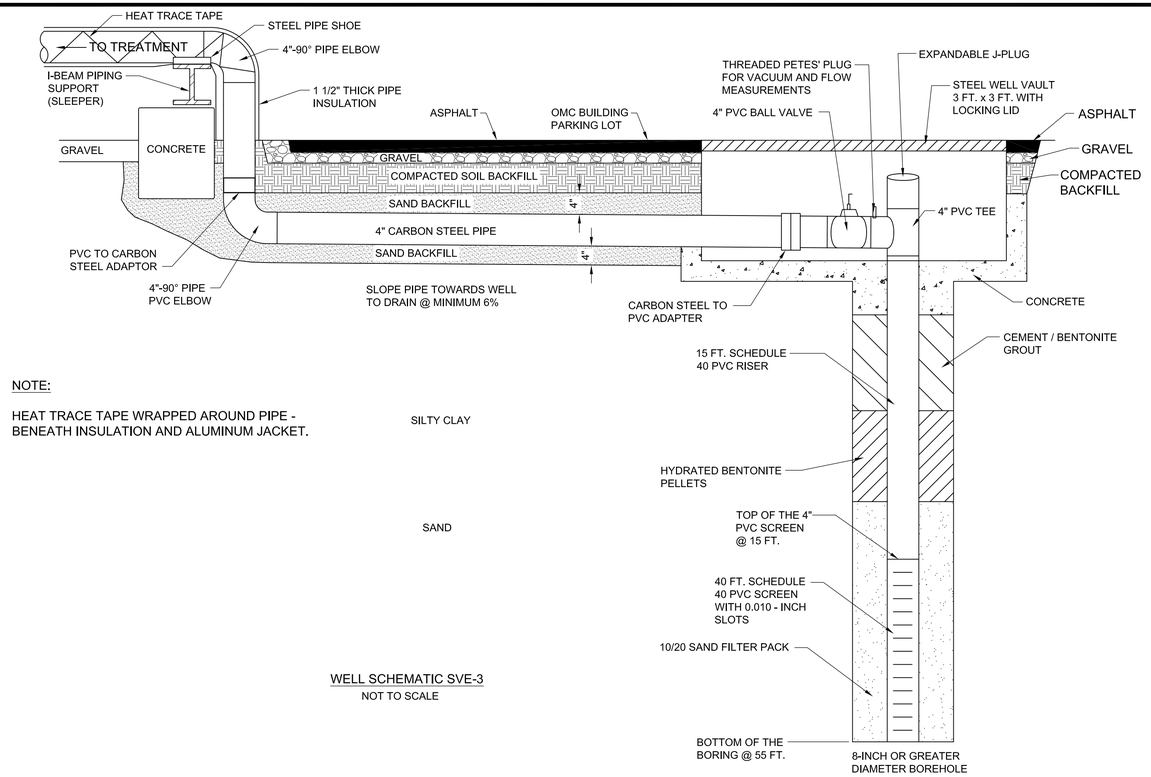
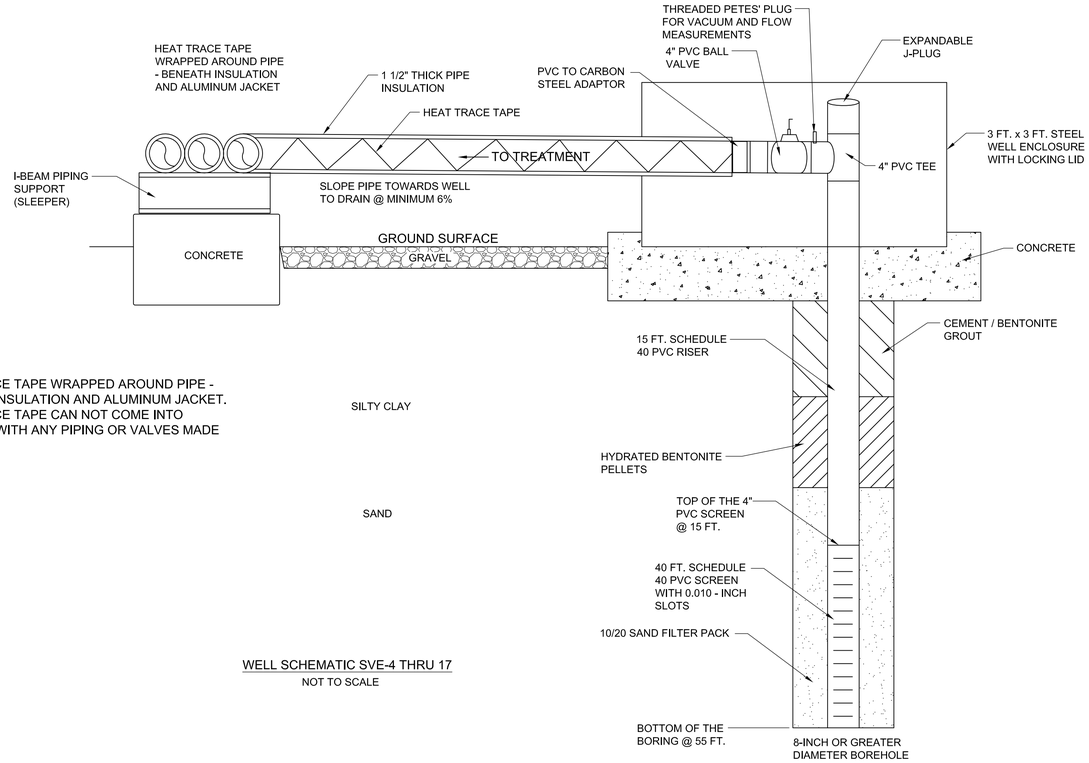


NOTE:

HEAT TRACE TAPE WRAPPED AROUND PIPE - BENEATH INSULATION AND ALUMINUM JACKET.

WELL SCHEMATIC SVE-3

NOT TO SCALE

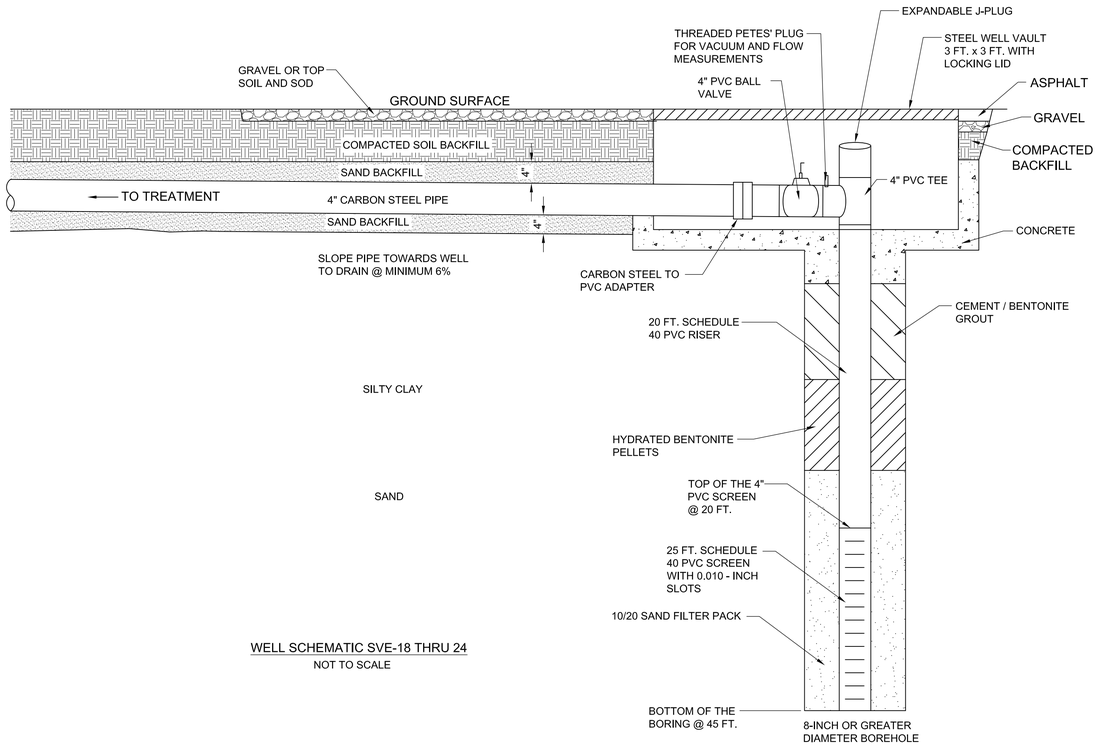


NOTE:

HEAT TRACE TAPE WRAPPED AROUND PIPE - BENEATH INSULATION AND ALUMINUM JACKET. HEAT TRACE TAPE CAN NOT COME INTO CONTACT WITH ANY PIPING OR VALVES MADE OF PVC.

WELL SCHEMATIC SVE-4 THRU 17

NOT TO SCALE



WELL SCHEMATIC SVE-18 THRU 24

NOT TO SCALE

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CLIENT: SHELL OIL PRODUCTS US

LOCATION: ROXANA, ILLINOIS

TITLE: SVE WELL DETAIL & PIPING LAYOUT

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May 3, 2011 4:25:40 pm (mlk)
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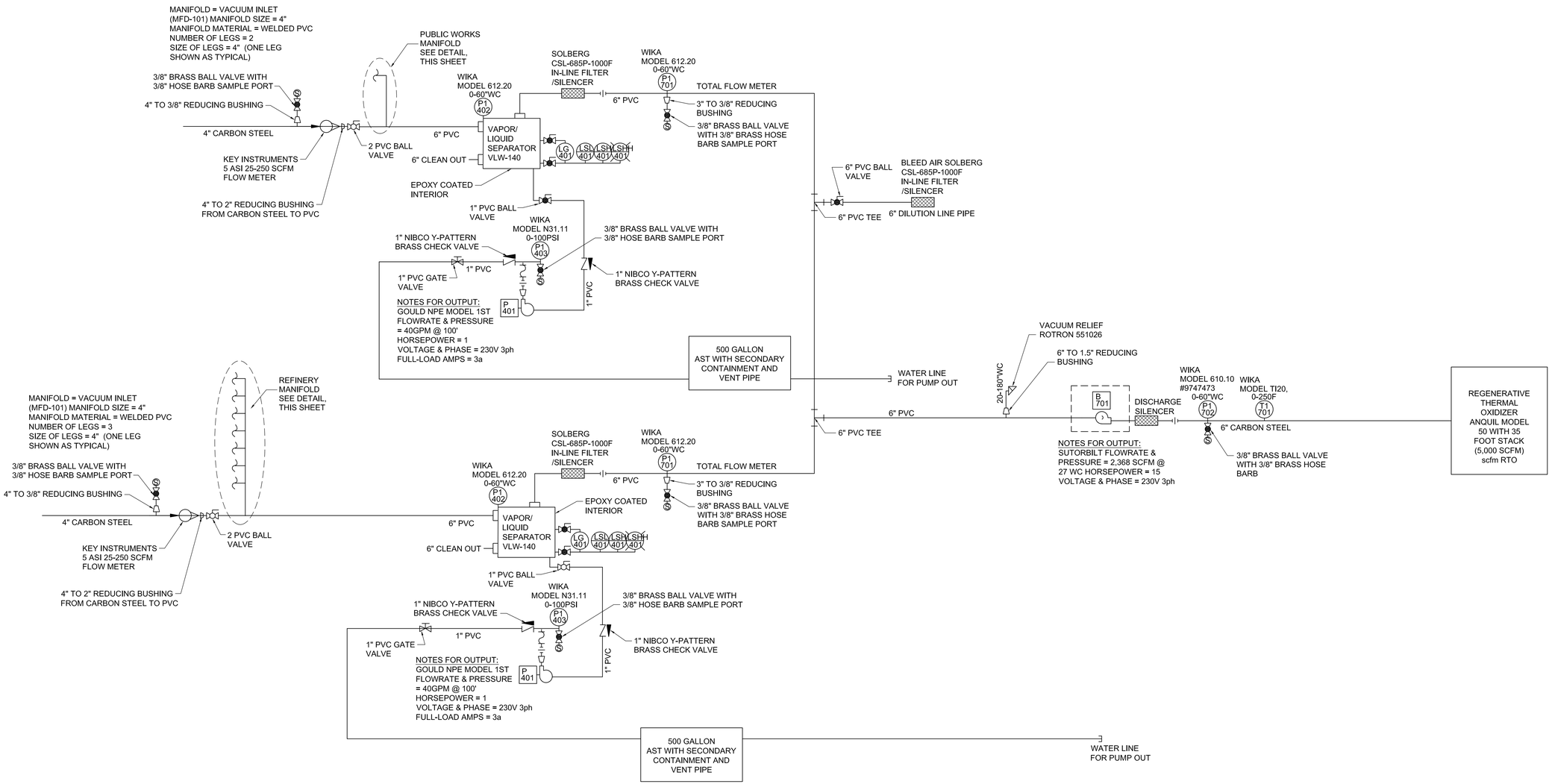
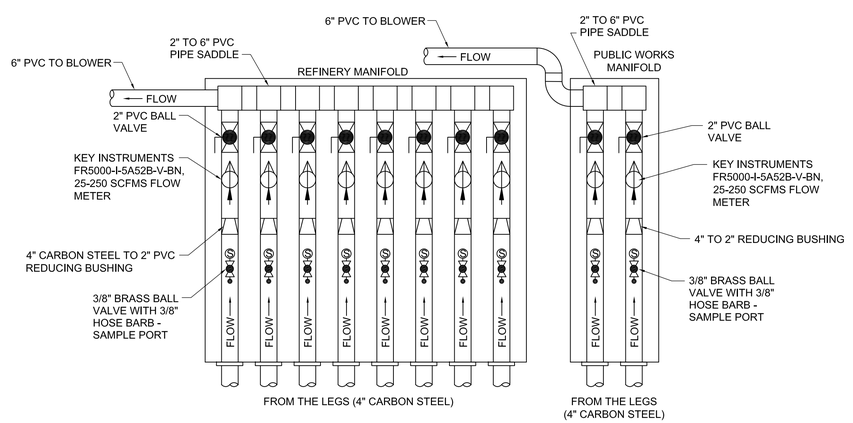


LEGEND:

- 0-100PSI P1 2201 — PRESSURE GAUGE - PRESSURE RANGE LISTED ABOVE SYMBOL, MODEL TYPE INDICATED BY NUMBER IN CIRCLE (IF IN INCHES THEN GAUGE MEASURES PRESSURE DIFFERENCE FOR FLOW READING
- 0-250F T1 2502 — TEMPERATURE GAUGE - TEMPERATURE RANGE LISTED ABOVE THE SYMBOL
- FLOW METER - DIRECTION OF FLOW IS INDICATED BY ARROW HEADS
- BALL VALVE - WITH HANDLE IN THE OPEN POSITION WHEN CIRCLE IS NOT FILLED IN
- BALL VALVE - WITH HANDLE IN THE CLOSED POSITION WHEN CIRCLE IS FILLED IN
- FLEX CONNECTION (RUBBER)
- TSH 2601 — ALARM FOR HIGH TEMPERATURE (PILOT LIGHT)
- GATE VALVE WITH HANDLE
- CHECK VALVE
- PRESSURE RELIEF VALVE
- VACUUM RELIEF VALVE
- LG — LEVEL GAUGE
- LSL — LEVEL SWITCH LOW
- LSH — LEVEL SWITCH HIGH
- LSHH — LEVEL SWITCH HIGH HIGH
- PSH — PRESSURE SWITCH FOR HIGH ALARM
- SAMPLE PORT - CLOSED WHEN CIRCLE IS FILLED IN
- REDUCER (FROM LARGER PIPE TO SMALLER PIPE)
- HOSE CONNECTION
- P 401 — TRANSFER PUMP
- B 701 — BLOWER



MANIFOLD DETAIL

NOT TO SCALE

DRAFT

Revisions			
Symbol	Descriptions	Date	Appr'd

URS 8300 College Blvd., Suite 200 Overland Park, Kansas 66210

CLIENT: SHELL OIL PRODUCTS US

LOCATION: ROXANA, ILLINOIS

TITLE: SVE PROCESS AND INSTRUMENTATION DIAGRAM

DRAWN BY	CHECKED BY	APPROVED BY
CTD	ROH	
PROJECT NO.	DATE	DRAWING NO.
21562593	APR. 2011	P101

May 3, 2011 4:23:34 pm (mik)
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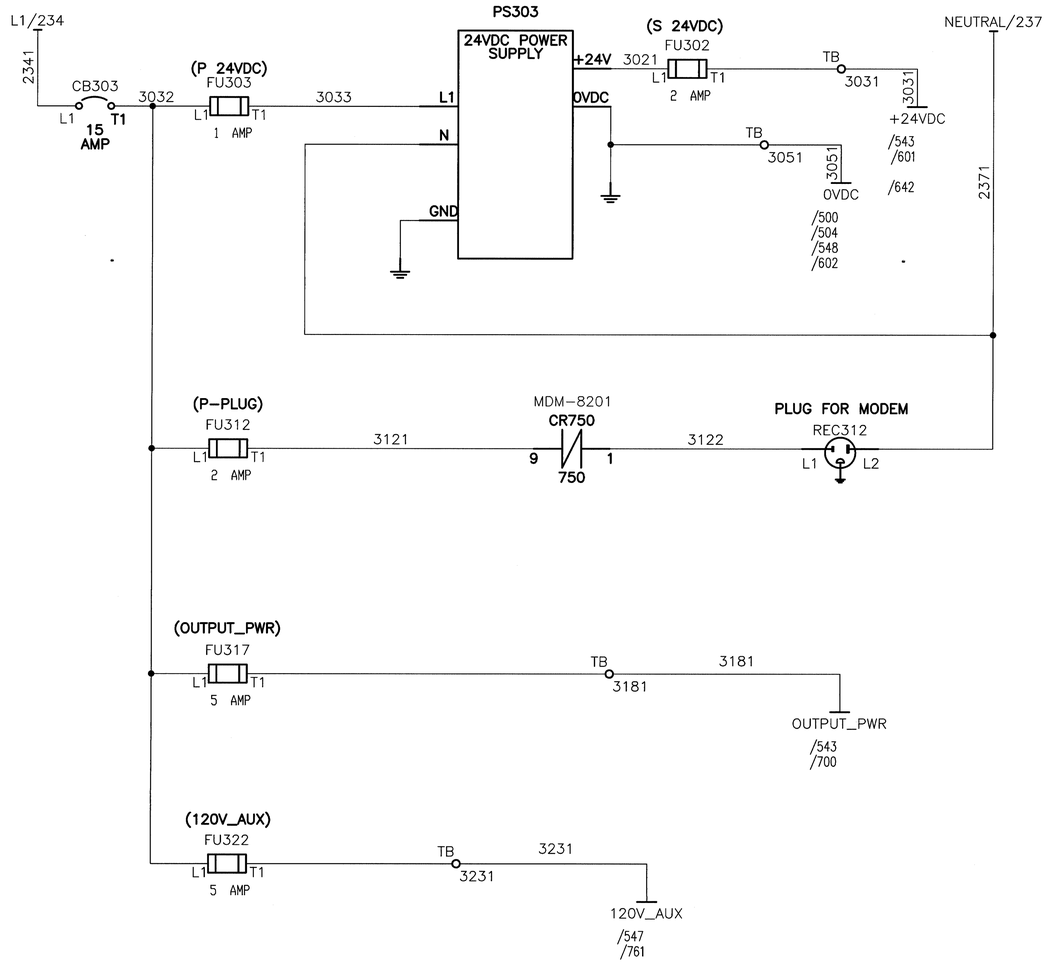

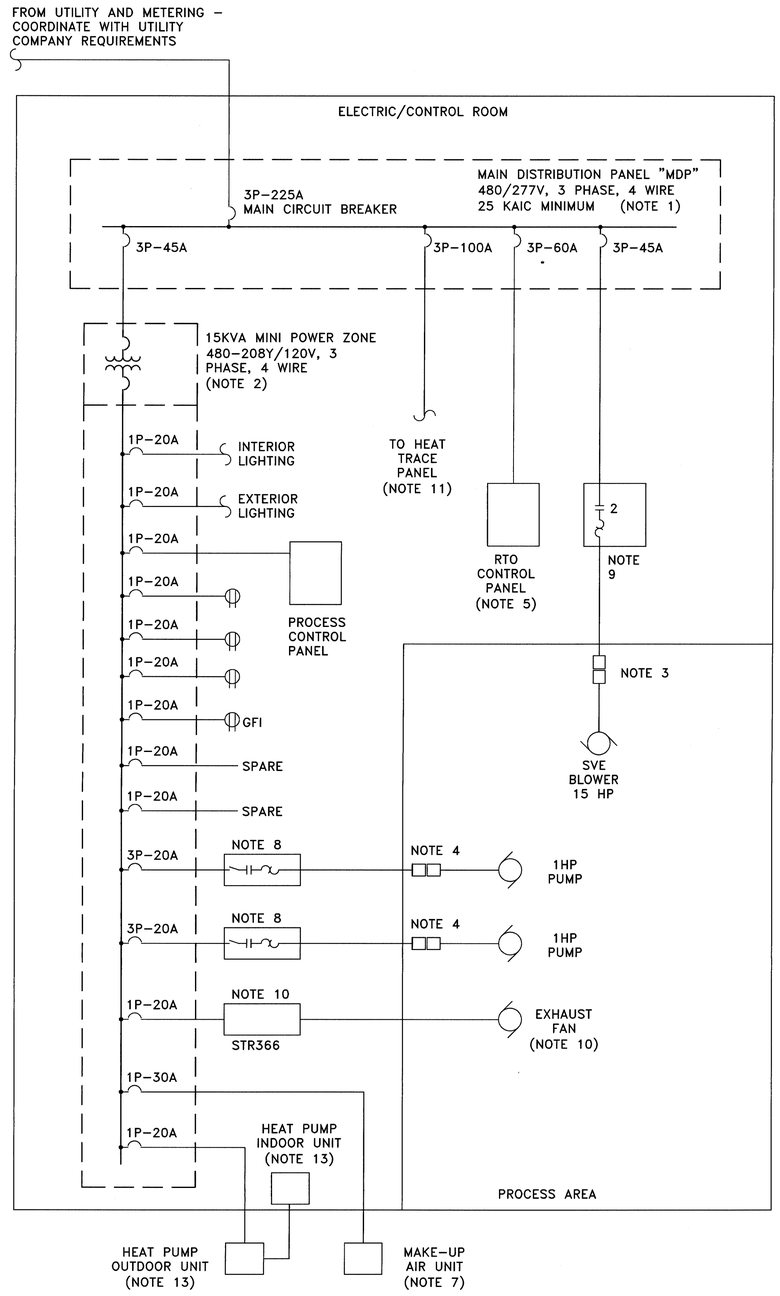

ELECTRICAL ONE-LINE DIAGRAM

NOTES:

GENERAL NOTE: PROVIDE SEALS IN CONDUITS AS REQUIRED BETWEEN HAZARDOUS AND NON-HAZARDOUS AREAS.

NOTE 1: PROVIDE 225 AMP, 480/277 VOLT, 3 PHASE, 4 WIRE, 60 HZ ELECTRIC SERVICE TO SERVICE ENTRANCE RATED MAIN DISTRIBUTION PANEL "MDP".

NOTE 2: MINI POWER CENTER EQUAL TO SQUARE D OR CUTLER-HAMMER WITH TRANSFORMER, PRIMARY AND SECONDARY MAIN CIRCUIT BREAKERS, A MINIMUM OF 18 POLES, AND CIRCUIT BREAKERS AS INDICATED.

NOTE 3: PROVIDE 60 AMP, 480 VOLT, 3 PHASE + GROUND PLUG AND RECEPTACLE EQUAL TO MELTRIC # DXN60 WITH WALL BOX AND LID FOR 30 DEGREE ANGLE MOUNTING. PROVIDE FLEXIBLE CORD AND CONNECTION TO MOTOR.

NOTE 4: PROVIDE 20 AMP, 208 VOLT, 3 PHASE + GROUND PLUG AND RECEPTACLES EQUAL TO MELTRIC # DXN20 WITH WALL BOX AND LID FOR 30 DEGREE ANGLE MOUNTING. PROVIDE FLEXIBLE CORD AND CONNECTION TO MOTOR.

NOTE 5: INSTALL REGENERATIVE THERMAL OXIDIZER (RTO) CONTROL PANEL IN NON-HAZARDOUS INTERIOR SPACE. PROVIDE 480 VOLT FEEDER AS INDICATED. PROVIDE FEEDERS, CONTROLS, AND CONNECTIONS AS REQUIRED BY RTO SUPPLIER BETWEEN RTO CONTROL PANEL, RTO UNIT, AND PROCESS CONTROL PANEL.

NOTE 6: PROVIDE PROCESS CONTROL PANEL ACCORDING TO INCLUDED DRAWINGS WITH MODIFICATIONS, ADDITIONS, AND PROGRAMMING AS REQUIRED FOR CONTROLLING THE PROCESS.

NOTE 7: MAKE-UP AIR UNIT (MAU) SHALL RUN CONTINUOUSLY AND HAVE ITS OWN OUTSIDE AIR TEMPERATURE SENSOR TO CONTROL THE HEAT. PROVIDE 3/4" C, 2 #10, 1 #10G FROM PANEL TO UNIT. DAMPERS FOR INTAKE AND EXHAUST WITH GRAVITY VENTILATION SHALL BE CONTROLLED FROM PROCESS CONTROL PANEL AND FROM TEMPERATURE SENSOR IN THE PROCESS AREA.

NOTE 8: PROVIDE SIZE 1 STARTER FOR 208 VOLT, 3 PHASE MOTOR AND CONTROL THROUGH PROCESS CONTROL PANEL.

NOTE 9: PROVIDE STARTER FOR 460 VOLT, 3 PHASE MOTOR. CONTROL THROUGH PROCESS CONTROL PANEL.

NOTE 10: EXHAUST FAN SHALL RUN CONTINUOUSLY. PROVIDE MANUAL MOTOR STARTER WITH PILOT LIGHT, OVERLOAD UNIT, AND AUXILIARY CONTACT FOR 120 VOLT, SINGLE PHASE MOTOR. REFER TO LINE 660 FOR CONNECTION OF AUXILIARY CONTACT.

NOTE 11: PROVIDE 1-1/4" CONDUIT WITH 4 #3, 1 #8 GROUND TO 480Y/277 VOLT, 3 PHASE, 4 WIRE HEAT TRACE PANEL (DESIGNED BY THERMON OR EQUAL).

NOTE 12: FOR VENTILATION GRAVITY INTAKE AND EXHAUST DAMPERS, CIRCUIT FROM PROCESS CONTROL PANEL.

NOTE 13: FOR HEAT PUMP, CONNECT 120 VOLT CIRCUIT TO OUTDOOR UNIT. CONNECT CIRCUITING FROM OUTDOOR UNIT TO INDOOR UNIT PER MANUFACTURER RECOMMENDATIONS.



URS
8300 College Blvd., Suite 200
Overland Park, Kansas 66210
TEL: 913-344-1000
FAX: 913-344-1011

SHELL OIL PRODUCTS ROXANA, ILLINOIS	Project Number 21562593	Date JUNE 2011
ELECTRICAL DIAGRAM	Checked by ROH	Figure No. E-101

June 6, 2011 2:35:34 pm (rth)
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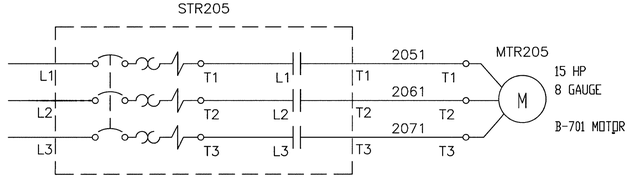
3 PHASE CIRCUIT
FROM 480 VOLT SERVICE
REFER TO ONE-LINE DIAGRAM

B-701
STR205

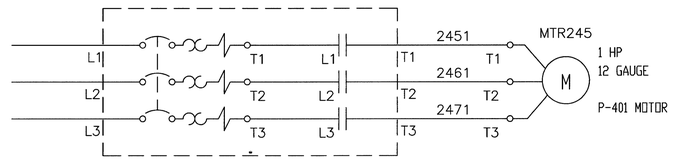


B-701

TERMINALS	
A1 A2	705
13 14	651
33 34	
43 44	
21 22	
97 98	643
17 18OL	705

208 VOLT 3 PHASE CIRCUIT
FROM MINI POWER CENTER
REFER TO ONE-LINE DIAGRAM

P-401
STR245

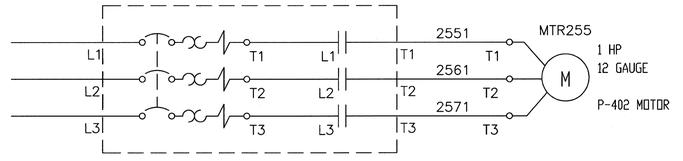


P-401

TERMINALS	
A1 A2	705
13 14	651
33 34	
43 44	
21 22	
97 98	645
17 18OL	705

208 VOLT 3 PHASE CIRCUIT
FROM MINI POWER CENTER
REFER TO ONE-LINE DIAGRAM

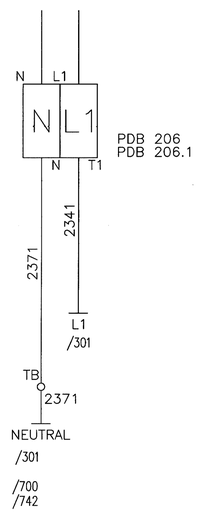
P-402
STR255



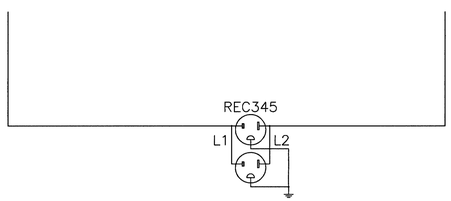
P-402

TERMINALS	
A1 A2	711
13 14	654
33 34	
43 44	
21 22	
97 98	647
17 18OL	711

120 VOLT CIRCUIT
FROM MINI POWER CENTER
REFER TO ONE-LINE DIAGRAM



120 VOLTS FROM MINI POWER CENTER – REFER TO ONE-LINE DIAGRAM



15A GFI RECEPTACLE
MOUNTED ADJACENT TO PANEL

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SHELL OIL PRODUCTS
ROXANA, ILLINOIS

ELECTRICAL DIAGRAM

Project Number	Date
21562593	JUNE 2011
Checked by	Figure No.
ROH	E-102

June 6, 2011 3:31:19 pm (rth)
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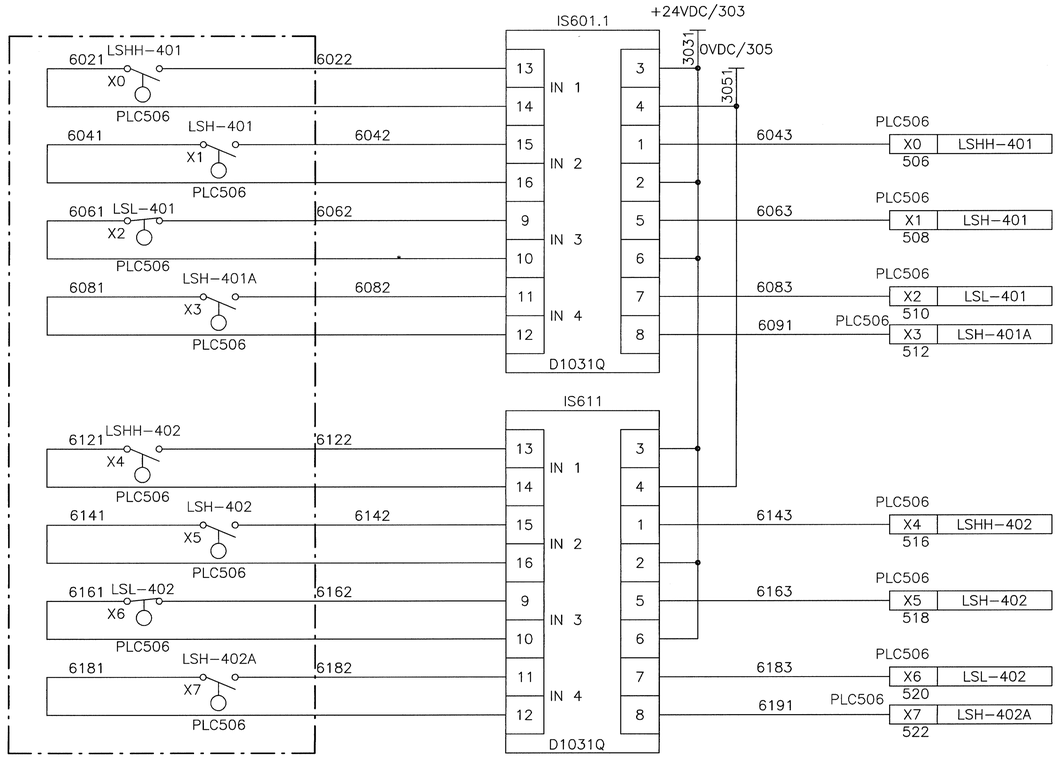

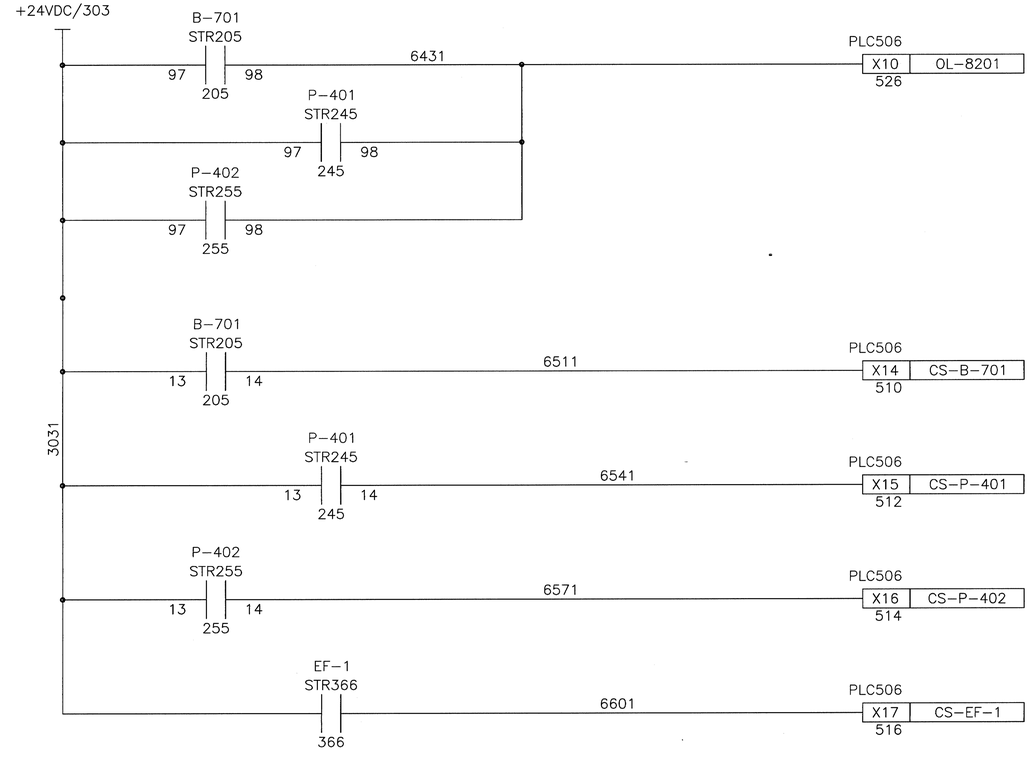

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FAX: 913-344-1011

SHELL OIL PRODUCTS ROXANA, ILLINOIS	Project Number 21562593	Date JUNE 2011
ELECTRICAL DIAGRAM	Checked by ROH	Figure No. E-103

6/6/11

June 6, 2011 2:16:38 pm (rth)
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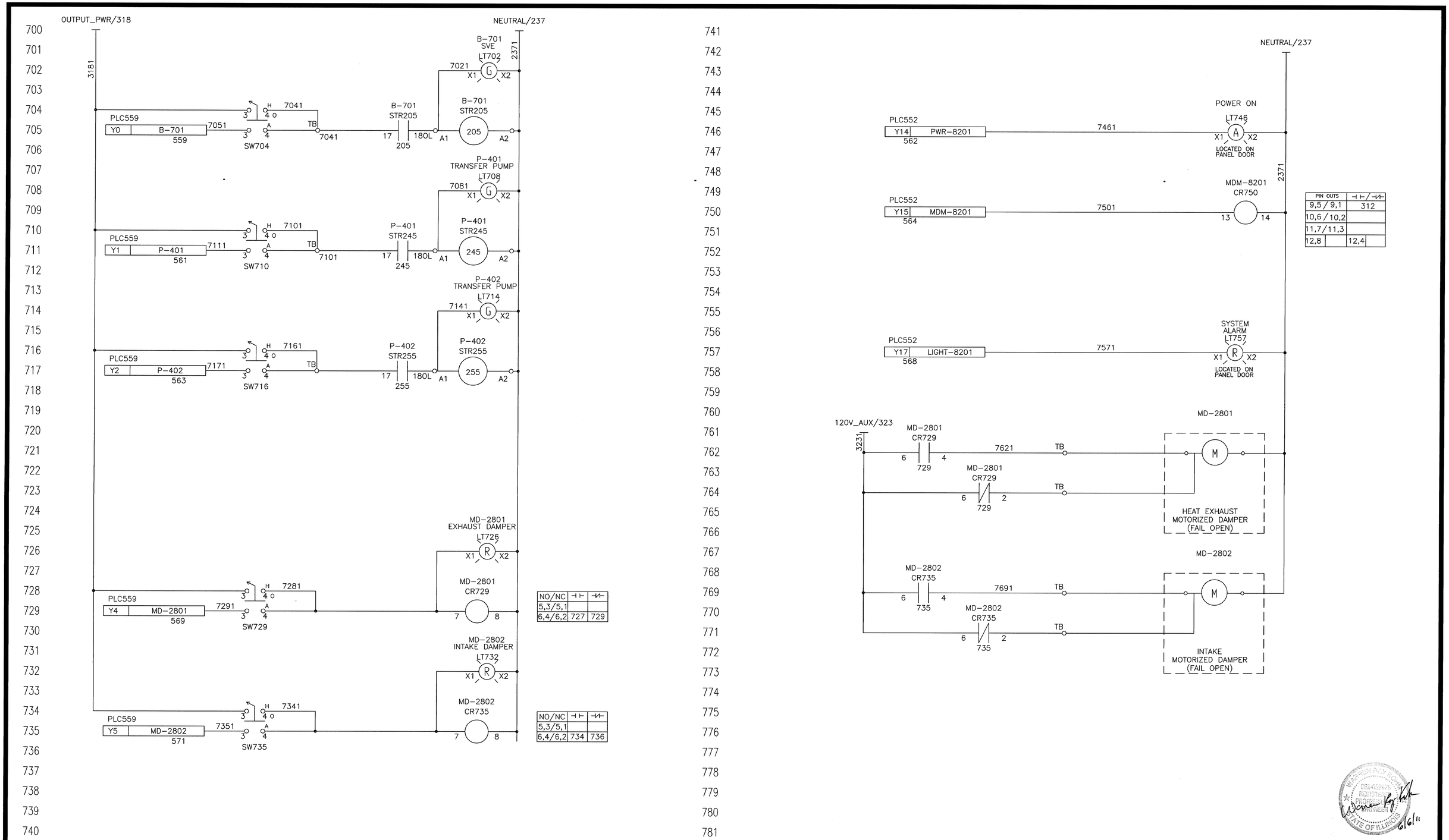

URS 8300 College Blvd., Suite 200 Overland Park, Kansas 66210 TEL: 913-344-1000 FAX: 913-344-1011	SHELL OIL PRODUCTS ROXANA, ILLINOIS	Project Number 21562593	Date JUNE 2011
	ELECTRICAL DIAGRAM	Checked by ROH	Figure No. E-104

June 6, 2011 2:17:11 pm (rth)
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WARNING: INTRINSICALLY SAFE CIRCUIT INSIDE

WARNING : SYSTEM WILL AUTOMATICALLY RESTART AFTER POWER FAILURE

CAUTION: DISCONNECT THE POWER BEFORE OPENING

CAUTION: POWER MAY BE PRESENT WHEN LIGHT IS NOT ON

OP404
MICRO-GRAPHIC

SYSTEM ALARM
R
LT757

POWER ON
A
LT746

B-701 SVE
G
LT702

P-401 TRANSFER PUMP
G
LT708

P-402 TRANSFER PUMP
G
LT714

MD-2801 EXHAUST DAMPER
G
LT726

MD-2802 INTAKE DAMPER
G
LT732

OFF HAND AUTO
SW704

OFF HAND AUTO
SW710

OFF HAND AUTO
SW717

OFF HAND AUTO
SW729

OFF HAND AUTO
SW736

36 X 36

HINGED DOOR

IS601.1 IS611

FDB206

FDB206.1

PLC506

DL06

CR750 CR729 CR735

CB303

PS303

FU303 FU312 FU317 FU322

60W 24Vdc

FU302

MDM425

56K Modem

REC312

INTERIOR PANEL

NOTE 1: NEMA 4 LOCKABLE PANEL

NOTE 2: LIGHTS AND SWITCHES MOUNTED ON FRONT OF PANEL

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SHELL OIL PRODUCTS ROXANA, ILLINOIS	Project Number 21562593	Date JUNE 2011
CONTROL PANEL	Checked by ROH	Figure No. E-105

WARREN RAY KOHL
062-062576
REGISTERED
PROFESSIONAL
ENGINEER
STATE OF ILLINOIS
6/6/11

June 6, 2011 2:17:39 pm (rh)
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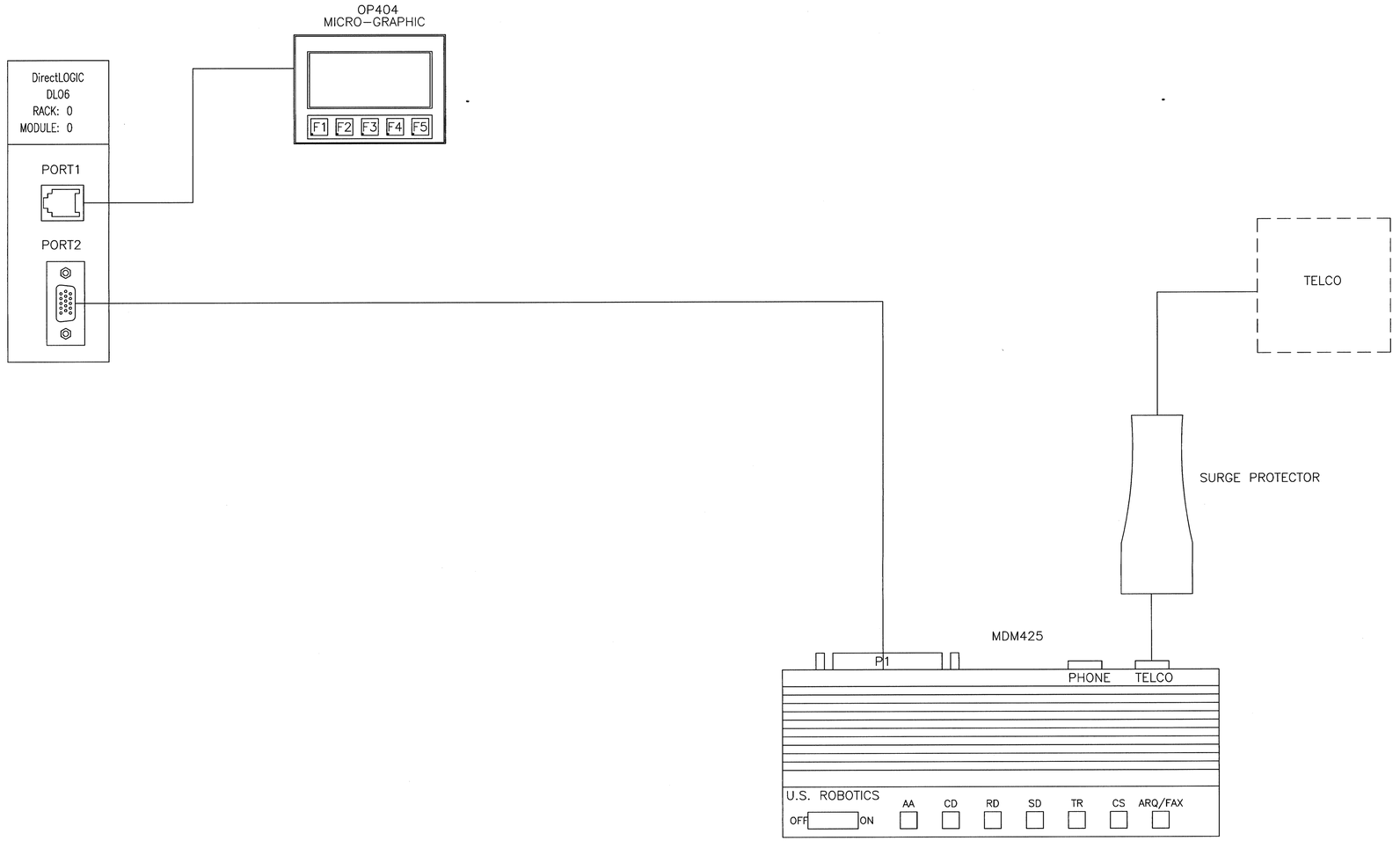

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SHELL OIL PRODUCTS ROXANA, ILLINOIS	Project Number 21562593	Date JUNE 2011
TELEMETRY DIAGRAM	Checked by ROH	Figure No. E-106

June 6, 2011 2:18.32 pm (rth)
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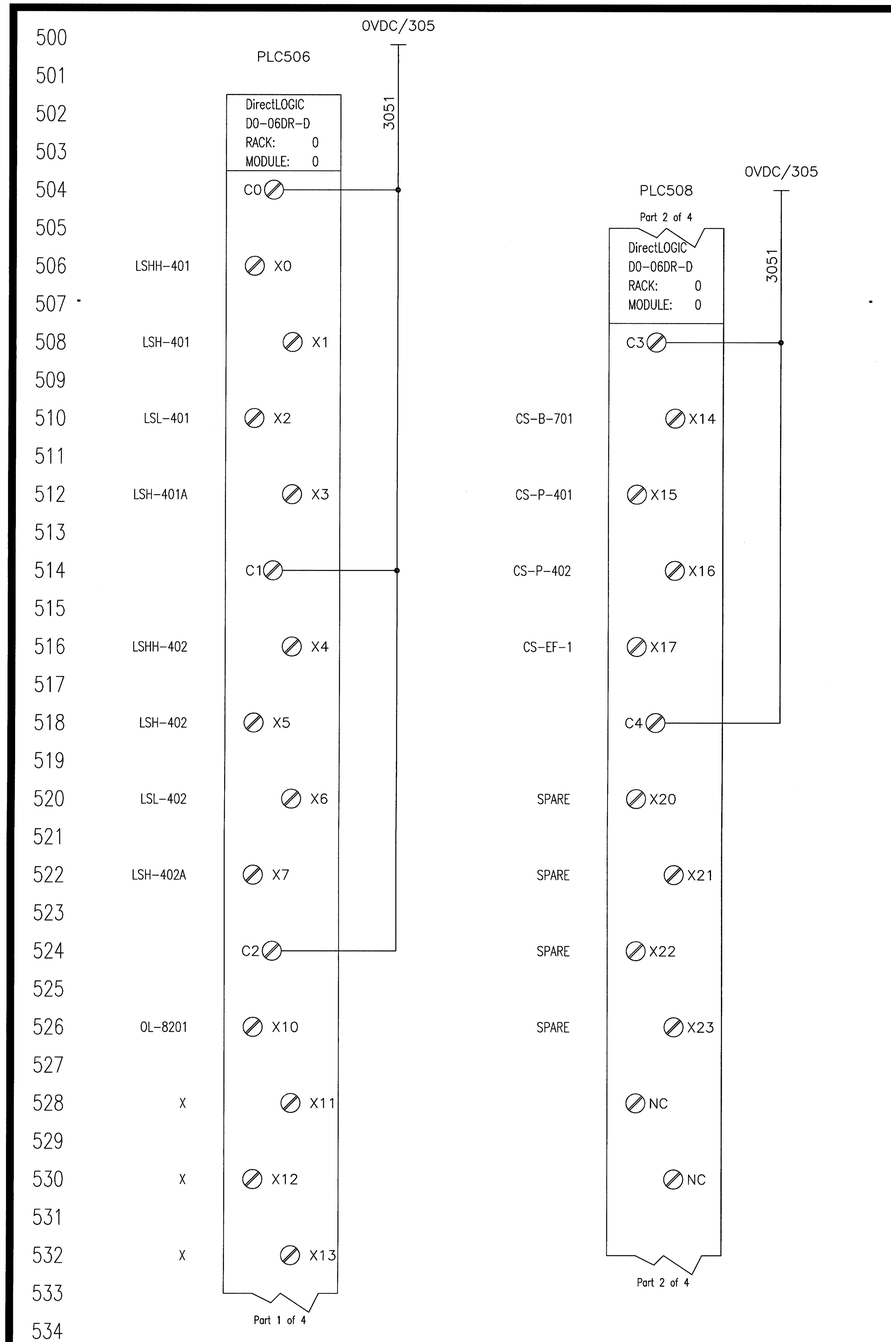

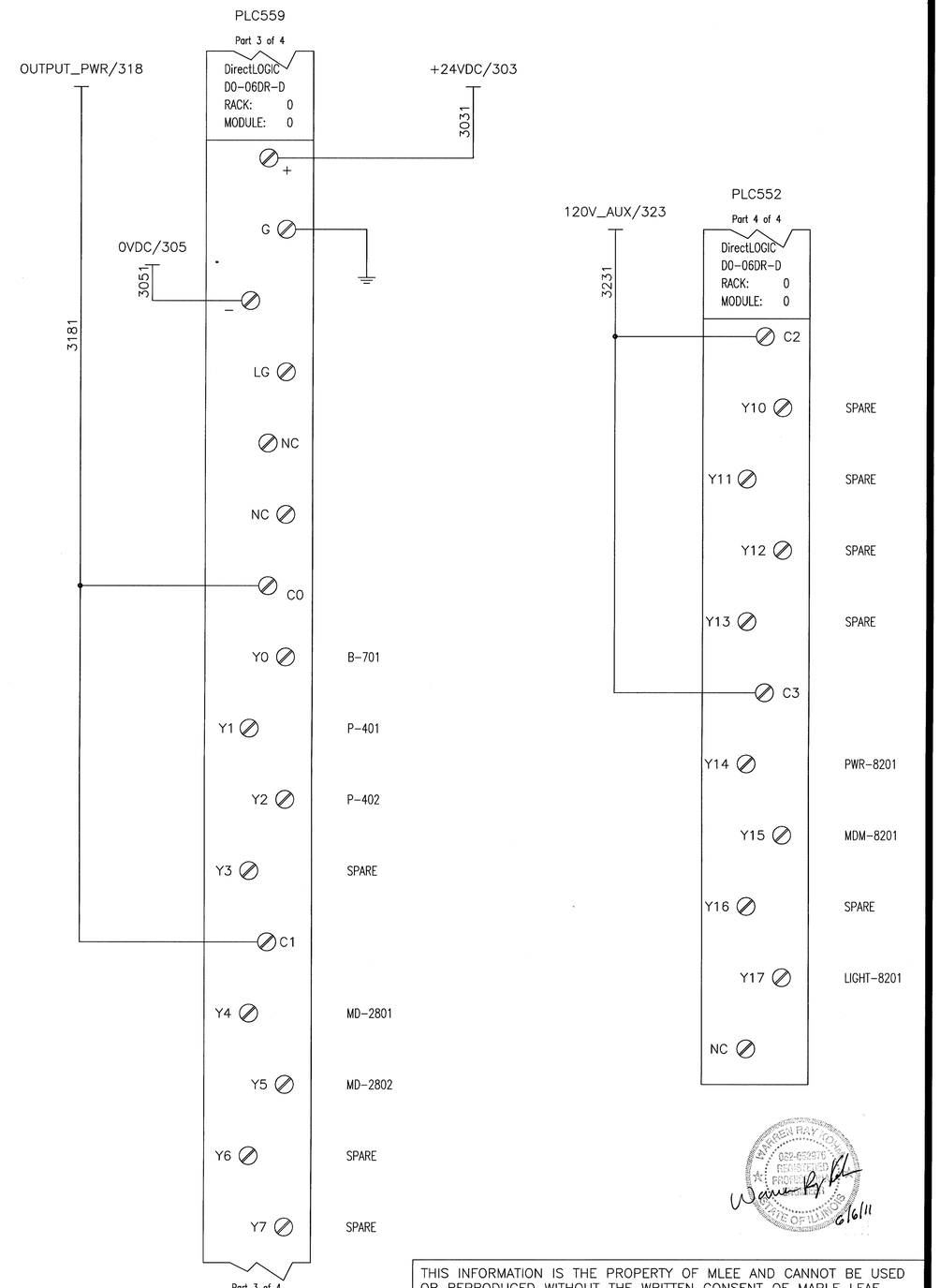

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SHELL OIL PRODUCTS
ROXANA, ILLINOIS

PLC ELECTRICAL DIAGRAM

Project Number	Date
21562593	JUNE 2011
Checked by	Figure No.
ROH	E-107

June 6, 2011 3:23:14 pm (rth)
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APPENDIX D

Air Permit Application

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
DIVISION OF AIR POLLUTION CONTROL -- PERMIT SECTION
P.O. BOX 19506
SPRINGFIELD, ILLINOIS 62794-9506

FEE DETERMINATION FOR CONSTRUCTION PERMIT APPLICATION

FOR AGENCY USE ONLY	
ID NUMBER:	
PERMIT #:	
COMPLETE ☐ INCOMPLETE ☐	DATE COMPLETE:
CHECK #:	ACCOUNT NAME:

THIS FORM IS TO BE USED BY ALL SOURCES TO SUPPLY FEE INFORMATION THAT MUST ACCOMPANY ALL CONSTRUCTION PERMIT APPLICATIONS. ***THIS APPLICATION MUST INCLUDE PAYMENT IN FULL TO BE DEEMED COMPLETE***. MAKE CHECK OR MONEY ORDER PAYABLE TO THE ILLINOIS ENVIRONMENTAL PROTECTION AGENCY. SEND TO THE ADDRESS ABOVE. DO NOT SEND CASH. REFER TO INSTRUCTIONS (197-INST) FOR ASSISTANCE.

SOURCE INFORMATION

1) SOURCE NAME: Soil Vapor Extraction Treatment System with RTO

2) PROJECT NAME: Roxana Site	3) SOURCE ID NO. (IF APPLICABLE):
4) CONTACT NAME: Kevin E. Dyer	5) CONTACT PHONE NUMBER: (618) 288-7237

FEE DETERMINATION

6) FILL IN THE FOLLOWING THREE BOXES AS DETERMINED IN SECTIONS 1 THROUGH 4 BELOW:

$ 5000	+	$ 500	=	$ 5,500
SECTION 1 SUBTOTAL		SECTION 2, 3 OR 4 SUBTOTAL		GRAND TOTAL

SECTION 1: STATUS OF SOURCE / PURPOSE OF SUBMITTAL

7) YOUR APPLICATION WILL FALL UNDER ONLY ONE OF THE FOLLOWING SIX CATEGORIES DESCRIBED BELOW. CHECK THE BOX THAT APPLIES, ENTER THE CORRESPONDING FEE IN THE BOX TO THE RIGHT AND COPY THIS FEE INTO THE SECTION 1 SUBTOTAL BOX ABOVE. PROCEED TO APPLICABLE SECTIONS.

FOR PURPOSES OF THIS FORM:

- ***MAJOR SOURCE*** IS A SOURCE THAT IS REQUIRED TO OBTAIN A CAAPP PERMIT.
- ***SYNTHETIC MINOR* SOURCE** IS A SOURCE THAT HAS TAKEN LIMITS ON POTENTIAL TO EMIT IN A PERMIT TO AVOID CAAPP PERMIT REQUIREMENTS (E.G., FESOP).
- ***NON-MAJOR* SOURCE** IS A SOURCE THAT IS NOT A MAJOR OR SYNTHETIC MINOR SOURCE.

☐ EXISTING SOURCE WITHOUT STATUS CHANGE OR WITH STATUS CHANGE FROM SYNTHETIC MINOR TO MAJOR SOURCE OR VICE VERSA. ENTER $0 AND PROCEED TO SECTION 2.	$ 5000 SECTION 1 SUBTOTAL
☐ EXISTING NON-MAJOR SOURCE THAT WILL BECOME SYNTHETIC MINOR OR MAJOR SOURCE. ENTER $5,000 AND PROCEED TO SECTION 4.	
☐ EXISTING MAJOR OR SYNTHETIC MINOR SOURCE THAT WILL BECOME NON-MAJOR SOURCE. ENTER $4,000 AND PROCEED TO SECTION 3.	
☒ NEW MAJOR OR SYNTHETIC MINOR SOURCE. ENTER $5,000 AND PROCEED TO SECTION 4.	
☐ NEW NON-MAJOR SOURCE. ENTER $500 AND PROCEED TO SECTION 3.	
☐ AGENCY ERROR. IF THIS IS A TIMELY REQUEST TO CORRECT AN ISSUED PERMIT THAT INVOLVES ONLY AN AGENCY ERROR AND IF THE REQUEST IS RECEIVED WITHIN THE DEADLINE FOR A PERMIT APPEAL TO THE POLLUTION CONTROL BOARD, THEN ENTER $0. SKIP SECTIONS 2, 3 AND 4. PROCEED DIRECTLY TO SECTION 5.	

SECTION 2: SPECIAL CASE FILING FEE

8) FILING FEE. IF THE APPLICATION ONLY ADDRESSES ONE OR MORE OF THE FOLLOWING, CHECK THE APPROPRIATE BOXES, ENTER $500 IN THE SECOND BOX UNDER FEE DETERMINATION ABOVE, SKIP SECTIONS 3 AND 4 AND PROCEED DIRECTLY TO SECTION 5. OTHERWISE, PROCEED TO SECTION 3 OR 4, AS APPROPRIATE.

- ☐ ADDITION OR REPLACEMENT OF CONTROL DEVICES ON PERMITTED UNITS
- ☐ PILOT PROJECTS/TRIAL BURNS BY A PERMITTED UNIT
- ☐ APPLICATIONS ONLY INVOLVING INSIGNIFICANT ACTIVITIES UNDER 35 IAC 201.210 (MAJOR SOURCES ONLY)
- ☒ LAND REMEDIATION PROJECTS
- ☐ REVISIONS RELATED TO METHODOLOGY OR TIMING FOR EMISSION TESTING
- ☐ MINOR ADMINISTRATIVE-TYPE CHANGE TO A PERMIT

THIS AGENCY IS AUTHORIZED TO REQUIRE AND YOU MUST DISCLOSE THIS INFORMATION UNDER 415 ILCS 5/39. FAILURE TO DO SO COULD RESULT IN THE APPLICATION BEING DENIED AND PENALTIES UNDER 415 ILCS 5 ET SEQ. IT IS NOT NECESSARY TO USE THIS FORM IN PROVIDING THIS INFORMATION. THIS FORM HAS BEEN APPROVED BY THE FORMS MANAGEMENT CENTER.

APPLICATION PAGE _____

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197-FEE

SECTION 3: FEES FOR CURRENT OR PROJECTED NON-MAJOR SOURCES

9) IF THIS APPLICATION CONSISTS OF A SINGLE NEW EMISSION UNIT OR NO MORE THAN TWO MODIFIED EMISSION UNITS, ENTER $500.	9)
10) IF THIS APPLICATION CONSISTS OF MORE THAN ONE NEW EMISSION UNIT OR MORE THAN TWO MODIFIED UNITS, ENTER $1,000.	10)
11) IF THIS APPLICATION CONSISTS OF A NEW SOURCE OR EMISSION UNIT SUBJECT TO SECTION 39.2 OF THE ACT (I.E., LOCAL SITING REVIEW); A COMMERCIAL INCINERATOR OR A MUNICIPAL WASTE, HAZARDOUS WASTE, OR WASTE TIRE INCINERATOR; A COMMERCIAL POWER GENERATOR; OR AN EMISSION UNIT DESIGNATED AS A COMPLEX SOURCE BY AGENCY RULEMAKING, ENTER $15,000.	11)
12) IF A PUBLIC HEARING IS HELD (SEE INSTRUCTIONS), ENTER $10,000.	12)
13) SECTION 3 SUBTOTAL (ADD LINES 9 THROUGH 12) TO BE ENTERED ON PAGE 1.	13)

SECTION 4: FEES FOR CURRENT OR PROJECTED MAJOR OR SYNTHETIC MINOR SOURCES

Application Contains Modified Emission Units Only	14) FOR THE FIRST MODIFIED EMISSION UNIT, ENTER $2,000.	14)	
	15) NUMBER OF ADDITIONAL MODIFIED EMISSION UNITS = _____ X $1,000.	15)	
	16) LINE 14 PLUS LINE 15, OR $5,000, WHICHEVER IS LESS.		16)
Application Contains New And/Or Modified Emission Units	17) FOR THE FIRST NEW EMISSION UNIT, ENTER $4,000.	17)	
	18) NUMBER OF ADDITIONAL NEW AND/OR MODIFIED EMISSION UNITS = _____ X $1,000.	18)	
	19) LINE 17 PLUS LINE 18, OR $10,000, WHICHEVER IS LESS.		19)
Application Contains Netting Exercise	20) NUMBER OF INDIVIDUAL POLLUTANTS THAT RELY ON A NETTING EXERCISE OR CONTEMPORANEOUS EMISSIONS DECREASE TO AVOID APPLICATION OF PSD OR NONATTAINMENT NSR = _____ X $3,000.		20)
Additional Supplemental Fees	21) IF THE NEW SOURCE OR EMISSION UNIT IS SUBJECT TO SECTION 39.2 OF THE ACT (I.E., SITING); A COMMERCIAL INCINERATOR OR OTHER MUNICIPAL WASTE, HAZARDOUS WASTE, OR WASTE TIRE INCINERATOR; A COMMERCIAL POWER GENERATOR; OR ONE OR MORE OTHER EMISSION UNITS DESIGNATED AS A COMPLEX SOURCE BY AGENCY RULEMAKING, ENTER $25,000.		21)
	22) IF THE SOURCE IS A NEW MAJOR SOURCE SUBJECT TO PSD, ENTER $12,000.		22)
	23) IF THE PROJECT IS A MAJOR MODIFICATION SUBJECT TO PSD, ENTER $6,000.		23)
	24) IF THIS IS A NEW MAJOR SOURCE SUBJECT TO NONATTAINMENT (NAA) NSR, ENTER $20,000.		24)
	25) IF THIS IS A MAJOR MODIFICATION SUBJECT TO NAA NSR, ENTER $12,000.		25)
	26) IF APPLICATION INVOLVES A DETERMINATION OF CLEAN UNIT STATUS AND THEREFORE IS NOT SUBJECT TO BACT OR LAER, ENTER $5,000 PER UNIT FOR WHICH A DETERMINATION IS REQUESTED OR OTHERWISE REQUIRED. _____ X $5,000.		26)
	27) IF APPLICATION INVOLVES A DETERMINATION OF MACT FOR A POLLUTANT AND THE PROJECT IS NOT SUBJECT TO BACT OR LAER FOR THE RELATED POLLUTANT UNDER PSD OR NSR (E.G., VOM FOR ORGANIC HAP), ENTER $5,000 PER UNIT FOR WHICH A DETERMINATION IS REQUESTED OR OTHERWISE REQUIRED. _____ X $5,000.		27)
	28) IF A PUBLIC HEARING IS HELD (SEE INSTRUCTIONS), ENTER $10,000.		28)
29) SECTION 4 SUBTOTAL (ADD LINES 16 AND LINES 19 THROUGH 28) TO BE ENTERED ON PAGE 1.			29)

SECTION 5: CERTIFICATION

NOTE: APPLICATIONS WITHOUT A SIGNED CERTIFICATION WILL BE DEEMED INCOMPLETE.

30) I CERTIFY UNDER PENALTY OF LAW THAT, BASED ON INFORMATION AND BELIEF FORMED AFTER REASONABLE INQUIRY, THE INFORMATION CONTAINED IN THIS FEE APPLICATION FORM IS TRUE, ACCURATE AND COMPLETE.

BY: _____ Principal Project Manager

SIGNATURE — TITLE OF SIGNATORY

Kevin E. Dyer — 6 / 5 / 11

TYPED OR PRINTED NAME OF SIGNATORY — DATE

APPLICATION PAGE _____

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197-FEE

Illinois Environmental Protection Agency
Division Of Air Pollution Control -- Permit Section
P.O. Box 19506
Springfield, Illinois 62794-9506

Construction Permit Application For a FESOP Source (FORM APC628)	For Illinois EPA use only
	BOA ID No.:
	Application No.:
	Date Received:

This form is to be used to supply information to obtain a construction permit for a proposed project involving a Federally Enforceable State Operating Permit (FESOP) or Synthetic Minor source, including construction of a new FESOP source. Other necessary information must accompany this form as discussed in the "General Instructions For Permit Applications," Form APC-201.

Proposed Project

1. Working Name of Proposed Project:
   Soil Vapor Extraction Treatment System
2. Is the project occurring at a source that already has a permit from the Bureau of Air (BOA)?
   ☒ No ☐ Yes If Yes, provide BOA ID Number: __ __ __ __ __ __ __ __ __ __
3. Does this application request a revision to an existing construction permit issued by the BOA?
   ☒ No ☐ Yes If Yes, provide Permit Number: __ __ __ __ __ __ __ __ __ __
4. Does this application request that the new/modified emission units be incorporated into an existing FESOP issued by the BOA?
   ☒ No ☐ Yes If Yes, provide Permit Number: __ __ __ __ __ __ __ __ __ __

Source Information

5. Source name:*
   Soil Vapor Extraction Treatment System
6. Source street address:*
   corner of Chaffer St. & 8th St.

7. City:	8. County:	9. Zip code:
Roxana	Madison	62084

ONLY COMPLETE THE FOLLOWING FOR A SOURCE WITHOUT AN ID NUMBER.

10. Is the source located within city limits? ☒ Yes ☐ No
    If no, provide Township Name:

11. Description of source and product(s) produced:	12. Primary Classification Code of source:
Regenerative Thermal Oxidizer/Treated Soil Vapor	SIC: 4613 or NAICS: __ __ __ __ __ __
13. Latitude (DD:MM:SS.SSSS): TBD	14. Longitude (DD:MM:SS.SSSS): TBD

* If this information different than previous information, then complete a new Form 200-CAAPP to change the source name in initial FESOP application for the source or Form APC-620 for Air Permit Name and/or Ownership Change if the FESOP has been previously issued.

Applicant Information

15. Who is the applicant?	16. All correspondence to: (check one)
☒ Owner ☐ Operator	☒ Owner ☐ Operator ☐ Source
17. Applicant's FEIN:	18. Attention name and/or title for written correspondence:
522074528	Kevin E. Dyer / Principal Program Manager

This Agency is authorized to require and you must disclose this information under 415 ILCS 5/39. Failure to do so could result in the application being denied and penalties under 415 ILCS 5 et seq. It is not necessary to use this form in providing this information. This form has been approved by the forms management center.

Owner Information*		
19. Name: Shell Oil Products US		
20. Address: 17 Junction Dr., PMB 399		
21. City: Glen Carbon	22. State: IL	23. Zip code: 62034

* If this information different than previous information, then complete Form 272-CAAPP for a Request for Ownership Change for CAAPP Permit for an initial FESOP application for the source or Form APC-620 for Air Permit Name and/or Ownership Change if the FESOP has been previously issued.

Operator Information (If Different from Owner)*		
24. Name URS Corporation		
25. Address: 1001 Highlands Plaza Dr., Suite 300		
26. City: St. Louis	27. State: MO	28. Zip code: 63110

* If this information different than previous information, then complete a new Form 200-CAAPP to change the source name in initial FESOP application for the source or Form APC-620 for Air Permit Name and/or Ownership Change if the FESOP has been previously issued.

Technical Contacts for Application	
29. Preferred technical contact: (check one) ☒ Applicant's contact ☐ Consultant	
30. Applicant's technical contact person for application: Ken Hagg	
31. Contact person's telephone number 314-743-4105	32. Contact person's email address: ken_hagg@urscorp.com
33. Applicant's consultant for application: Thomas Adams	
34. Consultant's telephone number: (314) 429-0100	35. Consultant's email address: Thomas_Adams@urscorp.com

Review Of Contents of the Application		
36. Is the emission unit covered by this application already constructed? If "yes", provide the date construction was completed: Note: The Illinois EPA is unable to issue a construction permit for a emission unit that has already been constructed.	☐ Yes	☒ No
37. Does the application include a narrative description of the proposed project?	☒ Yes	☐ No
38. Does the application contain a list or summary that clearly identifies the emission units and air pollution control equipment that are part of the project?	☒ Yes	☐ No
39. Does the application include process flow diagram(s) for the project showing new and modified emission units and control equipment and related existing equipment and their relationships?	☒ Yes	☐ No
40. If the project is at a source that has not previously received a permit from the BOA, does the application include a source description, plot plan and site map?	☒ Yes	☐ No

Review Of Contents of the Application (continued)	
41. Does the application include relevant information for the proposed project as requested on Illinois EPA, BOA application forms (or otherwise contain all the relevant information)?	☒ Yes ☐ No
42. Does the application identify and address all applicable or potentially applicable emissions standards, including: a. State emission standards (35 IAC Chapter I, Subtitle B); b. Federal New Source Performance Standards (40 CFR Part 60); c. Federal standards for HAPs (40 CFR Parts 61 and 63)?	☒ Yes ☐ No
43. Does the application address whether the proposed project or the source could be a major project for Prevention of Significant Deterioration (PSD), 40 CFR 52.21?	☒ Yes ☐ No . ☐ N/A
44. Does the application address for which pollutant(s) the proposed project or the source could be a major project for PSD, 40 CFR 52.21?	☒ Yes ☐ No . ☐ N/A
45. Does the application address whether the proposed project or the source could be a major project for "Nonattainment New Source Review," (NA NSR), 35 IAC Part 203?	☒ Yes ☐ No ☐ N/A
46. Does the application address for which pollutant(s) the proposed project or the source could be a major project for NA NSR, 35 IAC Part 203?	☒ Yes ☐ No ☐ N/A
47. Does the application address whether the proposed project or the source could potentially be subject to federal Maximum Achievable Control Technology (MACT) standard under 40 CFR Part 63 for Hazardous Air Pollutants (HAP) and identify the standard that could be applicable?	☐ Yes ☐ No ☒ N/A* * Source not major ☒ Project not major ☒
48. Does the application identify the HAP(s) from the proposed project or the source that would trigger the applicability of a MACT standard under 40 CFR Part 63?	☐ Yes ☐ No ☒ N/A
49. Does the application include a summary of the current and the future potential emissions of the source after the proposed project has been completed for each criteria air pollutant and/or HAP (tons/year)?	☒ Yes ☐ No ☐ N/A* * Applicability of PSD, NA NSR or 40 CFR 63 not applicable to the source's emissions.
50. Does the application include a summary of the requested permitted annual emissions of the proposed project for the new and modified emission units (tons/year)?	☒ Yes ☐ No ☐ N/A* * Project does not involve an increase in emissions from new or modified emission units.
51. Does the application include a summary of the requested permitted production, throughput, fuel, or raw material usage limits that correspond to the annual emissions limits of the proposed project for the new and modified emission units?	☒ Yes ☐ No ☐ N/A* * Project does not involve an increase in emissions from new or modified emission units.
52. Does the application include sample calculations or methodology for the emission estimations and the requested emission limits?	☒ Yes ☐ No
53. Does the application address the relationships with and implications of the proposed project for the source's FESOP?	☒ Yes ☐ No ☐ N/A* *FESOP not yet issued.
54. If the application contains information that is considered a TRADE SECRET, has such information been properly marked and claimed and other requirements to perfect such a claim been satisfied in accordance with 35 IAC Part 130? Note: "Claimed information will not be legally protected from disclosure to the public if it is not properly claimed or does not qualify as trade secret information.	☐ Yes ☐ No ☒ N/A* * No information in the application is claimed to be a TRADE SECRET

Review Of Contents of the Application (continued)		
55. If the source is located in a county other than Cook County, are two separate copies of this application being submitted?	☒ Yes	☐ No
56. If the source is located in Cook County, are three separate copies of this application being submitted?	☐ Yes	☒ No
57. Does the application include a completed "FEE DETERMINATION FOR CONSTRUCTION PERMIT APPLICATION," Form 197-FEE, for the emission units and control equipment for which a permit for construction or modification is being sought?	☒ Yes	☐ No
58. Does the application include a check in the proper amount for payment of the Construction permit fee?	☒ Yes	☐ No

Note: Answering "No" to Items 36 through 58 may result in the application being deemed incomplete.

Signature Block

Pursuant to 35 IAC 201.159, all applications and supplements thereto shall be signed by the owner and operator of the source, or their authorized agent, and shall be accompanied by evidence of authority to sign the application. Applications without a signed certification will be deemed incomplete.

59. Authorized Signature:

I certify under penalty of law that, based on information and belief formed after reasonable inquiry, the statements and information contained in this application are true, accurate and complete and that I am a responsible official for the source, as defined by Section 39.5(1) of the Environmental Protection Act. In addition, the technical contact person identified above is authorized to submit (by hard copy and/or by electronic copy) any supplemental information related to this application that may be requested by the Illinois EPA.

BY: _____ Principal Program Manager

AUTHORIZED SIGNATURE — TITLE OF SIGNATORY

Kevin E. Dyer — 6 5 11

TYPED OR PRINTED NAME OF SIGNATORY — DATE

STATE OF ILLINOIS
ENVIRONMENTAL PROTECTION AGENCY
DIVISION OF AIR POLLUTION CONTROL
PERMIT SECTION
P. O. BOX 19506
SPRINGFIELD, ILLINOIS 62794-9506

This Agency is authorized to require and you must disclose this information under 415 ILCS 5/39. Failure to do so could result in the application being denied and penalties under 415 ILCS 5 et seq. It is not necessary to use this form in providing this information. This form has been approved by the forms management center.

APPLICATION FOR PERMIT (A)

☒ CONSTRUCT ☒ OPERATE

NAME OF EQUIPMENT TO BE CONSTRUCTED OR OPERATED: Soil Vapor Extraction Treatment System (B)

FOR AGENCY USE ONLY

I.D. NO. _____

PERMIT NO. _____

DATE _____

NOTE: THIS APPLICATION FORM IS ONLY FOR SOURCES NOT REQUIRED TO OBTAIN A FESOP OR CAAPP PERMIT PURSUANT SECTION 39.5 OF THE ILLINOIS ENVIRONMENTAL PROTECTION ACT.

1a. NAME OF OWNER: Shell Oil Products US		2a. NAME OF OPERATOR: URS Corporation	
1b. STREET ADDRESS OF OWNER: 17 Junction Dr., PMB 399		2b. STREET ADDRESS OF OPERATOR: 1001 Highlands Plaza Dr. West, Suite 300	
1c. CITY OF OWNER: Glenn Carbon		2c. CITY OF OPERATOR: St. Louis	
1d. STATE OF OWNER: IL	1e. ZIP CODE: 62034	2d. STATE OF OPERATOR: MO	2e. ZIP CODE: 62084

3a. NAME OF CORPORATE DIVISION OR PLANT: Not Applicable		3b. STREET ADDRESS OF EMISSION SOURCE: corner of Chaffer St. and 8th St.		
3c. CITY OF EMISSION SOURCE: Roxana	3d. LOCATED WITHIN CITY LIMITS: ☒ YES ☐ NO	3e. TOWNSHIP: WoodRiver	3f. COUNTY: Madison	3g. ZIP CODE: 62048

4. ALL CORRESPONDENCE TO: (TITLE AND/OR NAME OF INDIVIDUAL) Kevin E. Dyer	5. YOUR DESIGNATION FOR THIS APPLICATION: (C) Roxana Site
6. ADDRESS FOR CORRESPONDENCE: (CHECK ONLY ONE) ☒ OWNER ☐ OPERATOR ☐ EMISSION SOURCE	7. WHO IS THE PERMIT APPLICANT? ☒ OWNER ☐ OPERATOR

8. THE UNDERSIGNED HEREBY MAKES APPLICATION FOR A PERMIT AND CERTIFIES THAT THE STATEMENTS CONTAINED HEREIN ARE TRUE AND CORRECT, AND FURTHER CERTIFIES THAT ALL PREVIOUSLY SUBMITTED INFORMATION REFERENCED IN THIS APPLICATION REMAINS TRUE, CORRECT AND CURRENT. BY AFFIXING HIS/HER SIGNATURE HERETO THE UNDERSIGNED FURTHER CERTIFIES THAT HE/SHE IS AUTHORIZED TO EXECUTE THIS APPLICATION.

AUTHORIZED SIGNATURE(S): (D)

BY [signature] 4/5/14 BY _____ _____

SIGNATURE — DATE — SIGNATURE — DATE

Kevin E. Dyer
TYPED OR PRINTED NAME OF SIGNER

Principal Program Manager
TITLE OF SIGNER

TYPED OR PRINTED NAME OF SIGNER

TITLE OF SIGNER

(A) THIS FORM IS TO PROVIDE THE ILLINOIS EPA WITH GENERAL INFORMATION ABOUT THE EQUIPMENT TO BE CONSTRUCTED OR OPERATED. THIS FORM MAY BE USED TO REQUEST A CONSTRUCTION PERMIT, AN OPERATING PERMIT, OR A JOINT CONSTRUCTION AND OPERATING PERMIT.

(B) ENTER THE GENERIC NAME OF THE EQUIPMENT TO BE CONSTRUCTED OR OPERATED. THIS NAME WILL APPEAR ON THE PERMIT WHICH MAY BE ISSUED PURSUANT TO THIS APPLICATION. THIS FORM MUST BE ACCOMPANIED BY OTHER APPLICABLE FORMS AND INFORMATION.

(C) PROVIDE A DESIGNATION IN ITEM 5 ABOVE WHICH YOU WOULD LIKE THE ILLINOIS EPA TO USE FOR IDENTIFICATION OF YOUR EQUIPMENT. YOUR DESIGNATION WILL BE REFERENCED IN CORRESPONDENCE FROM THIS AGENCY RELATIVE TO THIS APPLICATION. YOUR DESIGNATION MUST NOT EXCEED TEN (10) CHARACTERS. *(OPTIONAL)*

(D) THIS APPLICATION MUST BE SIGNED IN ACCORDANCE WITH 35 ILL. ADM. CODE 201.154 OR 201.159 WHICH STATES: "ALL APPLICATIONS AND SUPPLEMENTS THERETO SHALL BE SIGNED BY THE OWNER AND OPERATOR OF THE EMISSION SOURCE OR AIR POLLUTION CONTROL EQUIPMENT, OR THEIR AUTHORIZED AGENT, AND SHALL BE ACCOMPANIED BY EVIDENCE OF AUTHORITY TO SIGN THE APPLICATION."

IF THE OWNER OR OPERATOR IS A CORPORATION, SUCH CORPORATION MUST HAVE ON FILE WITH THE ILLINOIS EPA A CERTIFIED COPY OF A RESOLUTION OF THE CORPORATION'S BOARD OF DIRECTORS AUTHORIZING THE PERSONS SIGNING THIS APPLICATION TO CAUSE OR ALLOW THE CONSTRUCTION OR OPERATION OF THE EQUIPMENT TO BE COVERED BY THE PERMIT.

BILLING INFORMATION		10. CONTACT PERSON FOR APPLICATION: Ken Hagg	
9a. COMPANY NAME: Same as owner		11. CONTACT PERSON'S TELEPHONE NUMBER: (314) 429-0100	
9b. STREET ADDRESS:		12. CONTACT PERSON'S FACSIMILE NUMBER: (314) 429-0462	
9c. CITY:		13. FEDERAL EMPLOYER IDENTIFICATION NUMBER (FEIN): 522074528	
9d. STATE:	9f. BILLING CONTACT PERSON:	14. PRIMARY STANDARD INDUSTRIAL CLASSIFICATION (SIC) CATEGORY: Refined Petroleum Pipeline	
9e. ZIP CODE:	9g. CONTACT TELEPHONE NO.:	15. PRIMARY SIC NUMBER: 4613	16. TAXPAYER IDENTIFICATION NUMBER (TIN): 52-2074528

17. DOES THIS APPLICATION CONTAIN FORM 197-FEE, "CONSTRUCTION PERMIT APPLICATION FEE DETERMINATION?"
☒ YES ☐ NO

18. DOES THE APPLICATION CONTAIN A PLOT PLAN/MAP?
☒ YES ☐ NO
IF THE PLOT PLAN/MAP HAS PREVIOUSLY BEEN SUBMITTED, SPECIFY:
I. D. NO.: APPLICATION NUMBER
IS THE APPROXIMATE SIZE OF APPLICANT'S PREMISES LESS THAN 1 ACRE?
☒ YES ☐ NO IF "NO", SPECIFY _____ ACRES

19. DOES THE APPLICATION CONTAIN A PROCESS FLOW DIAGRAM(S) THAT ACCURATELY AND CLEARLY REPRESENTS CURRENT PRACTICE? ☒ YES ☐ NO

20. IS THE EMISSION UNIT COVERED BY THIS APPLICATION ALREADY CONSTRUCTED? ☐ YES ☒ NO
IF "YES", PROVIDE THE DATE CONSTRUCTION WAS COMPLETED:

21. IF THIS APPLICATION INCORPORATES BY REFERENCE A PREVIOUSLY GRANTED PERMIT(S), HAS FORM APC-210, "DATA AND INFORMATION-INCORPORATION BY REFERENCE" BEEN SUBMITTED? ☐ YES ☒ NO

APPLICATION FOR OPERATING PERMIT ONLY

22. DOES THE STARTUP OF AN EMISSION UNIT COVERED BY THIS APPLICATION PRODUCE AIR CONTAMINANT EMISSIONS IN EXCESS OF APPLICABLE STANDARDS?
☐ YES ☒ NO
IF "YES", HAS FORM APC-203, "OPERATION DURING STARTUP" BEEN COMPLETED FOR THIS UNIT?
☐ YES ☐ NO

23. DOES THIS APPLICATION REQUEST PERMISSION TO OPERATE AN EMISSION UNIT DURING MALFUNCTIONS OR BREAKDOWNS?
☐ YES ☒ NO
IF "YES", HAS FORM APC-204, "OPERATION DURING MALFUNCTION AND BREAKDOWN" BEEN COMPLETED FOR THIS UNIT?
☐ YES ☐ NO

24. IS AN EMISSION UNIT COVERED BY THIS APPLICATION SUBJECT TO A FUTURE COMPLIANCE DATE?
☐ YES ☒ NO
IF "YES", HAS FORM APC-202, "COMPLIANCE PROGRAM & PROJECT COMPLETION SCHEDULE" BEEN COMPLETED FOR THIS UNIT?
☐ YES ☐ NO

25. DOES THE SOURCE COVERED BY THIS APPLICATION REQUIRE AN EPISODE ACTION PLAN (REFER TO GUIDELINES FOR EPISODE ACTION PLANS)?
☐ YES ☒ NO

26. LIST AND IDENTIFY ALL FORMS, EXHIBITS, AND OTHER INFORMATION SUBMITTED AS PART OF THIS APPLICATION. INCLUDE THE PAGE NUMBERS OF EACH ITEM (ATTACH ADDITIONAL SHEETS IF NECESSARY):

197-FEE	Pages 1-2	Figure 1	Page 28
APC Form 628	Pages 3-6	Figure 2	Page 29
APC Form 200	Pages 7-8	Attachment A (Emission Reprot Summary)	Pages 30-32
APC Form 220 - RTO	Pages 9-11		
APC Form 260	Pages 12-17		
APC Form 220 - Tank	Page 18-20		
APC Form 232	Page 21-22		
Exhibit 260-1	Page 23-24		
Anguil Spec Sheet	Page 25-26		
Tank Spec Sheet	Page 27		

TOTAL NUMBER OF PAGES 32

STATE OF ILLINOIS
ENVIRONMENTAL PROTECTION AGENCY
DIVISION OF AIR POLLUTION CONTROL
1021 NORTH GRAND AVENUE, EAST
SPRINGFIELD, ILLINOIS 62702

* DATA AND INFORMATION PROCESS EMISSION SOURCE	

* THIS INFORMATION FORM IS TO BE COMPLETED FOR AN EMISSION SOURCE OTHER THAN A FUEL COMBUSTION EMISSION SOURCE OR AN INCINERATOR. A FUEL COMBUSTION EMISSION SOURCE IS A FURNACE, BOILER, OR SIMILAR EQUIPMENT USED PRIMARILY FOR PRODUCING HEAT OR POWER BY INDIRECT HEAT TRANSFER. AN INCINERATOR IS AN APPARATUS IN WHICH REFUSE IS BURNED.

1. NAME OF PLANT OWNER: Shell Oil Products US	2. NAME OF CORPORATE DIVISION OR PLANT (IF DIFFERENT FROM OWNER):
3. STREET ADDRESS OF EMISSION SOURCE: corner of Chaffer St. & 8th St.	4. CITY OF EMISSION SOURCE: Roxana

GENERAL INFORMATION		
5. NAME OF PROCESS: Soil Vapor Extraction System	6. NAME OF EMISSION SOURCE EQUIPMENT: Regenerative Thermal Oxidizer	
7. EMISSION SOURCE EQUIPMENT MANUFACTURER: Anguil Environmental Services, Inc.	8. MODEL NUMBER: RTO 100	9. SERIAL NUMBER:
10. FLOW DIAGRAM DESIGNATION(S) OF EMISSION SOURCE: Regenerative Thermal Oxidizer		
11. IDENTITY(S) OF ANY SIMILAR SOURCE(S) AT THE PLANT OR PREMISES NOT COVERED BY THE FORM (IF THE SOURCE IS COVERED BY ANOTHER APPLICATION, IDENTIFY THE APPLICATION):		
12. AVERAGE OPERATING TIME OF EMISSION SOURCE: 24 HRS/DAY 7 DAYS/WK 52 WKS/YR	13. MAXIMUM OPERATING TIME OF EMISSION SOURCE: 24 HRS/DAY 7 DAYS/WK 52 WKS/YR	
14. PERCENT OF ANNUAL THROUGHPUT: DEC-FEB 25 % MAR-MAY 25 % JUN-AUG 25 % SEPT-NOV 25 %		

INSTRUCTIONS
1. COMPLETE THE ABOVE IDENTIFICATION AND GENERAL INFORMATION SECTION. 2. COMPLETE THE RAW MATERIAL, PRODUCT, WASTE MATERIAL, AND FUEL USAGE SECTIONS FOR THE PARTICULAR SOURCE EQUIPMENT. COMPOSITIONS OF MATERIALS MUST BE SUFFICIENTLY DETAILED TO ALLOW DETERMINATION OF THE NATURE AND QUANTITY OF POTENTIAL EMISSIONS. IN PARTICULAR, THE COMPOSITION OF PAINTS, INKS, ETC., AND ANY SOLVENTS MUST BE FULLY DETAILED. 3. EMISSION AND EXHAUST POINT INFORMATION MUST BE COMPLETED, UNLESS EMISSIONS ARE EXHAUSTED THROUGH AIR POLLUTION CONTROL EQUIPMENT. 4. OPERATION TIME AND CERTAIN OTHER ITEMS REQUIRE BOTH AVERAGE AND MAXIMUM VALUES 5. FOR GENERAL INFORMATION REFER TO "GENERAL INSTRUCTIONS FOR PERMIT APPLICATIONS," APC-201.

DEFINITIONS
AVERAGE - THE VALUE THAT SUMMARIZES OR REPRESENTS THE GENERAL CONDITION OF THE EMISSION SOURCE, OR THE GENERAL STATE OF PRODUCTION OF THE EMISSION SOURCE. SPECIFICALLY: AVERAGE OPERATING TIME - ACTUAL TOTAL HOURS OF OPERATION FOR THE PRECEDING TWELVE MONTH PERIOD. AVERAGE RATE - ACTUAL TOTAL QUANTITY OF "MATERIAL" FOR THE PRECEDING TWELVE MONTH PERIOD, DIVIDED BY THE AVERAGE OPERATING TIME. AVERAGE OPERATION - OPERATION TYPICAL OF THE PRECEDING TWELVE MONTH PERIOD, AS REPRESENTED BY AVERAGE OPERATING TIME AND AVERAGE RATES. MAXIMUM - THE GREATEST VALUE ATTAINABLE OR ATTAINED FOR THE EMISSION SOURCE, OR THE PERIOD OF GREATEST OR UTMOST PRODUCTION OF THE EMISSION SOURCE. SPECIFICALLY: MAXIMUM OPERATING TIME - GREATEST EXPECTED TOTAL HOURS OF OPERATIONS FOR ANY TWELVE MONTH PERIOD. MAXIMUM RATE - GREATEST QUANTITY OF "MATERIAL" EXPECTED PER ANY ONE HOUR OF OPERATION. MAXIMUM OPERATION - GREATEST EXPECTED OPERATION, AS REPRESENTED BY MAXIMUM OPERATING TIME AND MAXIMUM RATES.

This Agency is authorized to require this information under Illinois Revised Statutes, 1979, Chapter 111 1/2, Section 1039. Disclosure of this information is required under that Section. Failure to do so may prevent this form from being processed and could result in your application being denied. This form has been approved by the Forms Management Center.

RAW MATERIAL INFORMATION		
NAME OF RAW MATERIAL	AVERAGE RATE PER IDENTICAL SOURCE	MAXIMUM RATE PER IDENTICAL SOURCE
20a. Contaminated soil vapor at 2500 cfm	b. LB/HR	c. LB/HR
21a.	b. LB/HR	c. LB/HR
22a.	b. LB/HR	c. LB/HR
23a.	b. LB/HR	c. LB/HR
24a.	b. LB/HR	c. LB/HR

PRODUCT INFORMATION		
NAME OF PRODUCT	AVERAGE RATE PER IDENTICAL SOURCE	MAXIMUM RATE PER IDENTICAL SOURCE
30a. Treated soil vapor	b. LB/HR	c. LB/HR
31a.	b. LB/HR	c. LB/HR
32a.	b. LB/HR	c. LB/HR
33a.	b. LB/HR	c. LB/HR
34a.	b. LB/HR	c. LB/HR

WASTE MATERIAL INFORMATION		
NAME OF WASTE MATERIAL	AVERAGE RATE PER IDENTICAL SOURCE	MAXIMUM RATE PER IDENTICAL SOURCE
40a. None	b. LB/HR	c. LB/HR
41a.	b. LB/HR	c. LB/HR
42a.	b. LB/HR	c. LB/HR
43a.	b. LB/HR	c. LB/HR
44a.	b. LB/HR	c. LB/HR

*FUEL USAGE INFORMATION			
FUEL USED		TYPE	HEAT CONTENT
50a. NATURAL GAS	☐	b. ----------	c. 1000 BTU/SCF
OTHER GAS	☒	natural gas	1050 BTU/SCF
OIL	☐		BTU/GAL
COAL	☐		BTU/LB
OTHER	☐		BTU/LB

d. AVERAGE FIRING RATE PER IDENTICAL SOURCE: BTU/HR	e. MAXIMUM FIRING RATE PER IDENTICAL SOURCE: BTU/HR

*THIS SECTION IS TO BE COMPLETED FOR ANY FUEL USED DIRECTLY IN THE PROCESS EMISSION SOURCE, E. G. GAS IN A DRYER, OR COAL IN A MELT FURNACE.

*EMISSION INFORMATION

51. NUMBER OF IDENTICAL SOURCES (DESCRIBE AS REQUIRED):

AVERAGE OPERATION

CONTAMINANT	CONCENTRATION OR EMISSION RATE PER IDENTICAL SOURCE		METHOD USED TO DETERMINE CONCENTRATION OR EMISSION RATE
PARTICULATE MATTER	52a. GR/SCF	b. 0.12 LB/HR	c. (see APC form 260)
CARBON MONOXIDE	53a. PPM (VOL)	b. 0.01 LB/HR	c. (see APC form 260)
NITROGEN OXIDES	54a. PPM (VOL)	b. 0.14 LB/HR	c. (see APC form 260)
ORGANIC MATERIAL	55a. PPM (VOL)	b. LB/HR	c.
SULFUR DIOXIDE	56a. PPM (VOL)	b. 0.84 LB/HR	c. (see APC form 260)
**OTHER (SPECIFY)	57a. PPM (VOL)	b. 3.50 LB/HR	c. HAPS (see APC form 260)

MAXIMUM OPERATION

CONTAMINANT	CONCENTRATION OR EMISSION RATE PER IDENTICAL SOURCE		METHOD USED TO DETERMINE CONCENTRATION OR EMISSION RATE
PARTICULATE MATTER	58a. GR/SCF	b. 0.12 LB/HR	c. (see APC form 260)
CARBON MONOXIDE	59a. PPM (VOL)	b. 0.01 LB/HR	c. (see APC form 260)
NITROGEN OXIDES	60a. PPM (VOL)	b. 0.14 LB/HR	c. (see APC form 260)
ORGANIC MATERIAL	61a. PPM (VOL)	b. LB/HR	c.
SULFUR DIOXIDE	62a. PPM (VOL)	b. 0.84 LB/HR	c. (see APC form 260)
**OTHER (SPECIFY)	63a. PPM (VOL)	b. 3.50 LB/HR	c. HAPS (see APC form 260)

*ITEMS 52 THROUGH 63 NEED NOT BE COMPLETED IF EMISSIONS ARE EXHAUSTED THROUGH AIR POLLUTION CONTROL EQUIPMENT.
**"OTHER" CONTAMINANT SHOULD BE USED FOR AN AIR CONTAMINANT NOT SPECIFICALLY NAMED ABOVE. POSSIBLE OTHER CONTAMINANTS ARE ASBESTOS, BERYLLIUM, MERCURY, VINYL CHLORIDE, LEAD, ETC.

***EXHAUST POINT INFORMATION

64. FLOW DIAGRAM DESIGNATION(S) OF EXHAUST POINT:

65. DESCRIPTION OF EXHAUST POINT (LOCATION IN RELATION TO BUILDINGS, DIRECTION, HOODING, ETC.):
22" vertical carbon steel/aluminized steel air stack from top of enclosure

66. EXIT HEIGHT ABOVE GRADE: 30ft.	67. EXIT DIAMETER: 22in.
68. GREATEST HEIGHT OF NEARBY BUILDINGS: 12ft.	69. EXIT DISTANCE FROM NEAREST PLANT BOUNDARY: <100ft.

AVERAGE OPERATION	MAXIMUM OPERATION
70. EXIT GAS TEMPERATURE: 200 °F	72. EXIT GAS TEMPERATURE: 200 °F
71. GAS FLOW RATE THROUGH EACH EXIT: 10000 ACFM	73. GAS FLOW RATE THROUGH EACH EXIT: 10000 ACFM

***THIS SECTION SHOULD NOT BE COMPLETED IF EMISSIONS ARE EXHAUSTED THROUGH AIR POLLUTION CONTROL EQUIPMENT.

STATE OF ILLINOIS
ENVIRONMENTAL PROTECTION AGENCY
DIVISION OF AIR POLLUTION CONTROL
1021 NORTH GRAND AVENUE, EAST
SPRINGFIELD, ILLINOIS 62702

* DATA AND INFORMATION AIR POLLUTION CONTROL EQUIPMENT	

* THIS INFORMATION FORM IS TO BE COMPLETED FOR AN EMISSION SOURCE OTHER THAN A FUEL COMBUSTION EMISSION SOURCE OR AN INCINERATOR. A FUEL COMBUSTION EMISSION SOURCE IS A FURNACE, BOILER, OR SIMILAR EQUIPMENT USED PRIMARILY FOR PRODUCING HEAT OR POWER BY INDIRECT HEAT TRANSFER. AN INCINERATOR IS AN APPARATUS IN WHICH REFUSE IS BURNED.

1. NAME OF OWNER: Shell Oil Products US	2. NAME OF CORPORATE DIVISION OR PLANT (IF DIFFERENT FROM OWNER): Not Applicable
3. STREET ADDRESS OF CONTROL EQUIPMENT: corner of Chaffer St. and 8th St.	4. CITY OF CONTROL EQUIPMENT Roxana
5. NAME OF CONTROL EQUIPMENT OR CONTROL SYSTEM: Soil Vapor Extraction/Treatment System with Regenerative Thermal Oxidizer	

INSTRUCTIONS

1. COMPLETE THE ABOVE IDENTIFICATION SECTION.
2. COMPLETE THE APPROPRIATE SECTION FOR THE UNIT OF CONTROL EQUIPMENT, OR THE APPROPRIATE SECTIONS FOR THE CONTROL SYSTEM. BE CERTAIN THAT THE ARRANGEMENT OF VARIOUS UNITS IN A CONTROL SYSTEM IS MADE CLEAR IN THE PROCESS FLOW DIAGRAM.
3. COMPLETE PAGE 6 OF THIS FORM, EMISSION INFORMATION AND EXHAUST POINT INFORMATION.
4. EFFICIENCY VALUES SHOULD BE SUPPORTED WITH A DETAILED EXPLANATION OF THE METHOD OF CALCULATION, THE MANNER OF ESTIMATION, OR THE SOURCE OF INFORMATION. REFERENCE TO THIS FORM ANY RELEVANT INFORMATION OR EXPLANATION INCLUDED IN THIS PERMIT APPLICATION.
5. EFFICIENCY VALUES AND CERTAIN OTHER ITEMS OF INFORMATION ARE TO BE GIVEN FOR AVERAGE AND MAXIMUM OPERATION OR THE SOURCE EQUIPMENT. FOR EXAMPLE, "MAXIMUM EFFICIENCY" IS THE EFFICIENCY OF THE CONTROL EQUIPMENT WHEN THE SOURCE IS AT MAXIMUM OPERATION, AND "AVERAGE FLOW RATE" IS THE FLOW RATE INTO HE CONTROL EQUIPMENT WHEN THE SOURCE IS AT AVERAGE OPERATION.
6. FOR GENERAL INFORMATION REFER TO "GENERAL INSTRUCTIONS FOR PERMIT APPLICATIONS," APC-201.

DEFINITIONS

AVERAGE - THE VALUE THAT SUMMARIZES OR REPRESENTS THE GENERAL CONDITION OF THE EMISSION SOURCE, OR THE GENERAL STATE OF PRODUCTION OF THE EMISSION SOURCE. SPECIFICALLY:
AVERAGE OPERATION - OPERATION TYPICAL OF THE PRECEDING TWELVE MONTH PERIOD, AS REPRESENTED BY AVERAGE OPERATING TIME AND AVERAGE RATES.

MAXIMUM - THE GREATEST VALUE ATTAINABLE OR ATTAINED FOR THE EMISSION SOURCE, OR THE PERIOD OF GREATEST OR UTMOST PRODUCTION OF THE EMISSION SOURCE. SPECIFICALLY:
MAXIMUM OPERATION - GREATEST EXPECTED OPERATION, AS REPRESENTED BY MAXIMUM OPERATING TIME AND MAXIMUM RATES.

This Agency is authorized to require this information under Illinois Revised Statutes, 1979, Chapter 111 1/2, Section 1039. Disclosure of this information is required under that Section. Failure to do so may prevent this form from being processed and could result in your application being denied. This form has been approved by the Forms Management Center.

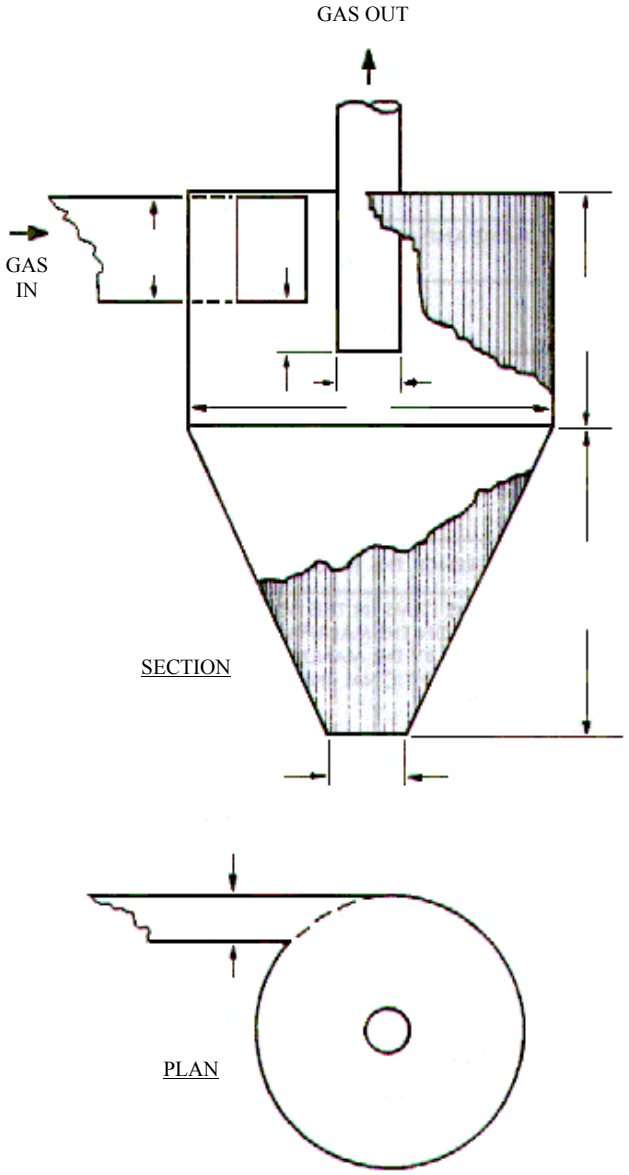
ADSORPTION UNIT	
1. FLOW DIAGRAM DESIGNATION(S) OF ADSORPTION UNIT:	
2. MANUFACTURER:	3. MODEL NAME AND NUMBER:
4. ADSORBENT: ☐ ACTIVATED CHARCOAL: TYPE _____ ☐ OTHER: SPECIFY _____	
5. ADSORBATE(S):	
6. NUMBER OF BEDS PER UNIT:	7. WEIGHT OF ABSORBENT PER BED: LB
8. DIMENSIONS OF BED: THICKNESS _____ IN, SURFACE AREA _____ SQUARE IN	
9. INLET GAS TEMPERATURE: °F	9. PRESSURE DROP ACROSS UNIT: INCH H_2O GAUGE
11. TYPE OF REGENERATION: ☐ REPLACEMENT ☐ STEAM ☐ OTHER: SPECIFY _____	
12. METHOD OF REGENERATION: ☐ ALTERNATE USE OF _____ ENTIRE UNITS ☐ ALTERNATE USE OF _____ BEDS IN A SINGLE UNIT ☐ SOURCE SHUT DOWN ☐ OTHER: DESCRIBE	
AVERAGE OPERATION OF SOURCE	MAXIMUM OPERATION OF SOURCE
13. TIME ON LINE BEFORE REGENERATION: MIN/BED	15. TIME ON LINE BEFORE REGENERATION: MIN/BED
14. EFFICIENCY OF ABSORBER (SEE INSTRUCTION 4): %	16. EFFICIENCY OF ABSORBER (SEE INSTRUCTION 4): %

AFTERBURNER	
1. FLOW DIAGRAM DESIGNATION(S) OF AFTERBURNER:	
2. MANUFACTURER:	3. MODEL NAME AND NUMBER:
4. COMBUSTION CHAMBER DIMENSIONS: LENGTH _____ IN, CROSS-SECTIONAL AREA _____ SQUARE IN	
5. INLET GAS TEMPERATURE: °F	7. FUEL: ☐ GAS ☐ OIL: SULFUR _____ WT%
6. OPERATING TEMPERATURE OF COMBUSTION CHAMBER: °F	8. BURNERS PER AFTERBURNER: _____ @ _____ BTU/HR EACH
9. CATALYST USED: ☐ NO ☐ YES: DESCRIBE CATALYST _____	
10. HEAT EXCHANGER USED: ☐ NO ☐ YES: DESCRIBE HEAT EXCHANGER _____	
AVERAGE OPERATION OF SOURCE	MAXIMUM OPERATION OF SOURCE
11. GAS FLOW RATE: SCFM	13. GAS FLOW RATE: SCFM
12. EFFICIENCY OF AFTERBURNER (SEE INSTRUCTION 4): %	14. EFFICIENCY OF AFTERBURNER (SEE INSTRUCTION 4): %

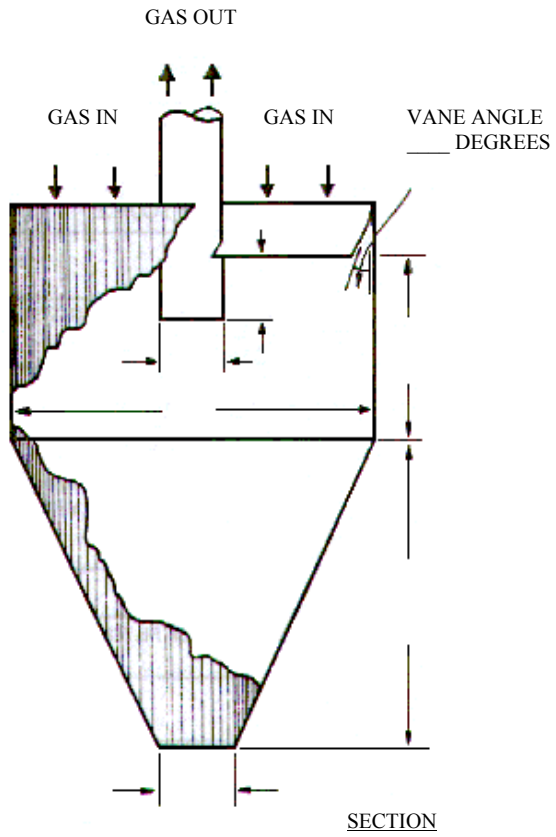
CYCLONE	
1. FLOW DIAGRAM DESIGNATION(S) OF CYCLONE:	
2. MANUFACTURER:	3. MODEL:
4. TYPE OF CYCLONE: ☐ SIMPLE ☐ MULTIPLE	5. NUMBER OF CYCLONES IN EACH MULTIPLE CYCLONE:

6. DIMENSION THE APPROPRIATE SKETCH (IN INCHES) OR PROVIDE A DRAWING WITH EQUIVALENT INFORMATION:

TANGENTIAL INLET CYCLONE



AXIAL INLET CYCLONE
(INDIVIDUAL CYCLONE OF MULTIPLE CYCLONE)



NOT TO SCALE

AVERAGE OPERATION OF SOURCE	MAXIMUM OPERATION OF SOURCE
7. GAS FLOW RATE: SCFM	9. GAS FLOW RATE: SCFM
8. EFFICIENCY OF CYCLONE (SEE INSTRUCTION 4): %	10. EFFICIENCY OF CYCLONE (SEE INSTRUCTION 4): %

CONDENSER		
1. FLOW DIAGRAM DESIGNATION(S) OF CONDENSER:		
2. MANUFACTURER:	3. MODEL NAME AND NUMBER:	4. HEAT EXCHANGE AREA: FT^2

AVERAGE OPERATION OF SOURCE		MAXIMUM OPERATION OF SOURCE	
5. COOLANT FLOW RATE PER CONDENSER: WATER _____ GPM AIR _____ SCFM OTHER: TYPE _____, FLOW RATE _____		10. COOLANT FLOW RATE PER CONDENSER: WATER _____ GPM AIR _____ SCFM OTHER: TYPE _____, FLOW RATE _____	
6. GAS FLOW RATE: SCFM		11. GAS FLOW RATE: SCFM	
7. COOLANT TEMPERATURE: INLET_____°F OUTLET_____°F	8. GAS TEMPERATURE: INLET_____°F OUTLET_____°F	12. COOLANT TEMPERATURE: INLET_____°F OUTLET_____°F	13. GAS TEMPERATURE: INLET_____°F OUTLET_____°F
9. EFFICIENCY OF CONDENSER (SEE INSTRUCTION 4): %		14. EFFICIENCY OF CONDENSER (SEE INSTRUCTION 4): %	

*ELECTRICAL PRECIPITATOR	
1. FLOW DIAGRAM DESIGNATION(S) OF ELECTRICAL PRECIPITATOR:	
2. MANUFACTURER:	3. MODEL NAME AND NUMBER:
4. COLLECTING ELECTRODE AREA PER CONTROL DEVICE: FT^2	

AVERAGE OPERATION OF SOURCE	MAXIMUM OPERATION OF SOURCE
5. GAS FLOW RATE: SCFM	7. GAS FLOW RATE: SCFM
6. EFFICIENCY OF ELECTRICAL PRECIPITATOR(SEE INSTRUCTION 4): %	8. EFFICIENCY OF ELECTRICAL PRECIPITATOR(SEE INSTRUCTION 4): %
SUBMIT THE MANUFACTURER'S SPECIFICATIONS FOR THE ELECTRICAL PRECIPITATOR. REFERENCE THE INFORMATION TO THIS FORM.	

*ELECTRICAL PRECIPITATORS VARY GREATLY IN THEIR DESIGN AND IN THEIR COMPLEXITY. THE ITEMS IN THIS SECTION PROVIDE A MINIMUM AMOUNT OF INFORMATION. THE APPLICANT MUST, HOWEVER, SUBMIT WITH THIS APPLICATION THE MANUFACTURER'S SPECIFICATIONS, INCLUDING ANY DRAWINGS, TECHNICAL DOCUMENTS, ETC. IF THE INFORMATION PROVIDED BY THE MANUFACTURER'S SPECIFICATIONS IS INSUFFICIENT FOR FULL AND ACCURATE ANALYSIS, THE AGENCY WILL REQUEST SPECIFIC ADDITIONAL INFORMATION.

FILTER UNIT	
1. FLOW DIAGRAM DESIGNATION(S) OF FILTER UNIT:	
2. MANUFACTURER:	3. MODEL NAME AND NUMBER:
4. FILTERING MATERIAL:	5. FILTERING AREA: FT^2
6. CLEANING METHOD: ☐ SHAKER ☐ REVERSE AIR ☐ PULSE AIR ☐ PULSE JET ☐ OTHER: SPECIFY _____	
7. GAS COOLING METHOD: ☐ DUCT WORK: LENGTH _____ FT., DIAM _____ IN. ☐ BLEED-IN AIR ☐ WATER SPRAY ☐ OTHER: SPECIFY _____	

AVERAGE OPERATION OF SOURCE	MAXIMUM OPERATION OF SOURCE
8. GAS FLOW RATE (FROM SOURCE): SCFM	12. GAS FLOW RATE (FROM SOURCE): SCFM
9. GAS COOLING FLOW RATE: BLEED-IN AIR _____ SCFM, WATER SPRAY _____ GPM	13. GAS COOLING FLOW RATE: BLEED-IN AIR _____ SCFM, WATER SPRAY _____ GPM
10. INLET GAS CONDITION: TEMPERATURE _____ °F DEWPOINT _____ °F	14. INLET GAS CONDITION: TEMPERATURE _____ °F DEWPOINT _____ °F
11. EFFICIENCY OF FILTER UNIT (SEE INSTRUCTION 4): %	15. EFFICIENCY OF FILTER UNIT (SEE INSTRUCTION 4): %

SCRUBBER	
1. FLOW DIAGRAM DESIGNATION(S) OF SCRUBBER:	
2. MANUFACTURER:	3. MODEL NAME AND NUMBER:
4. TYPE OF SCRUBBER: ☐ HIGH ENERGY: GAS STEAM PRESSURE DROP _____ INCH H_2O ☐ PACKED: PACKING TYPE _____, PACKING SIZE _____, PACKING HEIGHT _____ IN. ☐ SPRAY: NUMBER OF NOZZLES _____, NOZZLE PRESSURE _____ PSIG ☐ OTHER: SPECIFY _____ ATTACH DESCRIPTION AND SKETCH WITH DIMENSIONS	
5. TYPE OF FLOW: ☐ COCURRENT ☐ COUNTERCURRENT ☐ CROSSFLOW	
6. SCRUBBER GEOMETRY: LENGTH IN DIRECTION OF GAS FLOW _____ IN., CROSS-SECTIONAL AREA _____ SQUARE IN.	
7. CHEMICAL COMPOSITION OF SCRUBBANT:	
AVERAGE OPERATION OF SOURCE	MAXIMUM OPERATION OF SOURCE
8. SCRUBBANT FLOW RATE: GPM	12. SCRUBBANT FLOW RATE: GPM
9. GAS FLOW RATE: SCFM	13. GAS FLOW RATE: SCFM
10. INLET GAS TEMPERATURE: °F	14. INLET GAS TEMPERATURE: °F
11. EFFICIENCY OF SCRUBBER (SEE INSTRUCTION 4): _____ % PARTICULATE _____ % GASEOUS	15. EFFICIENCY OF SCRUBBER (SEE INSTRUCTION 4): _____ % PARTICULATE _____ % GASEOUS

OTHER TYPE OF CONTROL EQUIPMENT		
1. FLOW DIAGRAM DESIGNATION(S) OF "OTHER TYPE" OF CONTROL EQUIPMENT: Regenerative Thermal Oxidizer		
2. GENERIC NAME OF "OTHER" EQUIPMENT: RTO	3. MANUFACTURER: Anguil Environmental Systems	4. MODEL NAME AND NUMBER: RTO 100
5. DESCRIPTION AND SKETCH, WITH DIMENSIONS AND FLOW RATES, OF "OTHER" EQUIPMENT: See Exhibit 260-1 and RTO spec sheet for equipment description.		
AVERAGE OPERATION OF SOURCE		MAXIMUM OPERATION OF SOURCE
6. FLOW RATES: _____ GPM 2500 SCFM		8. FLOW RATES: _____ GPM 2500 SCFM
7. EFFICIENCY OF "OTHER" EQUIPMENT (SEE INSTRUCTION 4): 96-99 %		9. EFFICIENCY OF "OTHER" EQUIPMENT (SEE INSTRUCTION 4): 96-99 %

EMISSION INFORMATION

1. NUMBER OF IDENTICAL CONTROL UNITS OR CONTROL SYSTEMS (DESCRIBE AS REQUIRED):

AVERAGE OPERATION

CONTAMINANT	CONCENTRATION OR EMISSION RATE PER IDENTICAL CONTROL UNITS OR CONTROL SYSTEM		METHOD USED TO DETERMINE CONCENTRATION OR EMISSION RATE
PARTICULATE MATTER	2a. GR/SCF	b. 0.12 LB/HR	c. (see Exhibit 260-1)
CARBON MONOXIDE	3a. PPM (VOL)	b. 0.01 LB/HR	c. (see Exhibit 260-1)
NITROGEN OXIDES	4a. PPM (VOL)	b. 0.14 LB/HR	c. (see Exhibit 260-1)
ORGANIC MATERIAL	5a. PPM (VOL)	b. LB/HR	c.
SULFUR DIOXIDE	6a. PPM (VOL)	b. 0.84 LB/HR	c. (see Exhibit 260-1)
**OTHER (SPECIFY)	7a. PPM (VOL)	b. 3.50 LB/HR	c. HAPS (see Exhibit 260-1)

MAXIMUM OPERATION

CONTAMINANT	CONCENTRATION OR EMISSION RATE PER IDENTICAL CONTROL UNITS OR CONTROL SYSTEM		METHOD USED TO DETERMINE CONCENTRATION OR EMISSION RATE
PARTICULATE MATTER	8a. GR/SCF	b. 0.12 LB/HR	c. (see Exhibit 260-1)
CARBON MONOXIDE	9a. PPM (VOL)	b. 0.01 LB/HR	c. (see Exhibit 260-1)
NITROGEN OXIDES	10a. PPM (VOL)	b. 0.14 LB/HR	c. (see Exhibit 260-1)
ORGANIC MATERIAL	11a. PPM (VOL)	b. LB/HR	c.
SULFUR DIOXIDE	12a. PPM (VOL)	b. 0.84 LB/HR	c. (see Exhibit 260-1)
**OTHER (SPECIFY)	13a. PPM (VOL)	b. 3.50 LB/HR	c. HAPS (see Exhibit 260-1)

**"OTHER" CONTAMINANT SHOULD BE USED FOR AN AIR CONTAMINANT NOT SPECIFICALLY NAMED ABOVE. POSSIBLE OTHER CONTAMINANTS ARE ASBESTOS, BERYLLIUM, MERCURY, VINYL CHLORIDE, LEAD, ETC.

EXHAUST POINT INFORMATION

1. FLOW DIAGRAM DESIGNATION(S) OF EXHAUST POINT: Regenerative Thermal Oxidizer Exhaust

2. DESCRIPTION OF EXHAUST POINT (LOCATION IN RELATION TO BUILDINGS, DIRECTION, HOODING, ETC.):
22" vertical carbon steel / aluminized steel air stack from top of enclosure

3. EXIT HEIGHT ABOVE GRADE: 30ft.	4. EXIT DIAMETER: 22in.
5. GREATEST HEIGHT OF NEARBY BUILDINGS: 12ft.	6. EXIT DISTANCE FROM NEAREST PLANT BOUNDARY: <100ft.

AVERAGE OPERATION	MAXIMUM OPERATION
7. EXIT GAS TEMPERATURE: 200 °F	9. EXIT GAS TEMPERATURE: 200 °F
8. GAS FLOW RATE THROUGH EACH EXIT: 10000 ACFM	10. GAS FLOW RATE THROUGH EACH EXIT: 10000 ACFM

STATE OF ILLINOIS
ENVIRONMENTAL PROTECTION AGENCY
DIVISION OF AIR POLLUTION CONTROL
1021 NORTH GRAND AVENUE, EAST
SPRINGFIELD, ILLINOIS 62702

* DATA AND INFORMATION PROCESS EMISSION SOURCE	

* THIS INFORMATION FORM IS TO BE COMPLETED FOR AN EMISSION SOURCE OTHER THAN A FUEL COMBUSTION EMISSION SOURCE OR AN INCINERATOR. A FUEL COMBUSTION EMISSION SOURCE IS A FURNACE, BOILER, OR SIMILAR EQUIPMENT USED PRIMARILY FOR PRODUCING HEAT OR POWER BY INDIRECT HEAT TRANSFER. AN INCINERATOR IS AN APPARATUS IN WHICH REFUSE IS BURNED.

1. NAME OF PLANT OWNER: Shell Oil Products US	2. NAME OF CORPORATE DIVISION OR PLANT (IF DIFFERENT FROM OWNER):
3. STREET ADDRESS OF EMISSION SOURCE: corner of Chaffer St. & 8th St.	4. CITY OF EMISSION SOURCE: Roxana

GENERAL INFORMATION		
5. NAME OF PROCESS: Soil Vapor Extraction System	6. NAME OF EMISSION SOURCE EQUIPMENT: Storage Tank	
7. EMISSION SOURCE EQUIPMENT MANUFACTURER: Buckeye Fabricating Company	8. MODEL NUMBER:	9. SERIAL NUMBER:
10. FLOW DIAGRAM DESIGNATION(S) OF EMISSION SOURCE: Storage Tank		
11. IDENTITY(S) OF ANY SIMILAR SOURCE(S) AT THE PLANT OR PREMISES NOT COVERED BY THE FORM (IF THE SOURCE IS COVERED BY ANOTHER APPLICATION, IDENTIFY THE APPLICATION):		
12. AVERAGE OPERATING TIME OF EMISSION SOURCE: 24 HRS/DAY 7 DAYS/WK 52 WKS/YR	13. MAXIMUM OPERATING TIME OF EMISSION SOURCE: 24 HRS/DAY 7 DAYS/WK 52 WKS/YR	
14. PERCENT OF ANNUAL THROUGHPUT: DEC-FEB 25 % MAR-MAY 25 % JUN-AUG 25 % SEPT-NOV 25 %		

INSTRUCTIONS
1. COMPLETE THE ABOVE IDENTIFICATION AND GENERAL INFORMATION SECTION. 2. COMPLETE THE RAW MATERIAL, PRODUCT, WASTE MATERIAL, AND FUEL USAGE SECTIONS FOR THE PARTICULAR SOURCE EQUIPMENT. COMPOSITIONS OF MATERIALS MUST BE SUFFICIENTLY DETAILED TO ALLOW DETERMINATION OF THE NATURE AND QUANTITY OF POTENTIAL EMISSIONS. IN PARTICULAR, THE COMPOSITION OF PAINTS, INKS, ETC., AND ANY SOLVENTS MUST BE FULLY DETAILED. 3. EMISSION AND EXHAUST POINT INFORMATION MUST BE COMPLETED, UNLESS EMISSIONS ARE EXHAUSTED THROUGH AIR POLLUTION CONTROL EQUIPMENT. 4. OPERATION TIME AND CERTAIN OTHER ITEMS REQUIRE BOTH AVERAGE AND MAXIMUM VALUES 5. FOR GENERAL INFORMATION REFER TO "GENERAL INSTRUCTIONS FOR PERMIT APPLICATIONS," APC-201.

DEFINITIONS
AVERAGE - THE VALUE THAT SUMMARIZES OR REPRESENTS THE GENERAL CONDITION OF THE EMISSION SOURCE, OR THE GENERAL STATE OF PRODUCTION OF THE EMISSION SOURCE. SPECIFICALLY: AVERAGE OPERATING TIME - ACTUAL TOTAL HOURS OF OPERATION FOR THE PRECEDING TWELVE MONTH PERIOD. AVERAGE RATE - ACTUAL TOTAL QUANTITY OF "MATERIAL" FOR THE PRECEDING TWELVE MONTH PERIOD, DIVIDED BY THE AVERAGE OPERATING TIME. AVERAGE OPERATION - OPERATION TYPICAL OF THE PRECEDING TWELVE MONTH PERIOD, AS REPRESENTED BY AVERAGE OPERATING TIME AND AVERAGE RATES. MAXIMUM - THE GREATEST VALUE ATTAINABLE OR ATTAINED FOR THE EMISSION SOURCE, OR THE PERIOD OF GREATEST OR UTMOST PRODUCTION OF THE EMISSION SOURCE. SPECIFICALLY: MAXIMUM OPERATING TIME - GREATEST EXPECTED TOTAL HOURS OF OPERATIONS FOR ANY TWELVE MONTH PERIOD. MAXIMUM RATE - GREATEST QUANTITY OF "MATERIAL" EXPECTED PER ANY ONE HOUR OF OPERATION. MAXIMUM OPERATION - GREATEST EXPECTED OPERATION, AS REPRESENTED BY MAXIMUM OPERATING TIME AND MAXIMUM RATES.

This Agency is authorized to require this information under Illinois Revised Statutes, 1979, Chapter 111 1/2, Section 1039. Disclosure of this information is required under that Section. Failure to do so may prevent this form from being processed and could result in your application being denied. This form has been approved by the Forms Management Center.

RAW MATERIAL INFORMATION		
NAME OF RAW MATERIAL	AVERAGE RATE PER IDENTICAL SOURCE	MAXIMUM RATE PER IDENTICAL SOURCE
20a. condensate from soil vapor extraction	b. LB/HR	c. LB/HR
21a.	b. LB/HR	c. LB/HR
22a.	b. LB/HR	c. LB/HR
23a.	b. LB/HR	c. LB/HR
24a.	b. LB/HR	c. LB/HR

PRODUCT INFORMATION		
NAME OF PRODUCT	AVERAGE RATE PER IDENTICAL SOURCE	MAXIMUM RATE PER IDENTICAL SOURCE
30a.	b. LB/HR	c. LB/HR
31a.	b. LB/HR	c. LB/HR
32a.	b. LB/HR	c. LB/HR
33a.	b. LB/HR	c. LB/HR
34a.	b. LB/HR	c. LB/HR

WASTE MATERIAL INFORMATION		
NAME OF WASTE MATERIAL	AVERAGE RATE PER IDENTICAL SOURCE	MAXIMUM RATE PER IDENTICAL SOURCE
40a. condensate from soil vapor extraction	b. LB/HR	c. LB/HR
41a.	b. LB/HR	c. LB/HR
42a.	b. LB/HR	c. LB/HR
43a.	b. LB/HR	c. LB/HR
44a.	b. LB/HR	c. LB/HR

*FUEL USAGE INFORMATION		
FUEL USED	TYPE	HEAT CONTENT
50a. NATURAL GAS ☐	b. ----------	c. 1000 BTU/SCF
OTHER GAS ☐		BTU/SCF
OIL ☐		BTU/GAL
COAL ☐		BTU/LB
OTHER ☐		BTU/LB
d. AVERAGE FIRING RATE PER IDENTICAL SOURCE: BTU/HR	e. MAXIMUM FIRING RATE PER IDENTICAL SOURCE: BTU/HR	

*THIS SECTION IS TO BE COMPLETED FOR ANY FUEL USED DIRECTLY IN THE PROCESS EMISSION SOURCE, E. G. GAS IN A DRYER, OR COAL IN A MELT FURNACE.

*EMISSION INFORMATION

51. NUMBER OF IDENTICAL SOURCES (DESCRIBE AS REQUIRED):

AVERAGE OPERATION

CONTAMINANT	CONCENTRATION OR EMISSION RATE PER IDENTICAL SOURCE		METHOD USED TO DETERMINE CONCENTRATION OR EMISSION RATE
PARTICULATE MATTER	52a. GR/SCF	b. LB/HR	c.
CARBON MONOXIDE	53a. PPM (VOL)	b. LB/HR	c.
NITROGEN OXIDES	54a. PPM (VOL)	b. LB/HR	c.
ORGANIC MATERIAL	55a. PPM (VOL)	b. 0.011 LB/HR	c. see Attachment A - TANKS summary
SULFUR DIOXIDE	56a. PPM (VOL)	b. LB/HR	c.
**OTHER (SPECIFY)	57a. PPM (VOL)	b. 0.011 LB/HR	c. HAPS (see Attachment A - TANKS summary)

MAXIMUM OPERATION

CONTAMINANT	CONCENTRATION OR EMISSION RATE PER IDENTICAL SOURCE		METHOD USED TO DETERMINE CONCENTRATION OR EMISSION RATE
PARTICULATE MATTER	58a. GR/SCF	b. LB/HR	c.
CARBON MONOXIDE	59a. PPM (VOL)	b. LB/HR	c.
NITROGEN OXIDES	60a. PPM (VOL)	b. LB/HR	c.
ORGANIC MATERIAL	61a. PPM (VOL)	b. 0.011 LB/HR	c. see Attachment A - TANKS summary
SULFUR DIOXIDE	62a. PPM (VOL)	b. LB/HR	c.
**OTHER (SPECIFY)	63a. PPM (VOL)	b. 0.011 LB/HR	c. HAPS (see Attachment A - TANKS summary)

*ITEMS 52 THROUGH 63 NEED NOT BE COMPLETED IF EMISSIONS ARE EXHAUSTED THROUGH AIR POLLUTION CONTROL EQUIPMENT.
**"OTHER" CONTAMINANT SHOULD BE USED FOR AN AIR CONTAMINANT NOT SPECIFICALLY NAMED ABOVE. POSSIBLE OTHER CONTAMINANTS ARE ASBESTOS, BERYLLIUM, MERCURY, VINYL CHLORIDE, LEAD, ETC.

***EXHAUST POINT INFORMATION

64. FLOW DIAGRAM DESIGNATION(S) OF EXHAUST POINT:
stroage tanks

65. DESCRIPTION OF EXHAUST POINT (LOCATION IN RELATION TO BUILDINGS, DIRECTION, HOODING, ETC.):

66. EXIT HEIGHT ABOVE GRADE: 13 ft.	67. EXIT DIAMETER: 2in.
68. GREATEST HEIGHT OF NEARBY BUILDINGS: N/A	69. EXIT DISTANCE FROM NEAREST PLANT BOUNDARY: <100ft.
AVERAGE OPERATION	MAXIMUM OPERATION
70. EXIT GAS TEMPERATURE: ambeint °F	72. EXIT GAS TEMPERATURE: ambeint °F
71. GAS FLOW RATE THROUGH EACH EXIT: ambeint ACFM	73. GAS FLOW RATE THROUGH EACH EXIT: ambeint ACFM

***THIS SECTION SHOULD NOT BE COMPLETED IF EMISSIONS ARE EXHAUSTED THROUGH AIR POLLUTION CONTROL EQUIPMENT.

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STATE OF ILLINOIS
ENVIRONMENTAL PROTECTION AGENCY
DIVISION OF AIR POLLUTION CONTROL
P. O. Box 19506
SPRINGFIELD, ILLINOIS 62794-9506

PROCESS EMISSION SOURCE ADDENDUM TANK	FOR AGENCY USE ONLY

1. NAME OF OWNER:	2. NAME OF CORPORATE DIVISION OR PLANT (IF DIFFERENT FROM OWNER):
Shell Oil Products US	Not Applicable
3. STREET ADDRESS OF EMISSION SOURCE:	4. CITY OF EMISSION SOURCE:
corner of Chaffer St. and 8th St.	Roxana

TANK INFORMATION			
5. NAME OF TANK MANUFACTURER: Buckeye Fabricating Company		6. DESIGNATION OF TANK:	
7. SERIAL NUMBER:		8. CAPACITY: 500 gallons	
9. TANK USE: storage tank		10. NUMBER OF SAME CAPACITY TANKS STORING THE SAME MATERIAL: 2	
11. TANK SHAPE: ☐ HORIZONTAL	☒ CYLINDRICAL	☐ SPHERICAL	☐ OTHER (SPECIFY)____
12. TANK DIAMETER: 4 FT	13. TANK HEIGHT: 4.3 FT	14. TANK LENGTH: 5.5 FT	
15. STATUS: ☐ EXISTING ☐ ALTERATION		16. TANK TYPE: ☒ FIXED ROOF ☐ FLOATING ROOF ☐ PRESSURE ☐ OTHER (SPECIFY)____	
17. SEAL: ☐ SINGLE ☐ DOUBLE ☒ OTHER (SPECIFY) tank vent		18. AVERAGE DISTANCE FROM TOP OF TANK SHELL TO LIQUID: FT	
19. SHELL TYPE: ☐ RIVETED ☒ WELDED ☐ OTHER (SPECIFY)____		20. PAINT COLOR: white	

VENT VALVE DATA			
TYPE OF VENT	NUMBER OF VENTS	PRESSURE SETTING	DISCHARGE VENTED TO (ATMOSPHERE, FLARE, ETC.)
21. COMBINATION	a. ____	b. ____	c. ____
22. PRESSURE	a. ____	b. ____	c. ____
23. VACUM	a. ____	b. ____	c. ____
24. OPEN	a. 1	b. ambeint	c. atmosphere

MATERIAL TO BE STORED		
25. MATERIAL: condensate from soil vapor extraction system	26. DENSITY: 62.3 LB/FT^3	27. VAPOR PRESSURE AT 70 °F: 0.363 PSIA

STORAGE CONFITIONS			
28. STORAGE TEMPERATURE: MINIMUM amb. °F MAXIMUM amb. °F		29. TANK TURN OVER PER YEAR: 0	☐ BBLS/ ☒ GALS/
30. MAXIMUM FILLING RATE:	☐ BBLS/DAY ☒ GALS/DAY	31. AVERAGE THROUGHPUT: 75	☐ BBLS/DAY ☒ GALS/DAY
32. PRESSURE EQUALIZERS USED? ☐ YES ☒ NO		33. PERMANENT SUBMERGED LOADING PIPE USED? ☐ YES ☒ NO	
34. VAPOR LOSS CONTROL DEVICE? ☐ YES ☒ NO	IF VAPOR LOSS CONTROL DEVICE IS USED, COMPLETE "DATA & INFORMATION –AIR POLLUTION CONTROL EQUIPMENT," (FORM APC-260, AS PART OF THIS APPLICATION		

Exhibit 260-1
Soil Vapor Extraction System Description and Emission Calculations

Shell Oil Products US proposes to install a full-scale soil vapor extraction system at the Roxana Site as shown in Figure 1. The system will use a 15 hp blower/motor to pull vacuum from several extraction wells to extract soil vapor. The system will be equipped with a knockout tank, regenerative thermal oxidizer (RTO), water pump and storage, as shown in Figure 2. The vacuum extraction rate will be maintained at or below 2500 standard cubic feet per minute (scfm). The vacuum will develop the vacuum pressure necessary to extract and convey the soil vapor to a knockout tank, where the soil vapor and condensate water will be separated. The vapors will be conveyed by vacuum to the RTO unit for destruction of hydrocarbon constituents. The condensate water will be conveyed by a water pump to a holding tank for subsequent transport and treatment/discharge.

The holding tanks for the condensate will consist of two 500 gallon stainless steel above-ground storage tanks (AST). The tanks will each be four feet in diameter and 5.5 feet in length with a holding capacity of 516 gallons. The tank will be kept under ambient conditions and will not be pressurized. A 2 inch diameter vent, which will extend through the roof of the equipment building, will vent the tank to the atmosphere.

The minimum hydrocarbon destruction efficiency is estimated between 96 - 99 percent. Based on the anticipated destruction efficiency of 96 percent and the expected flow rates; the maximum potential hydrocarbon mass emission rate is calculated at 3.50 pounds per hour (lb/hr) as shown in Table 1 below. Based on the TANKS calculation, the combined hazardous air pollutants (HAPS) mass emission rate for the tanks is 0.022 lb/hr (TANKS summary is included as Attachment A). The total HAPS anticipated for this application are 15.41 tons per year (TPY). Table 2 contains the potential criteria pollutant emissions for the RTO unit.

Table 1: Calculation of Potential HAPS Emissions for Regenerative Thermal Oxidizer

Pollutant	HAPS (mg/m^3)	Volume Flow Rate (cfm)	HAPS Mass Flow Rate (kg/day)	HAPS Mass Flow Rate (lb/day)	Efficiency	Emission Rate (lb/day)	Emission Rate (lb/hr)	Potential Emission Rate (TPY)
Benzene	113.71	2500	11.59	25.56	0.96	1.02	0.04	0.19
Hexane	5501.45	2500	560.90	1236.70	0.96	49.47	2.06	9.03
Ethylbenzene	90.57	2500	9.23	20.36	0.96	0.81	0.03	0.15
Toluene	189.14	2500	19.28	42.52	0.96	1.70	0.07	0.31
2,2,4-Trimethylpentane	3227.10	2500	329.02	725.44	0.96	29.02	1.21	5.30
m,p-Xylene	155.92	2500	15.90	35.05	0.96	1.40	0.06	0.26
o-Xylene	52.49	2500	5.35	11.80	0.96	0.47	0.02	0.09
						Totals	3.50	15.31

Table 2: Calculation of Potential Criteria Pollutant Emissions

Maximum Design Rate (MMBTU/hr)	Maximum Fuel Throughput	Units	SO_2 [1] Emission Factor (lb/MMBtu)	NOx [1] Emission Factor (lb/MMBtu)	CO [2] Emission Factor (lb/MMBtu)	PM [2] Emission Factor (lb/MMBtu)	Potential SO_2 Emission Rate (TPY)	Potential NOx Emission Rate (TPY)	Potential CO Emission Rate (TPY)	Potential PM Emission Rate (TPY)
1.4	1333	SCF/hr	6.00E-01	1.00E-01	7.45E-03	8.24E-02	3.68E+00	6.13E-01	4.57E-02	5.05E-01

1 Emission factor from manufacturer

2 Emission factor from AP-42 External Combution Sources, 1.4 Natrual Gas Combustion (per manufacturer's recommendation)

Table 3: Calculation of Potential HAPS Emissions for RTO and 2 Storage Tanks

	Caculated emissions for RTO		Caculated emissions for 2 Storage Tanks		Totals for both RTO and Tanks	
Pollutant	Emission Rate (lb/hr)	Potential Emission Rate (TPY)	Emission Rate (lb/hr)	Potential Emission Rate (TPY)	Emission Rate (lb/hr)	Potential Emission Rate (TPY)
Benzene	0.04	0.19	0.00	0.00	0.04	0.19
Hexane	2.06	9.03	0.02	0.08	2.08	9.11
Ethylbenzene	0.03	0.15	0.00	0.00	0.03	0.15
Toluene	0.07	0.31	0.00	0.00	0.07	0.31
2,2,4-Trimethylpentane	1.21	5.30	0.00	0.01	1.21	5.31
m,p-Xylene	0.06	0.26	0.00	0.00	0.06	0.26
o-Xylene	0.02	0.09	0.00	0.00	0.02	0.09
	3.50	15.31	0.02	0.10	3.52	15.41

WEST PROPERTY

1986 APPROXIMATE BENZENE RELEASE SITE

(S. CENTRAL AVE) HIGHWAY 111

VILLAGE OF ROXANA

EIGHTH ST | SEVENTH ST | SIXTH ST | FIFTH ST | FOURTH ST | THIRD ST | SECOND ST

PUBLIC WORKS PROPERTY

CHAFFER ST

PETROLEUM PIPELINE (TYP.)

PETROLEUM PIPE ABOVE GROUND

TREATMENT BUILDING

RTO

ASPHALT PARKING

OMC BUILDING

BUILDING

METER SHELTER

NORTH PROPERTY

WOOD RIVER REFINERY

VMP-1 VMP-2 VMP-3 VMP-4 VMP-5 VMP-6 VMP-7 VMP-8 VMP-9 VMP-10 VMP-11 VMP-12 VMP-13 VMP-14 VMP-15 VMP-16 VMP-17 VMP-18 VMP-19 VMP-20 VMP-21 VMP-22 VMP-23 VMP-24 VMP-25 VMP-26 VMP-27 VMP-28 VMP-29 VMP-30 VMP-31 VMP-32

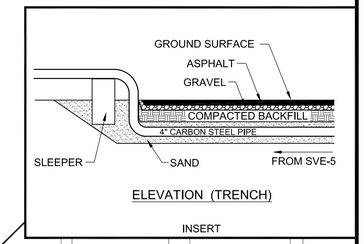
SVE-1 SVE-2 SVE-3 SVE-4 SVE-5 SVE-6 SVE-7 SVE-8 SVE-9 SVE-10 SVE-11 SVE-12 SVE-13 SVE-14 SVE-15 SVE-16 SVE-17 SVE-18 SVE-19 SVE-20 SVE-21 SVE-22 SVE-23 SVE-24 SVE-25 SVE-26 SVE-27

F-73 F-74 F-75 F-76 F-77 F-78

A-22 A-27 A-28 A-31 A-32 A-33 A-34

W-77 W-78 W-79 W-80 W-81 W-85

60



ELEVATION (TRENCH)

INSERT

IDENTIFICATION TAPE (FADE RESISTANT / SELF ADHESIVE)

LEG #	SVE WELLS	COLOR
1	SVE-5 THROUGH SVE-7	RED
2	SVE-8 THROUGH SVE-10	BLUE
3	SVE-11 THROUGH SVE-13	YELLOW
4	SVE-14 THROUGH SVE-16	GREEN
5	SVE-17 THROUGH SVE-19	BLACK
6	SVE-20 THROUGH SVE-23	ORANGE
7	SVE-24, SVE-26 & SVE-27	WHITE

LEGEND:

- VAPOR MONITORING POINT (VMP) LOCATION
- SVE EXTRACTION WELL
- "HOT BOXES" (METERING FOR DOMESTIC WATER USE)
- PIPE SLEEPER
- UNDERGROUND PIPING (DASHED)
- ABOVEGROUND PIPING
- PROPERTY BOUNDARY
- ESTIMATED RADIUS OF INFLUENCE
- POTENTIAL TREATMENT ZONE BASED ON A RADIUS OF INFLUENCE OF 90 FEET

N

100 0 100

SCALE IN FEET

NOTES:

1. CONTRACTOR SHALL FIELD VERIFY UTILITY LOCATIONS PRIOR TO CONSTRUCTION.
2. WELL LOCATIONS ARE PROPOSED AND WILL BE MOVED AS CLOSE TO THE FENCE LINE AS IS SAFE.

Revisions			
Symbol	Descriptions	Date	Apprv'd

URS 8300 College Blvd., Suite 200 Overland Park, Kansas 66210

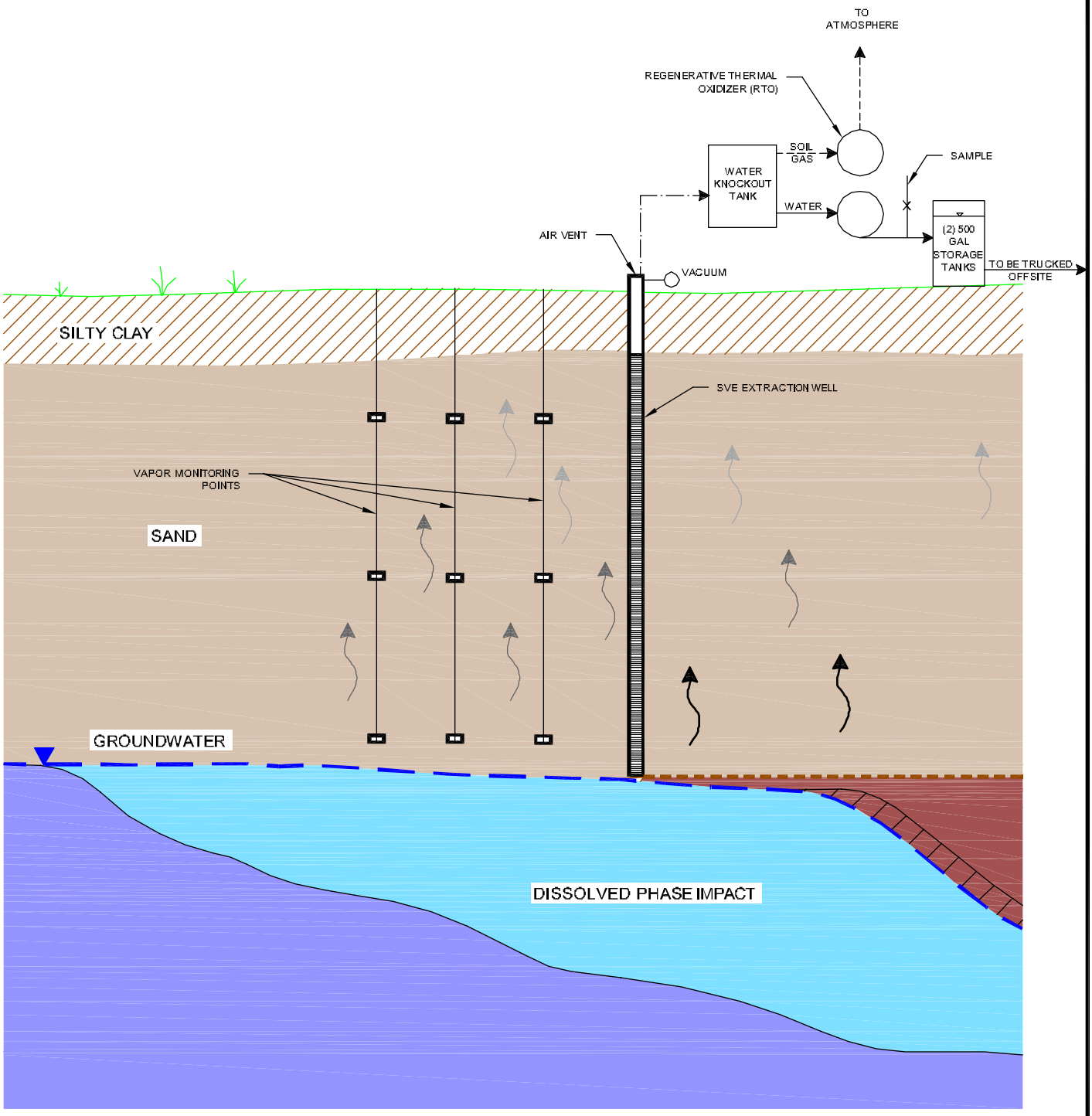
CLIENT: SHELL OIL PRODUCTS US

LOCATION: ROXANA, ILLINOIS

TITLE: PROPOSED SOIL VAPOR EXTRACTION (SVE) SYSTEM W/ REFINERY BUILDING

DRAWN BY	CHECKED BY	APPROVED BY
CTD	ROH	
PROJECT NO.	DATE	DRAWING NO.
21562593	APR. 2011	1

May 20, 2011 1:21:07 pm (mlk)
J:\Shell\Roxana\Plan Sheets\Proposed SVE Layout.dwg



NOTES:

NOT TO SCALE

SHELL OIL PRODUCTS US ROXANA, ILLINOIS		PROJECT NO. 21562593
URS		
DRN. BY:dab 5/26/11 DSGN. BY:nmb CHKD. BY: nmb	Schematic Cross Section	FIG. NO. 2

File: P:\ENVIRONMENTAL\SHELL OIL PRODUCT US\B-ROXANA-ROUTE 111\21562XXXX_ROXANA INVESTIGATION & ASSESSMENT\CONCEPTUAL DESIGN REPORT\CONCEPTUAL PILOT TEST SCHEMATIC CROSS SECTION.DWG Last edited: MAY 26, 11 @ 5:12 p.m. by: drew_brouk

Regenerative Thermal Oxidizer (RTO)

The Regenerative Thermal Oxidizer destroys Hazardous Air Pollutants (HAPs), Volatile Organic Compounds (VOCs) and odorous emissions that are often discharged from industrial processes. Anguil RTOs achieve emission destruction through the process of high temperature thermal oxidation, using the proper mix of temperature, residence time, turbulence and oxygen to convert pollutants into carbon dioxide and water vapor while reusing the thermal energy generated to reduce operating costs.

How the RTO Works

VOC and HAP laden process gas is either pushed or pulled into the inlet manifold of the oxidizer via a system fan. Flow control or poppet valves then direct this gas into energy recovery chambers where it is preheated. The process gas and contaminants are progressively heated in the ceramic media beds as they move toward the combustion chamber.

Once oxidized in the combustion chamber, the hot purified air releases thermal energy as it passes through the media bed in the outlet flow direction. The outlet bed is heated and the gas is cooled so that the outlet gas temperature is only slightly higher than the process inlet temperature. Poppet valves alternate the airflow direction into the media beds to maximize energy recovery within the oxidizer. The high energy recovery within these oxidizers reduces the auxiliary fuel requirement and saves operating cost. The Anguil oxidizer achieves high destruction efficiency and self-sustaining operation with no auxiliary fuel usage at low concentrations.

Features:

- Completely shop assembled, pre-wired and tested prior to shipment
- Skid mounted designs available for airflows up to 30,000 SCFM (47,313 Nm3/hr) and single unit systems up to 75,000 SCFM (118,283 Nm3/hr)
- Up to 25% Lower Explosive Limits (LEL) RTO operation while self-sustaining as low as 3% LEL, reducing the need for auxiliary fuel
- Gas trains designed for FM/TSSA/CGA certifications
- Low NOX burner designed to maintain temperature during full flow, no VOC process conditions
- Programmable Logic Controller (PLC) based controls with digital data recorder and remote telemetry
- Variable Frequency Drive (VFD) allows for high volumetric turn-down during idle or low process conditions
- Bake-out feature to remove organic particulate build up
- Hinged access doors for ease of maintenance

Available Options:

- Complete "turnkey" packages
- Two chamber and multi-bed configurations
- Forced or induced draft fan arrangements
- Supplemental Fuel Injection (SFI) for increased fuel efficiency and ultra low NOX emissions
- Hot Side Bypass for high loading conditions
- Diverse material of construction options for high temperature or corrosive applications such as halogenated compounds
- Skid or remote mounted panels and enclosure rooms available for system controls
- Custom oxidizer design options to meet space restrictions
- Primary or secondary heat and Energy Recovery Solutions

The Anguil RTO Advantage:

- Zero leakage, dual-disk Poppet valve design achieves 99+% destruction efficiency without a puff chamber or reliability concerns
- Regulatory Compliance Guaranteed
- System flexibility addresses a wide range of process conditions and easily controls multiple sources
- Customized ceramic media with true thermal energy recovery up to 97% Low pressure drop reduces electrical consumption
- Competitive capital equipment cost
- Rapid installation time on most systems
- Small equipment footprint

Anguil's Cost Effective Design:

The RTO is designed as part of Anguil's broad line of technologically advanced, yet user-friendly, air pollution control products. Anguil's experience includes over 30 years of Regenerative, Recuperative, Catalytic and Direct-Fired oxidizer manufacturing, ranging in size from 100 to 500,000 SCFM (150-800,000 Nm3/hr). These oxidizers are used in conjunction with Rotary Concentrator Systems, Scrubbers, Soil Remediation Equipment and Ceramic Filter Systems for industrial processes. Each product line represents value-engineered systems with emphasis on cost minimization. All systems are designed for seamless integration into the process, optimal performance and trouble-free operation.

Operating Cost Reduction Strategies:

- Alternative to add catalyst-Regenerative Catalytic Oxidizer (RCO)
- Primary or secondary heat and Energy Recovery Solutions Recirculation Systems
- Oxidizer Service and Preventive Maintenance Evaluations (PME)

The Anguil philosophy is to provide innovative pollution control technology including engineering, equipment manufacturing, installation, startup and post-sale service. Other benefits to working with Anguil:

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- 24 Hour customer service and support
- Multiple technology offerings ensure unbiased recommendations
- Complete aftermarket sales department
- Over 30 years of oxidizer manufacturing experience

Contact Anguil
8855 North 55th Street
Milwaukee, Wisconsin 53223
United States of America
Phone: 414-365-6400
Fax: 414-365-6410
www.anguil.com

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BUCKEYE FABRICATING COMPANY

Storage Tanks

Call Us 1-800-688-9821









Storage Tanks

For more than 45 years Buckeye Fabricating Company has produced custom storage tanks to meet our customers' exact specifications. Our storage tanks can be ASME code constructed and stamped, or non-pressurized based on your needs. Buckeye has the capacity to build to maximum dimensions of 12 feet in diameter and 40 feet long, with a volume of more than 30,000 gallons.

Regardless of your particular application, Buckeye Fabricating Company has the capability to produce storage tanks with a variety of metals (from stainless steel and carbon, to Hastelloy and Monel). Whether you need large volume storage tanks or very small process holding tanks, pressurized or not, we have the capacity and expertise to make it happen.

Supporting Custom Fabrication

Buckeye's design services team integrates your specific project requirements with detailed CAD drawings and our broad engineering expertise to produce some of the finest quality storage tanks in the industry. Our CNC plasma cutter guarantees the highest degree of accuracy for the location and fit-up sizing of all storage tank cutouts. In addition, the system has line-marking capability to ensure that all attachments are accurately located. We build what you want and work with you on the details. Whether it's producing an ASME tank, pressure vessel, stainless steel tank or custom storage tank, you'll always be satisfied with the end result.

History of Reliability and Dependability

Founded in 1963, Buckeye Fabricating Company is a widely recognized producer of high-quality, custom fabricated storage tanks. Centrally located in Springboro, Ohio, Buckeye Fabricating Company is the preferred source of storage tanks for companies nationwide. With nearly a half century of industry experience, our customers depend on us to deliver only the highest quality storage tanks while maintaining the most competitive pricing.

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Attachment A

TANKS 4.0.9d

Emissions Report - Summary Format

Tank Indentification and Physical Characteristics

Identification

User Identification:	Roxana Tank 1
City:	St. Louis
State:	Missouri
Company:	
Type of Tank:	Horizontal Tank
Description:	

Tank Dimensions

Shell Length (ft):	5.50
Diameter (ft):	4.00
Volume (gallons):	516.00
Turnovers:	0.00
Net Throughput(gal/yr):	27,375.00
Is Tank Heated (y/n):	N
Is Tank Underground (y/n):	N

Paint Characteristics

Shell Color/Shade:	White/White
Shell Condition	Good

Breather Vent Settings

Vacuum Settings (psig):	0.00
Pressure Settings (psig)	0.00

Meterological Data used in Emissions Calculations: St. Louis, Missouri (Avg Atmospheric Pressure = 14.46 psia)

Attachment A

TANKS 4.0.9d
Emissions Report - Summary Format
Liquid Contents of Storage Tank

Roxana Tank 1 - Horizontal Tank
St. Louis, Missouri

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Gasoline (RVP 10)	All	57.84	52.89	62.80	56.05	1.3339	1.1671	1.5200	88.3404			93.02	Option 4: RVP=10, ASTM Slope=3
2,2,4-Trimethylpentane (isooctane)						0.5596	0.4836	0.6453	114.2300	0.2278	0.1006	114.23	Option 2: A=6.8118, B=1257.84, C=220.74
Benzene						1.0997	0.9555	1.2614	78.1100	0.0246	0.0214	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Ethylbenzene						0.1006	0.0844	0.1195	106.1700	0.0258	0.0020	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Hexane (-n)						1.8084	1.5852	2.0568	86.1700	0.6007	0.8575	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.3086	0.2635	0.3600	92.1300	0.0600	0.0146	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.0837	0.0701	0.0996	106.1700	0.0465	0.0031	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Xylene (-o)						0.0657	0.0548	0.0785	106.1700	0.0146	0.0008	106.17	Option 2: A=6.998, B=1474.679, C=213.69

Attachment A

TANKS 4.0.9d
Emissions Report - Summary Format
Individual Tank Emission Totals

Emissions Report for: Annual

Roxana Tank 1 - Horizontal Tank
St. Louis, Missouri

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Gasoline (RVP 10)	76.81	19.47	96.28
Benzene	1.64	0.42	2.06
Hexane (-n)	65.86	16.70	82.56
Ethylbenzene	0.16	0.04	0.20
Toluene	1.12	0.28	1.41
2,2,4-Trimethylpentane (isooctane)	7.73	1.96	9.69
Xylene (-m)	0.24	0.06	0.30
Xylene (-o)	0.06	0.01	0.07

APPENDIX E Operation & Maintenance Plan

SVE OPERATING AND MAINTENANCE PLAN

WRB REFINING LP
WOOD RIVER REFINERY
& ROXANA PUBLIC WORKS SITE
ROXANA, ILLINOIS

Prepared for
Shell Oil Products US
17 Junction Drive
PMB#39
Glen Carbon, IL 62034

Rev. 0
May 2011

URS Corporation
1001 Highland Plaza Drive West, Suite 300
St. Louis, MO 63110
(314) 429-0100
Project # 21562593

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ADMINISTRATIVE INFORMATION

Client Name: ..... Shell Oil Products US

Site Name ..... WRB Refining LP – Wood River Refinery

Site Location: ..... Roxana, Illinois

URS Program Manager: ..... Bob Billman

IEPA Project Manager ..... Jim Moore

Effective Date: ..... ____, 2011

APPROVAL:

_____	_____
SOPUS Project Manager	Date
_____	_____
URS Program Manager	Date
_____	_____
URS Operator	Date

REVISIONS

Date	Name/Company of Reviewer	Section	Revision

SECTION ONE Introduction

Note: Throughout the SVE O&M Plan, a number of blank spaces exist that will be filled in once final selection of certain components of the SVE system have been made and the system installed. The revised O&M Plan will be submitted as part of the Construction Completion Report following installation of the system.

This Operation and Maintenance Plan (Plan) has been prepared by URS Corporation (URS), on behalf of Shell Oil Products US (SOPUS) for the Soil Vapor Extraction (SVE) system along the west property boundary (a/k/a west fenceline) of the WRB Refining LP, Wood River Refinery (WRR) located at 900 South Central Avenue, Roxana, Illinois. The SVE system will be positioned along the WRR west fenceline and at the Village of Roxana Public Works Yard (Public Works) located at South Chaffer Avenue and East 8th Street in Roxana. The purpose of this Plan is to provide general guidance for the startup, shutdown, operation, preventative maintenance, troubleshooting, and performance monitoring of the vapor recovery and treatment components of the SVE system.

The proposed SVE system and corresponding vapor distribution in the Village is dynamic and this O&M Plan is intended to provide the information necessary to operate the system. Therefore, this plan will be updated as operational conditions change Some of these changes include but are not limited to:

- Equipment, which may result in changes to routine maintenance,
- Monitoring frequency,
- Monitoring locations, and
- Monitoring procedures, including eliminating the need for venting prior to collecting measurements at VMP locations,

As this plan is updated, records will be maintained of the changes, the revision page of this plan will be updated, and revised copies of this plan will be provided to IEPA for informational purposes. It is not anticipated that IEPA will approve the changes. Permitting and other regulatory requirements will be communicated to the appropriate agencies through other documentation.

The vapor recovery and treatment system will utilize 24 extraction wells (**Figure 1**) and will consist of vapor extraction blowers, a regenerative thermal oxidizer (RTO), a condensate management system, and a control room (**Figure 2**). The system equipment building will be

located on Conoco Phillips (COP) or Village property.

This Plan is divided into seven sections.

- Section 1.0 presents a general introduction, including major components of the System and a summary of and contact information for project personnel.
- Section 2.0 presents initial startup and testing procedures for the System.
- Section 3.0 addresses full-scale startup and operation of the System including emergency shutdown procedures.
- Sections 4.0 and 5.0 discuss routine maintenance, troubleshooting, and spare parts inventory for the vapor extraction blower system and RTO.
- Section 6.0 deals with the management of water condensate collected in the vapor extraction collection piping and by the blower's Vapor Liquid Separator (VLS) system.
- Section 7.0 discusses system monitoring and reporting.

Figure 3 presents a schematic diagram of this SVE System. As-built drawings for the SVE System can be found in **Appendix A**.

1.1 SOIL VAPOR EXRACTION SYSTEM OVERVIEW

The proposed SVE system includes 24 extraction wells (17 wells at the WRR site and 7 wells at the Public Works site), valves, well vaults, underground and above ground header piping, VLS system, one vapor extraction blower, and one RTO. The vapor extraction blower consists of a 15 Hp positive displacement blower, interconnection piping, control valves, sample ports, vacuum, pressure, and differential pressure gauges, flow meters, and temperature indicators. The blower includes a Programmable Logic Controller (PLC)-based control panel. The RTO consists of a combustion chamber and burner with a tertiary and combustion air blower, several temperature and pressure sensors, fuel control system, and main PLC based control panel. The VLS system consists of two 140 gallon VLS tanks, two electric transfer pumps, and two 500 gallon aboveground storage tanks (ASTs). The blower and oxidizer PLC control panels transmit data to a computer in the control room that logs and displays operational parameters of the systems.

1.1.1 Vapor Extraction Blower

Electrical components of the blower are constructed to comply with National Electrical Code (NEC) Class 1 Division 1 standards. The blower consists of the following equipment:

- Sutorbilt vacuum blower with a design capacity of 2,370 cubic feet per minute (cfm) at an inlet vacuum of 16 ___ inches of water column (in. wc) (or equivalent).
- 15 Hp, explosion proof, 3 phase, 460 volt, 1800 rpm motor
- Blower inlet piping with vacuum gauge, vacuum relief valve, and sample port
- Six-inch diameter manual dilution valve with Erdco flow meter/transmitter and Solberg filter (or equivalent)
- Differential vacuum gauges to measure the differential pressure across the filter element
- Discharge piping with a silencer, sample port, flow meter, pressure gauge, and temperature gauge
- Control System with control panel, circuit breakers, and remote telemetry and communications system

Detailed information on the vapor extraction blower system can be found in **Appendix B**.

1.1.2 Regenerative Thermal Oxidizer

Recovered soil vapors are mixed with atmospheric (combustion) air provided by the combustion blower and natural gas or propane in the burner, and the mixture is then ignited. The inlet, outlet, and exhaust temperatures of the combustion chamber are monitored and the amount of natural gas or propane added to the air stream is automatically controlled to maintain the predetermined operating temperature. If the hydrocarbon concentrations in soil vapors are sufficiently high, and the combustion chamber temperature exceeds an predetermined outlet temperature, additional atmospheric air is automatically introduced into the combustion chamber from the tertiary blower.

Differential pressure is monitored on the combustion and tertiary blower inlet filters. Operation of the oxidizer is controlled by a PLC based control panel that includes temperature controllers that provide automated control of both the natural gas/propane and tertiary air supplies. The control panel PLC is connected via Ethernet cable to the main computer in the control room through a router. Data collected by the PLC is logged on the computer and displayed on a

Human Machine Interface (HMI).

Typical vapor destruction efficiencies are over 95 percent. After treatment in the RTO the exhaust gas is directed to the atmosphere through a velocity duct exhaust stack. Additional cooling air is mixed with the exhaust gasses at the base of the stack via induction of atmospheric air. The RTO stack terminates at approximately 35 feet above ground surface.

Detailed information on the RTO unit can be found in **Appendix C**.

1.1.3 System Building

A new building will be fabricated to allow for safe operation of the treatment system. The building will house the blower, the VLS system, and the main computer. The RTO will be located immediately adjacent to the building. This configuration allows the operator to access and download operating data in real time from the blowers and RTO, and also has emergency stop capabilities. All alarms and operation parameters are monitored in this building.

1.1.4 PLCs and Data Logging

The PLCs are located in the blower and oxidizer control panel and have their own program. The individual PLC is connected to the main computer via Ethernet cables. The computer in the control room provides all data logging, alarm logging, and the HMI. The computer is equipped with an un-interruptible power supply (UPS). In the event of a power outage, the UPS will provide backup power for the computer.

Detailed information on the PLC configuration and programming, data logging and remote data transfer is included in **Appendix D**.

1.1.5 Vapor/Liquid Separator System

The VLS system is intended to remove liquid from the vapor stream prior to it entering the blowers. The water is intended to collect in the bottom of the separator while the air exits the discharge pipe in the top of the separator. The VLS consists of the following equipment:

- Two 140 gallon VLSs with removable top cover, high level alarm float switch, high and low level pump control switches, and bottom manual drain valve
- VLS transfer pumps powered by a ___ Hp, explosion proof, ___volt, 3 phase motor rated for ___gallons per minute (gpm) at ___feet total dynamic head with pressure gauge and gate valve.

- Two vented 500 gallon double walled polyethylene ASTs with high level alarm float switches.
- Quick connect Camlock fittings on ASTs for discharge to vacuum trucks

Detailed information on the SVE VLS system is included in **Appendix E**.

After initial installation, the blower and RTO will be tested under simulated operating conditions. These procedures should be followed again after a prolonged shutdown period.

The system startup period will be used for testing and verification of the proper operation of the individual system components, control logic, alarms, final programming of the PLC, and overall optimization of the system performance. The system startup period will be implemented with ambient air.

2.1 VAPOR EXTRACTION BLOWER STARTUP AND TESTING

Under normal operating conditions the blower will not operate without the RTO. When the Hand-Off-Auto (HOA) switch for the blower is in the Auto position, operation of the blower is controlled by the oxidizer. The blower can be operated independently from the oxidizer in the Hand position for testing purposes.

2.1.1 Blower Testing

Ambient air will be drawn in through the blower ambient air dilution valve in order to test equipment components and blower control features. The inlet valve on the cross header will remain closed during this testing period. The following steps will be performed as part of the blowers clean air startup.

1 *Equipment specific information will be added when available*

2

3

2.1.2 Blower Startup

Prior to startup of the blower the following procedures need to be followed:

1 *Equipment specific information will be added when available*

2

3

2.1.3 Blower Adjustments

During operation of the blower, the outlet temperature, blower vacuum, discharge pressure, and discharge flow are parameters that will be monitored. The discharge temperature, inlet vacuum,

and discharge pressure should not exceed the manufacturer's specifications as provided in **Appendix B**.

2.2 RTO STARTUP AND TESTING

When an oxidizer is started it controls the corresponding blower if it is in the Auto position. Startup of the oxidizer is automated but steps to follow immediately before startup are described below. At this point, a manufacturer's representative or other qualified person should have already completed the initial tuning of the oxidizer.

The RTO introduces soil vapors and natural gas into the combustion chamber and burns the mixture in a controlled environment. There are several safety interlocks on the oxidizer, but the operator should realize at all times that improper operation of an RTO can result in an explosion, damage to the oxidizer, and serious injury or death.

2.2.1 RTO Testing

Ambient air will be used to test the RTO components after initial installation. Each piece of major equipment (combustion air blower, tertiary air blower, fuel train and burner) will be tested manually before the oxidizers are put into operation with the blower.

2.2.2 RTO Startup

During startup of the oxidizer, the HOA switch for the blower will placed in the Auto position. When the Start button on the oxidizer control panel is pushed the RTO will follow programmed steps during startup.

Adjustments and calibrations will be made as needed. Detailed adjustment of RTO (tuning) will be conducted by a manufacturer's representative as coordinated.

2.2.3 RTO Adjustments

It is recommended that adjustments of the RTO (tuning), other than normal startup and shutdown, be conducted only by a qualified individual. Flow rates can vary at the discretion of a qualified operator. Additional system optimization can be achieved through valve adjustment at individual SVE well locations depending on localized hydrocarbon concentrations.

Specific technical information including manufacturers operation and maintenance manuals and step-by-step procedures for startup, maintenance and operation for the oxidizer are included in **Appendix C**.

SECTION THREE Full Scale SVE Startup and Shutdown

3.1 SVE SYSTEM STARTUP

The RTO and blower should be allowed to reach operating temperature before starting. After conducting the pre-startup adjustments described in Sections 2.1.3 and 2.2.3 the next step is to push the Start button on the oxidizer control panel. Once the temperature of the oxidizer is stable, the system will be brought on line to begin recovery of soil vapor.

For initial startup of the system, the individual legs of the system will be brought on line one by one based on concentrations and performance of the system. The legs will be brought on line in a sequence that will maximize efficiency and reduce the risk of initial concentrations overextending the capability of the RTO.

3.2 SVE SYSTEM SHUTDOWN

A controlled shutdown of the system is basically the opposite of startup steps described above.

3.3 EMERGENCY SHUTDOWN

If immediate shutdown of the individual oxidizer/blower systems or the entire SVE is desired, there are indicated Emergency Stop (E-Stop) buttons on the equipment pad. A main E-Stop is located within the system building which shuts down the oxidizer and blower.

SECTION FOUR Maintenance

4.1 VAPOR EXTRACTION BLOWER

This section provides a summary of routine maintenance, troubleshooting, and a recommended inventory of spare parts for the vapor extraction blower system. Specific technical information relating to the maintenance of the system is included in **Appendix B**. Blower troubleshooting and maintenance should only be conducted by a qualified individual.

4.1.1 Routine Maintenance

Recommended routine maintenance of the blower system includes the following:

- Record operating parameters daily (See **Appendix F** for daily log sheet)
-
-

A summary of the routine maintenance schedule will be added to the system O&M Plan upon receipt from the manufacturer.

4.1.2 Troubleshooting

Specific technical information relating to the troubleshooting of the blower system is included in **Appendix B**. General troubleshooting guides for components of the blower system is provided on **Table 1**.

4.1.3 Spare Parts Inventory

Certain spare parts should be kept in inventory to be used for preventative maintenance and to be available for alarm shutdown situations. A comprehensive list of parts and model numbers is provided in the Manufacturer's literature in **Appendix B**. A summary of the recommended spare parts to keep in inventory, manufacturer/supplier, model number, are provided on **Table 2**.

4.2 RTO SYSTEM

This section provides a summary of routine maintenance, troubleshooting, and a recommended inventory of spare parts for the RTO system. Specific technical information relating to the maintenance of the system is included in **Appendix C**. RTO troubleshooting and maintenance should only be conducted by a qualified individual.

4.2.1 Routine Maintenance

Recommended routine maintenance of the RTO system includes the following:

- Record operating parameters daily (See **Appendix F** for daily log sheet)
-
-

4.2.2 Troubleshooting

Specific technical information relating to the troubleshooting of the RTO systems is included in **Appendix C**. General troubleshooting guides for components of the RTO system are provided on **Table 3**.

4.2.3 Spare Parts Inventory

Certain spare parts should be kept in inventory to be used for preventative maintenance and to be available for alarm shutdown situations. A comprehensive list of parts and model numbers is provided in the Manufacturer's literature in **Appendix C**. A summary of the recommended spare parts to keep in inventory, manufacturer/supplier, model number, are provided in **Table 4**.

4.3 VLS SYSTEM

4.3.1 Routine Maintenance

Routine maintenance of the VLS system includes

- Cleaning accumulated sediment quarterly or on an as needed basis.
- Clean the float switches on the VLS tanks monthly if water is accumulating

Specific technical information relating to the maintenance of the system is included in **Appendix E**.

4.3.2 Spare Parts Inventory

A summary of the recommended spare parts to keep in inventory, manufacturer/supplier, model number, are provided on **Table 5**.

4.3.3 Condensate Management

Water recovered by the SVE system is referred to as condensate. The water originates as moisture in the recovered soil vapor. This water is intermittently vacuumed into the system piping and accumulates in low areas of the piping, subsequently restricting airflow. The velocity of air moving through the piping carries this water to the SVE treatment area, where it is recovered by the VLS system.

Condensate management includes the monitoring of water accumulation in, and transfer from, the VLSs to the ASTs. Water collected will be sampled and determination will be made if waste water is designated hazardous or non-hazardous. If found to be hazardous, waste water will be transported within 90 days to a designated treatment facility. If found to be non-hazardous, waste water will be transported to an alternate treatment facility.

SECTION FIVE SVE Well Performance Monitoring Program

The objective of the SVE Well Performance Monitoring Program is to optimize the operation and performance of the SVE system. Routine SVE well monitoring and maintenance will initially be conducted on a daily schedule at each of the 24 SVE wells as outlined below. Additional monitoring and maintenance of approximately 45 vapor monitoring point (VMP) locations, each consisting of multiple ports screened at different depths, will be performed in conjunction with monitoring the SVE wells. Sampling is sequenced to ensure SVE and VMP well data corresponds spatially and temporally. The daily gauging will be reduced to weekly after the first two weeks of operation. The gauging frequency will then be reduced to monthly after the first month and quarterly after the first quarter. A schedule of the SVE performance monitoring activities is presented in **Table 6**.

Monitoring and maintenance frequencies are likely to change based on the needs of the SVE system. Therefore, the procedures presented in this document shall be reviewed and updated on an ongoing basis to remain consistent with changing field conditions.

Field activities are conducted by the system operators. The scope of data collection includes:

- Pressure, air flow, fluid level, and screening measurements at operational SVE wells
- Pressure, gauging and screening measurements at specified VMPs

Equipment used in the subsurface monitoring includes:

- Manometers (Digital) for pressure measurements.
- Photo Ionization Detectors (PIDs) / Flame Ionization Detectors (FIDs) for vapor concentration
- Gas meters for O_2, CO_2, LEL, methane gas measurements
- Airflow meters for air velocities at SVE wells and piping
- Dataloggers for digitally compiling data.

The Scope of the SVE Performance Monitoring Program is summarized in the text below. The following Standard Operating Procedures (SOPs) are included in the **Appendix E**:

- Roxana SOP-01 – Soil Vapor Extraction Well Data Collection and Sampling
- Roxana SOP-02 – Regional Effectiveness Monitoring
- Roxana SOP-03 – Soil Vapor Field Laboratory Screening
- Roxana SOP-04 – Dwyer Digital Manometer
- URS SOP No. 3 – Calibration and Maintenance of Field Instruments
- URS SOP No. 4 – Equipment Decontamination

5.1 SVE WELLS

Monitoring and maintenance at each SVE well location will include the activities listed below.

Water Removal from Well Vaults

SVE well vaults will be checked for the presence of water. If water is present a suitable portable pump will be used to dewater the well vault.

Soil Vapor Screening

A field screening sample will be collected from SVE wells with open screens. Screening samples will be collected in tedlar bags using a vacuum chamber and vacuum pump or direct read instrument. Specific screening sample procedures are presented in Roxana SOP-01. Specific procedures for field analysis of samples are presented in Roxana SOP-03.

Typical ranges for readings in SVE wells are:

- FID: ___-___ ppmv
- PID: ___-___ ppmv
- O_2: ___-___ %
- CO_2: ___-___ %
- Methane: ___-___ ppmv.

Vacuum and Flow Readings

A digital manometer will be used to measure the vacuum at each SVE well. Flow will be measured at each SVE well using a pitot tube connected to a digital manometer. Specific procedures for the collection of vacuum and flow measurements are presented in Roxana SOP-01.

Typical ranges for readings in SVE wells are:

- Vacuum: 10-20 in WC
- Flow: 50-60 CFM

Fluid Level Measurement

In order to determine open screen lengths and potential silt accumulation, each SVE well will be gauged for depth to product (if present), depth to water, and total depth using a decontaminated

interface meter. Specific procedures for collection of fluid level measurements are presented in Roxana SOP-01.

Before accessing SVE wells located on the WRR, URS personnel will obtain necessary permits and follow WRR health and safety procedures.

5.1.1 Maintenance – SVE Wells

Based on the SVE well monitoring, various maintenance and adjustment activities will be performed.

Condition	Recommended Maintenance / Adjustment
Air flow = 50-60cfm	Normal operating range
Air flow = <35 cfm	Install/modify wellhead with a 2" flow tube
Air flow = >70 cfm	Adjust rotary control valve, in the well vault, until an air flow <70 cfm is achieved.
>2 ft of silt present in the well	Silt build-up will be removed
<10 ft of open screen due to DTW	Install stinger/straw
<3 ft of open screen in a static condition	Rotary control valve is completely closed
Wells with LNAPL and a stinger present	Rotary control valve is completely closed
High air flow along with normal oxygen level readings	Rotary control valve is completely closed and evaluate for short circuiting
Stingers with bio-fouling	Clean or replace stingers
Cracked stinger seals	Replace

5.2 VMP LOCATIONS

In order to evaluate the effectiveness of the SVE system, VMP monitoring at approximately 45 well clusters will be conducted (**Figure 1**). In addition to the 34 VMP well locations that will initially be monitored daily, another 11 VMP well locations will be monitored monthly. Data collected from the VMP wells will help in determining the zone of influence from the SVE system and the extent of the hydrocarbon vapor plume. Based on this information, the SVE system can be adjusted to maximize hydrocarbon vapor recovery. VMP monitoring and maintenance will consist of the activities described below.

Initial Vacuum/Pressure Measurement

Using a digital manometer, the initial vacuum/pressure will be measured at each VMP monitoring location. Basic manometer operation instructions can be found in Roxana SOP-04.

The pressure, and time it was observed, is immediately read and recorded to the nearest hundredth of an inch (or tenth of an inch if using 0-200 manometer) of water column. Specific procedures for collection of initial vacuum/pressure measurements are presented in Roxana SOP-02.

Well Purging

After obtaining the initial vacuum/pressure measurements and prior to soil vapor sample collection, a 60 mL syringe will be used at each VMP monitoring location to purge a predetermined amount based on the volume of the well riser and screen. The purge volume shall be equivalent to a minimum of three well volumes. Specific procedures for well purging are presented in Roxana SOP-02

Soil Vapor Screening

Upon completion of well purging, a soil vapor screening sample will be collected. Soil vapor samples for on-site screening shall be collected using a Tedlar bag and peristaltic pump. Specific procedures for collection of soil vapor screening samples are presented in Roxana SOP-02.

Venting

Upon completion of soil vapor screening, VMP monitoring locations are vented (opened to atmosphere) for 15 minutes. This allows for well stabilization to occur.

Stabilized Vacuum/Pressure Measurement

Once the VMP has been allowed to vent for 15 minutes, a stabilized vacuum/pressure measurement will be recorded using a digital manometer. A pressure is considered to be stabilized when it does not fluctuate more than 5% in one minute. The manometer shall be allowed a maximum of thirty (30) minutes to stabilize before the vacuum/pressure is recorded. Specific procedures for the collection of stabilized vacuum/pressure measurements are presented in Roxana SOP-02.

Soil Vapor Field Laboratory Screening

Soil vapor screening samples collected from the VMP monitoring locations will be analyzed in the field using the following equipment:

- TVA-1000 or performance equivalent for volatile organic compounds (VOCs) and methane by FID and for VOCs by PID

- LANDTEC GEM-2000 or performance equivalent for oxygen and carbon dioxide.

Specific procedures, including those for equipment calibration and quality control, are presented in Roxana SOP-03.

Work must be performed in accordance with the Roxana Health and Safety Plan.

SECTION SIX Staffing

Project personnel include:

- Program Manager – Bob Billman
- Project Manager – Steve Shroff
- Site Safety Officer – Kelly Hurst
- Data Manager – Meg Reynolds
- System Operators – Rich Hart (primary) and Nathan McNurlen (secondary/backup)

The SVE monitoring program will be conducted by the SVE system operator(s)
General responsibilities of the operators are as follows:

- Setting up site
- Calibrating the laboratory instruments
- Collecting samples
- Screening the soil vapor samples
- Recording data
- Labeling of soil vapor samples
- Sorting the samples
- Logging the samples
- Recording data electronically.
- Following data collection, the data will electronically submitted to the Data Manager for incorporation into the project specific data management system.

SECTION SEVEN Reporting

7.1 OPERATIONAL STATUS REPORTS

Data collected during the quarterly sampling vapor monitoring events will continue to be reported following each quarterly sampling event.

7.2 EQUIPMENT FAILURE NOTIFICATION

In the event of an equipment failure directly causing a deviation from conditions of the operating permit, URS will discontinue operation of the affected unit(s) until repairs are made. URS will also notify the Illinois EPA of the deviations as required. The report will include a description of the deviation, the probable cause of such a deviation, and any corrective measures taken to correct the deviation.

Tables

Table 6
SVE Performance Monitoring Schedule

	Activity	Frequency	Equipment	SOP
SVE Wells (22)	Soil Vapor Screening	Weekly	Tedlar bag Vacuum chamber Vacuum pump	Roxana SOP-03
	Vacuum/Pressure Measurement	Weekly	Digital manometer	Roxana SOP-01
	Flow Measurement	Weekly	Digital manometer Pitot tube	Roxana SOP-01
	Fluid Level Measurement	Weekly	Interface meter	Roxana SOP-01
System VMP Wells (32)	Initial Vacuum/Pressure Measurement	Weekly	Digital manometer	Roxana SOP-02 Roxana SOP-04
	Well Purging	Weekly	60 mL syringe	Roxana SOP-02
	Soil Vapor Screening	Weekly	Tedlar bag Peristaltic pump	Roxana SOP-02
	Venting	Weekly	None	Roxana SOP-02
	Stabilized Vacuum Pressure Measurement	Weekly	Digital manometer	Roxana SOP-02 Roxana SOP-04
	Soil Vapor Field Laboratory Screening	Weekly	TVA-1000 (PID/FID) ppbRAE (PID) Landtec Gem 2000 (O2, CO2)	Roxana SOP-03
Village VMP Wells (11)	Initial Vacuum/Pressure Measurement	Monthly	Digital manometer	Roxana SOP-02 Roxana SOP-04
	Well Purging	Monthly	60 mL syringe	Roxana SOP-02
	Soil Vapor Screening	Monthly	Tedlar bag Peristaltic pump	Roxana SOP-02
	Venting	Monthly	None	Roxana SOP-02
	Stabilized Vacuum Pressure Measurement	Monthly	Digital manometer	Roxana SOP-02 Roxana SOP-04
	Soil Vapor Field Laboratory Screening	Monthly	TVA-1000 (PID/FID) ppbRAE (PID) Landtec Gem 2000 (O2, CO2)	Roxana SOP-03

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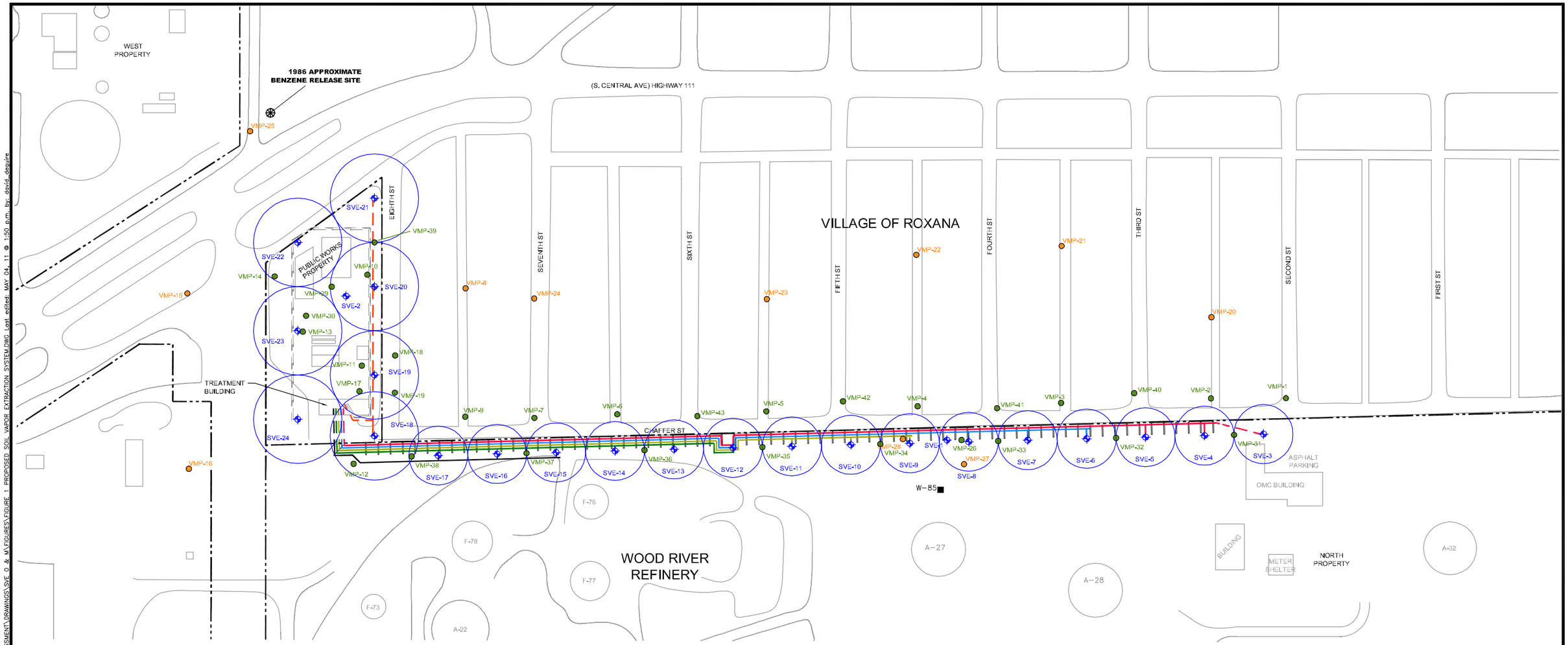
Figures



LEGEND:

- VAPOR MONITORING POINT (VMP) LOCATION - MONTHLY MONITORING
- VAPOR MONITORING POINT (VMP) LOCATION - INITIAL WEEKLY MONITORING/LONG-TERM MONTHLY MONITORING
- SVE EXTRACTION WELL - WEEKLY MONITORING
- UNDERGROUND PIPING (DASHED)
- ABOVEGROUND PIPING
- PROPERTY BOUNDARY
- ESTIMATED RADIUS OF INFLUENCE

NOTES:
1. WELL LOCATIONS ARE PROPOSED AND WILL BE MOVED AS CLOSE TO THE FENCE LINE AS IS SAFE.
2. VMP-31 THROUGH VMP-43 ARE PROPOSED LOCATIONS.

LEG #	SVE WELLS	COLOR
1	SVE-3 THROUGH SVE 5	RED
2	SVE-6 THROUGH SVE-8	BLUE
3	SVE-9 THROUGH SVE-11	YELLOW
4	SVE-12 THROUGH SVE-14	GREEN
5	SVE-15 THROUGH SVE-17	BLACK
6	SVE-18 THROUGH SVE-21	ORANGE
7	SVE-22 THROUGH SVE-24	WHITE

N

200 0 200

SCALE IN FEET

DRAFT

SHELL OIL PRODUCTS US
ROXANA, ILLINOIS

PROJECT NO. 21562593

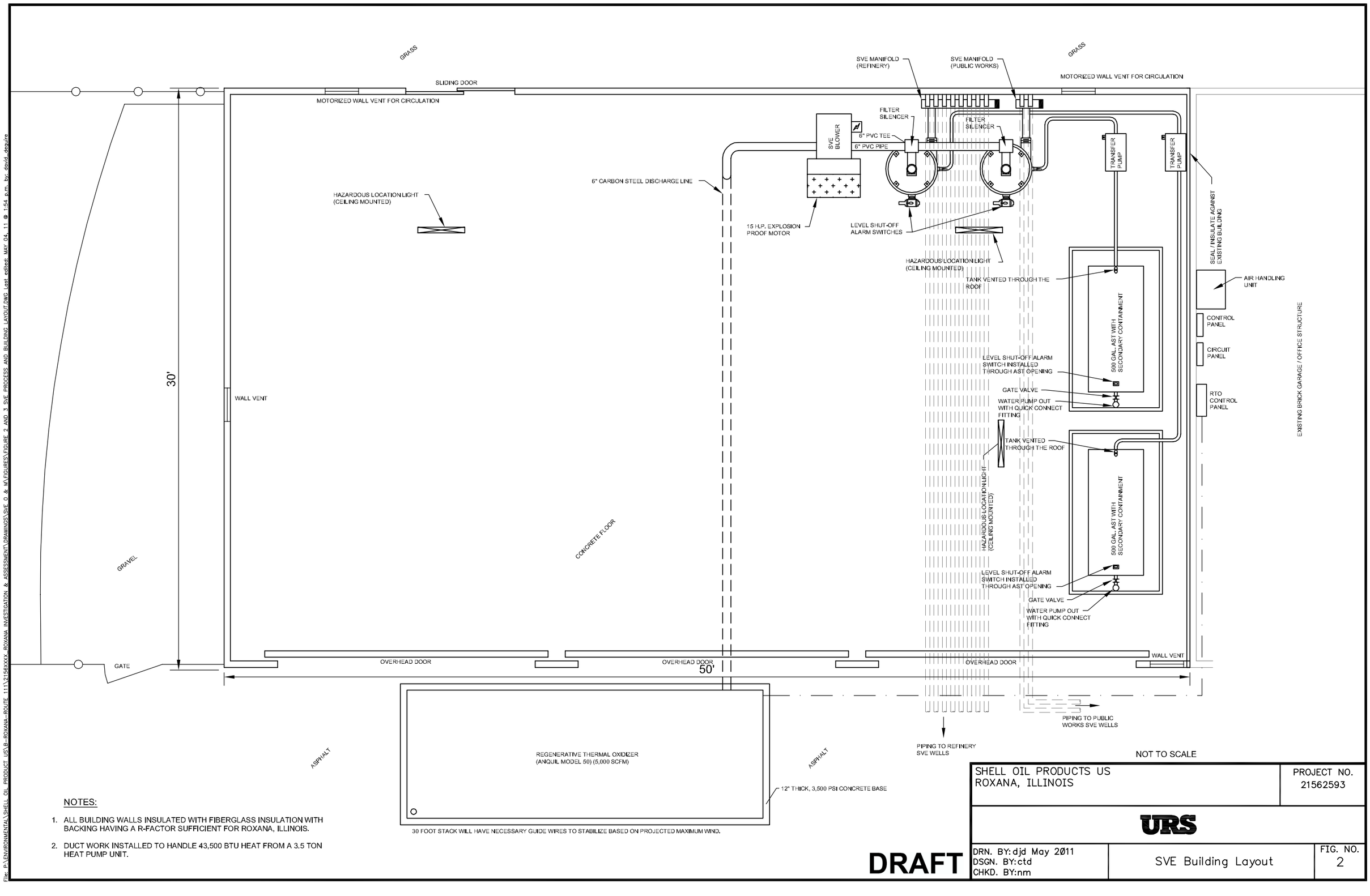
URS

DRN. BY: djd May 2011
DSGN. BY: ctd
CHKD. BY: nm

Proposed Soil Vapor Extraction System

FIG. NO. 1

File: P:\ENVIRONMENTAL\SHELL OIL PRODUCT US\B-ROXANA-ROUTE 111\2156XXXX ROXANA INVESTIGATION & ASSESSMENT\DRAWINGS\SVE O & M\FIGURES\FIGURE 1 PROPOSED SOIL VAPOR EXTRACTION SYSTEM.DWG Last edited: MAY 04, 11 @ 1:50 p.m. by: david_deguire



NOT TO SCALE

30 FOOT STACK WILL HAVE NECESSARY GUIDE WIRES TO STABILIZE BASED ON PROJECTED MAXIMUM WIND.

NOTES:

1. ALL BUILDING WALLS INSULATED WITH FIBERGLASS INSULATION WITH BACKING HAVING A R-FACTOR SUFFICIENT FOR ROXANA, ILLINOIS.
2. DUCT WORK INSTALLED TO HANDLE 43,500 BTU HEAT FROM A 3.5 TON HEAT PUMP UNIT.

DRAFT

SHELL OIL PRODUCTS US ROXANA, ILLINOIS		PROJECT NO. 21562593
URS		
DRN. BY: djd May 2011 DSGN. BY: ctd CHKD. BY: nm	SVE Building Layout	FIG. NO. 2

File: P:\ENVIRONMENTAL\SHELL OIL PRODUCT US\B-ROXANA-ROUTE 111\21562XXX-ROXANA INVESTIGATION & ASSESSMENT\DRAWINGS\SVE 0 & M\FIGURES\FIGURE 2 AND 3 SVE PROCESS AND BUILDING LAYOUT.DWG Last edited: MAY 04, 11 @ 1:54 p.m. by: david desaire

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MANIFOLD = VACUUM INLET
(MFD-101) MANIFOLD SIZE = 4"
MANIFOLD MATERIAL = WELDED PVC
NUMBER OF LEGS = 2
SIZE OF LEGS = 4" (ONE LEG SHOWN AS TYPICAL)

PUBLIC WORKS MANIFOLD SEE DETAIL, THIS SHEET

3/8" BRASS BALL VALVE WITH 3/8" HOSE BARB SAMPLE PORT

4" TO 3/8" REDUCING BUSHING

4" CARBON STEEL

KEY INSTRUMENTS 5 ASI 25-250 SCFM FLOW METER

2 PVC BALL VALVE

4" TO 2" REDUCING BUSHING FROM CARBON STEEL TO PVC

WIKA MODEL 612.20 0-60"WC P1 402

6" PVC

VAPOR/ LIQUID SEPARATOR VLW-140

LG 401 LSL 401 LSH 401 LSHH 401

6" CLEAN OUT

EPOXY COATED INTERIOR

1" PVC BALL VALVE

SOLBERG CSL-685P-1000F IN-LINE FILTER /SILENCER

WIKA MODEL 612,20 0-60"WC P1 701

TOTAL FLOW METER

6" PVC

3" TO 3/8" REDUCING BUSHING

3/8" BRASS BALL VALVE WITH 3/8" HOSE BARB SAMPLE PORT

6" PVC BALL VALVE

BLEED AIR SOLBERG CSL-685P-1000F IN-LINE FILTER /SILENCER

6" DILUTION LINE PIPE

6" PVC TEE

WIKA MODEL N31,11 0-100PSI P1 403

1" NIBCO Y-PATTERN BRASS CHECK VALVE

1" PVC

1" PVC GATE VALVE

3/8" BRASS BALL VALVE WITH 3/8" HOSE BARB SAMPLE PORT

1" NIBCO Y-PATTERN BRASS CHECK VALVE

1" PVC

P 401

NOTES FOR OUTPUT:
GOULD NPE MODEL 1ST
FLOWRATE & PRESSURE = 40GPM @ 100'
HORSEPOWER = 1
VOLTAGE & PHASE = 230V 3ph
FULL-LOAD AMPS = 3a

500 GALLON AST WITH SECONDARY CONTAINMENT AND VENT PIPE

WATER LINE FOR PUMP OUT

VACUUM RELIEF ROTRON 551026

6" TO 1.5" REDUCING BUSHING

20-180"WC

B 701

DISCHARGE SILENCER

WIKA MODEL 610.10 #9747473 0-60"WC P1 702

WIKA MODEL TI20, 0-250F TI 701

6" CARBON STEEL

3/8" BRASS BALL VALVE WITH 3/8" BRASS HOSE BARB

NOTES FOR OUTPUT:
SUTORBILT FLOWRATE & PRESSURE = 2,368 SCFM @ 27 WC HORSEPOWER = 15
VOLTAGE & PHASE = 230V 3ph

REGENERATIVE THERMAL OXIDIZER ANQUIL MODEL 50 WITH 35 FOOT STACK (5,000 SCFM) scfm RTO

MANIFOLD = VACUUM INLET
(MFD-101) MANIFOLD SIZE = 4"
MANIFOLD MATERIAL = WELDED PVC
NUMBER OF LEGS = 3
SIZE OF LEGS = 4" (ONE LEG SHOWN AS TYPICAL)

REFINERY MANIFOLD SEE DETAIL, THIS SHEET

3/8" BRASS BALL VALVE WITH 3/8" HOSE BARB SAMPLE PORT

4" TO 3/8" REDUCING BUSHING

4" CARBON STEEL

KEY INSTRUMENTS 5 ASI 25-250 SCFM FLOW METER

2 PVC BALL VALVE

4" TO 2" REDUCING BUSHING FROM CARBON STEEL TO PVC

WIKA MODEL 612,20 0-60"WC P1 402

6" PVC

VAPOR/ LIQUID SEPARATOR VLW-140

LG 401 LSL 401 LSH 401 LSHH 401

6" CLEAN OUT

EPOXY COATED INTERIOR

1" PVC BALL VALVE

SOLBERG CSL-685P-1000F IN-LINE FILTER /SILENCER

WIKA MODEL 612,20 0-60"WC P1 701

TOTAL FLOW METER

6" PVC

3" TO 3/8" REDUCING BUSHING

3/8" BRASS BALL VALVE WITH 3/8" HOSE BARB SAMPLE PORT

6" PVC TEE

WIKA MODEL N31,11 0-100PSI P1 403

1" NIBCO Y-PATTERN BRASS CHECK VALVE

1" PVC

1" PVC GATE VALVE

3/8" BRASS BALL VALVE WITH 3/8" HOSE BARB SAMPLE PORT

1" NIBCO Y-PATTERN BRASS CHECK VALVE

1" PVC

P 401

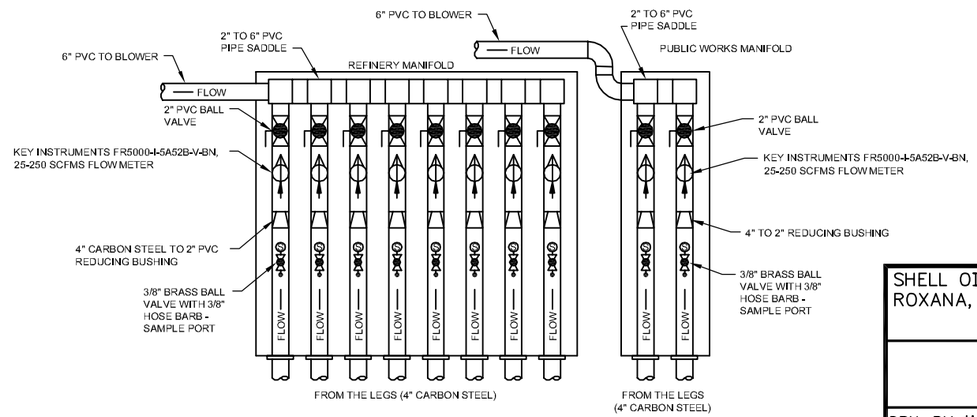
NOTES FOR OUTPUT:
GOULD NPE MODEL 1ST
FLOWRATE & PRESSURE = 40GPM @ 100'
HORSEPOWER = 1
VOLTAGE & PHASE = 230V 3ph
FULL-LOAD AMPS = 3a

500 GALLON AST WITH SECONDARY CONTAINMENT AND VENT PIPE

WATER LINE FOR PUMP OUT

LEGEND:

- PRESSURE GAUGE - PRESSURE RANGE LISTED ABOVE SYMBOL, MODEL TYPE INDICATED BY NUMBER IN CIRCLE (IF IN INCHES THEN GAUGE MEASURES PRESSURE DIFFERENCE FOR FLOW READING
- TEMPERATURE GAUGE - TEMPERATURE RANGE LISTED ABOVE THE SYMBOL
- FLOW METER - DIRECTION OF FLOW IS INDICATED BY ARROW HEADS
- BALL VALVE - WITH HANDLE IN THE OPEN POSITION WHEN CIRCLE IS NOT FILLED IN
- BALL VALVE - WITH HANDLE IN THE CLOSED POSITION WHEN CIRCLE IS FILLED IN
- FLEX CONNECTION (RUBBER)
- ALARM FOR HIGH TEMPERATURE (PILOT LIGHT)
- GATE VALVE WITH HANDLE
- CHECK VALVE
- PRESSURE RELIEF VALVE
- VACUUM RELIEF VALVE
- LEVEL GAUGE
- LEVEL SWITCH LOW
- LEVEL SWITCH HIGH
- LEVEL SWITCH HIGH HIGH
- PRESSURE SWITCH FOR HIGH ALARM
- SAMPLE PORT - CLOSED WHEN CIRCLE IS FILLED IN
- REDUCER (FROM LARGER PIPE TO SMALLER PIPE)
- HOSE CONNECTION
- TRANSFER PUMP
- BLOWER



MANIFOLD DETAIL

DRAFT

SHELL OIL PRODUCTS US ROXANA, ILLINOIS	PROJECT NO. 21562593
URS	
DRN. BY: djd May 2011 DSGN. BY: ctd CHKD. BY: nm	SVE Process and Instrumentation Diagram
	FIG. NO. 3

APPENDIX F SVE SOPs

1.0 OBJECTIVE

The purpose of this Standard Operating Procedure (SOP) is to provide a consistent methodology for data and soil vapor sample collection at the Roxana SVE System. This SOP is applicable to:

- Collecting data from and sampling Roxana Soil Vapor Extraction (SVE) wells
- Collecting data from and sampling the Main Header Line

2.0 DATA COLLECTION & SAMPLING PROCEDURE FOR SVE WELLS

This section provides step-by-step procedures for data collection and soil vapor sampling of SVE wells. The field data sheet or the appropriate fields in the SVE Monitoring software should be filled out completely with the appropriate observations and data collected during sampling. All applicable components of the Health and Safety Plan, including completion of Job Safety Analysis (JSA) forms, will be followed while performing the activities described in this SOP.

2.1 Equipment

The following equipment is required for SVE well data collection and sampling:

- Crow bars (2)
- Extension cord
- SVE Data Collection sheets or Toughbook with SVE Monitoring software
- Impact driver (or socket set) with sockets
- Oil/Water Interface probe
- Isopropyl alcohol
- Manometer (0-20 inches water column)
- Manometer (0-200 inches water column)
- 12 V Marine battery
- Nut drivers
- Paper towels
- Pitot tube
- PPE
    - ANSI Class II safety vest

  - Hardhat
  - Nitrile gloves
  - Leather gloves
  - Safety glasses
  - Steel-toe boots
  - FRC Clothing
  - Hearing protection
- Polyethylene tubing – 3/16" ID x 1/4" OD
- Power inverter
- Silicone tubing - 3/16" ID x 3/8" OD
- Sump pump
- Tedlar bags
- Traffic barricades
- Vacuum chamber
- Vacuum pump

2.2 Upon Arrival at Well

1. Position truck in front of the well to be sampled, turn on hazard lights.
2. Place traffic cones in front of and behind the truck.
3. Remove well vault bolts and use crow bars to release vault latch and pry open. Engage safety latch to secure vault lid in open position. Record position of main SVE valve.
4. If sufficient rain water is present in vault to impede work, use a sump pump to drain the vault.

2.3 Sample Collection

5. Write the well ID, date, and sample time on a Tedlar bag and place in vacuum chamber.

6. Using a clean piece of disposable silicone tubing, connect the Tedlar bag to the interior barb of the vacuum chamber sample inlet port. Open the valve on the Tedlar bag by turning it counterclockwise ½ to 1 full turn.
7. Connect the vacuum pump to the vacuum port on the exterior of the vacuum chamber.
8. Connect the exterior barb of the vacuum chamber sample inlet port to the sample port of the well. Turn the lever on the sample port of the well and also of the vacuum chamber inlet port to the open position.
9. Turn on the vacuum pump to fill the Tedlar bag.
10. Once the Tedlar bag is full, turn the lever on the vacuum chamber sample inlet port to the off position and disconnect the vacuum line from the vacuum chamber. (*Note: This is not the final sample. Steps 6 through 10 were performed to purge ambient air from the tubing)*
11. Open the vacuum chamber, disconnect the Tedlar bag, and connect the vacuum line to Tedlar bag to remove purged ambient air. Reconnect Tedlar bag to sample inlet of vacuum chamber and reconnect vacuum line to vacuum chamber.
12. Open the sample inlet port on the vacuum chamber to refill the Tedlar bag.
13. Once the Tedlar bag is full, turn the lever on the vacuum chamber sample inlet port to the off position, disconnect the vacuum line from the vacuum chamber, turn off the vacuum pump, and turn the lever of the sample port on the well to the closed position.
14. Close the valve on the Tedlar bag, remove it from the vacuum chamber, and check for leaks by holding the bag close to ear. If no leaks are detected, thread bag onto a string for later analysis (See Roxana SOP-03).

2.4 Vacuum and Flow Data Collection

15. Record the vacuum on the SVE well by connecting the digital manometer (0-200 in. w.c.)(Roxana SOP-04) to the sample port of the well and turning the sample port lever to the open position. If the vacuum reading fluctuates, record the highest, lowest, and the most consistent reading.
16. Record the flow measurement by first connecting the digital manometer (0-20 in. w.c.)(Roxana SOP-04) to the pitot tube (the top port of the pitot tube connects to the high pressure port of the manometer and the side port of the pitot tube connects to the low pressure port of the manometer). Unscrew the sample port or plug located on the SVE well and insert the pitot tube. If the flow reading fluctuates, record the highest, lowest, and the most consistent reading.

17. Upon removal from the well, check the pitot tube for moisture by placing the tip of the pitot tub next to the vacuum of the well. Record any moisture that is observed exiting the pitot tube.
18. Replace the sample port or plug.

2.5 Fluid Level Measurement

19. Turn the main SVE valve to its fully closed position.
20. Remove the well cap.
21. Turn the interface probe on and lower probe into the SVE well. Record fluid levels and total depth as described in URS SOP No. 10. Additionally, record if the bottom surface of the well is hard or soft. Decontaminate the probe and tape as described in URS SOP No. 4.
22. Record the condition of the probe and tape upon removal (e.g. clean, product, sludge, foam, silt) and any well defects or maintenance issues.
23. Replace the well cap.
24. Return the main SVE valve to its original position.
25. Disengage safety latch and lower vault lid. Replace well vault bolts.
26. Load traffic cones and other equipment and move to next well location.

3.0 DATA COLLECTION & SAMPLING PROCEDURE FOR THE MAIN HEADER LINE

This section provides step-by-step procedures for data collection and soil vapor sampling of the Main Header Line, located immediately upstream of the VLS units. The field data sheet or the appropriate fields in the SVE Monitoring software should be filled out completely with the appropriate observations and data collected during sampling.

3.1 Equipment

The following equipment is required for Main Header Line data collection and sampling:

- Crescent wrench
- Extension cord
- Main Header Line Data Collection sheets or Toughbook with SVE Monitoring software
- Manometer (0-20 inches water column)
- Manometer (0-200 inches water column)
- PPE

- ANSI Class II safety vest
- Hardhat
- Nitrile gloves
- Safety glasses
- Steel-toe boots

- Silicone tubing - 3/16" ID x 3/8" OD
- Polyethylene tubing – 3/16" ID x 1/4" OD
- Summa canister
- Tedlar bags
- Vacuum chamber
- Vacuum pump

3.2 Data Collection at the Regenerative Oxidizer Unit

1. Record the temperature of the inflowing soil vapor from the temperature gauge.
2. Record the differential pressure reading. If the reading fluctuates, record the highest, lowest, and the most consistent reading.
3. Record the vacuum reading by connecting a manometer (0-200 in. w.c.)(Roxana SOP-04) to the sample port located on main header line and turning the valve to the open position. If the vacuum reading fluctuates, record the highest, lowest, and the most consistent reading.
4. Record the status of the SVE system, on or off.
5. From the computer located in the control building, record the main header vacuum and flow readings.

3.3 Tedlar Bag Sample Collection

6. Write the sample ID, date, and sample time on a Tedlar bag and place in the vacuum chamber. Record this data on the field data sheet.
7. Using a clean piece of disposable silicone tubing, connect the Tedlar bag to the interior barb of the vacuum chamber sample inlet port. Open the valve on the Tedlar bag by turning it counterclockwise ½ to 1 full turn.
8. Connect the vacuum pump to the vacuum port on the exterior of the vacuum chamber.

9. Connect exterior barb of the vacuum chamber sample inlet port to the sample port on the main header line. Turn the lever on the sample port of the main header line and also of the vacuum chamber inlet port to the open position.
10. Turn on the vacuum pump to fill the Tedlar bag.
11. Once the Tedlar bag is full, turn the lever on the vacuum chamber sample inlet port and the main header line lever to the closed position and disconnect the vacuum pump line from the vacuum chamber. (*Note: This is not the final sample. Steps 10 through 14 were performed to purge ambient air from the tubing)*
12. Open the vacuum chamber, disconnect the Tedlar bag, and manually push all the air out of the Tedlar bag to remove purged ambient air. Reconnect Tedlar bag to sample inlet of vacuum chamber.
13. Reconnect the vacuum pump line and open the sample inlet port on the vacuum chamber to refill the Tedlar bag.
14. Once the Tedlar bag is full, turn the lever on the vacuum chamber sample inlet port and the main header sample port to the closed position, disconnect the vacuum pump line from the vacuum chamber.
15. Close the valve on the Tedlar bag, remove it from the vacuum chamber, and check for leaks by holding the bag close to ear. If no leaks are detected, the bag is ready for analysis (See Roxana SOP-03).

3.4 Summa Canister Sample Collection

19. Use a crescent wrench to attach the vacuum gauge to the top of a new summa canister.
20. Using a clean piece of disposable silicone tubing, connect the sample nipple coming off the vacuum gauge to the main header sample port. Do not open the sample port. Open the valve on summa canister and record the initial vacuum reading of the summa canister.
21. Turn the main header sample port lever to the open position and wait until the vacuum reading on the summa canister vacuum gauge stabilizes.
22. Close the inlet valve on the summa canister and turn the main header sample port lever to the closed position.
23. Record the final vacuum reading of the summa canister and then disconnect the silicone tubing.
24. Fill out chain of custody form, including sample ID, date and time of collection, initial and final vacuum, summa canister number, and analyses requested.

URS
Shell Oil Products US
SVE Effectiveness Monitoring

SVE:_____ Date:_____

Technician(s):_____ Time Arrived:_____

SVE System Running at_____ in wc

Gauge Reading_____ in Hg Gauge type/brand_____

Valve Position Upon Arrival: Open / Closed Position/Notch # :_____
Valve Position Upon Departure: Open / Closed Position/Notch # :_____

Vacuum Reading:_____ in wc Time:_____ Surface Temp of Flow Meter

If Surging:_____ in wc to_____ in wc _____°F

Flow Differential (pitot / venturi):_____ in wc Time:_____

If Surging:_____ in wc to_____ in wc
Water in Pitot Tube: Yes / No

Tedlar Bag Sample: Yes / No If Yes: Time Sample Taken:_____

Well/Vault Integrity
Quantity of Water in Vault:_____ Short Circuiting: Yes / No

Drain Plug: In / Out / Pulled - Time:_____ Hear Well Surge Yes / No

Condition of Well/Vault/Valves:

SILT and WATER INVESTIGATION

Time:_____ DTW:_____ Bottom: Hard / Soft

TD:_____

Condition of Tape After Removal:
Circle One: Dilution Valve / Stinger / Bubbler Tube / None in Well

Date Well Last Cleaned:_____ Header Line Last Cleaned:_____

AIR ANALYSIS

FID TVA 1000 4-Gas Meter

PID ppm FID ppm $\%O_2$ $\%CO_2$ %LEL

Dilution Probe Used: Yes / No If Yes, Dilution Ratio:_____

1.0 OBJECTIVE

The purpose of this Standard Operating Procedure (SOP) is to provide a consistent methodology for the collection of soil vapor samples at the Roxana SVE System. This SOP details the necessary procedures to follow so that representative samples are collected. These procedures are applicable to any soil vapor sample collected at the site, with the exception of those collected directly from SVE wells. Important uses of these data include:

- Soil vapor extraction (SVE) system performance evaluation
- Evaluation of sub-slab VOC concentrations
- Hydrocarbon plume definition

2.0 REQUIRED MATERIALS FOR SAMPLE COLLECTION

- Dwyer Series 475 Mark III Digital manometer
- 1-liter Tedlar bags
- Silicone tubing - 3/16" ID x 3/8" OD
- Polyethylene tubing – 3/16" ID x 1/4" OD
- Peristaltic pump – 60-350 RPM
- BIOS DC-LITE flow calibrator or calibrated rotometer (0-500 mL/min)
- 60-mL syringe
- Crescent wrench (or equivalent hand tools)
- SVE System Effectiveness Monitoring Forms or Toughbook with SVE Monitoring software

3.0 INITIAL VACUUM/PRESSURE MEASUREMENT

Using a Dwyer Series 475 Mark III digital manometer, the initial vacuum/pressure is measured. Basic manometer operation instructions can be found in Roxana SOP-04.

At VMP monitoring locations, the positive fitting of the manometer shall be connected to the well. The negative fitting on the manometer shall remain open to the atmosphere. The pressure and time it was observed, is immediately read and recorded to the nearest hundredth of an inch (or tenth of an inch if using 0-200 manometer) of water column on the SVE System

Effectiveness Monitoring Form or Toughbook with SVE Monitoring software. Immediately following the recording of the vacuum/pressure measurement, the well shall be closed to the atmosphere.

4.0 WELL PURGING

After obtaining the initial vacuum/pressure measurements and prior to soil vapor sample collection, each monitoring location shall be purged a predetermined amount based on the volume of the well riser and screen. The purge volume shall be equivalent to a minimum of three well volumes. The actual purge volume removed shall be recorded. If the well will not yield the purge volume or if water and/or product are encountered during purging, this observation shall be documented. The well screen is presumed to be submerged when this condition is encountered. No sample is to be collected and no stabilized reading is required.

To purge VMP monitoring locations, a 60-mL plastic syringe is attached to the well to allow the removal of the required purge volume. The syringe plunger shall be drawn back to evacuate a purge volume.

5.0 WELL SAMPLING

Upon completion of well purging, soil vapor sample collection using Tedlar sample media may commence. If water and/or product are encountered during sample collection, this observation shall be documented. Note that samples which indicate the presence of water and/or product shall not be analyzed.

Tedlar Bag Samples

Air samples for on-site screening shall be collected using a Tedlar bag and a peristaltic pump. For VMP monitoring locations, the inlet of the peristaltic pump tubing is attached to the well and the positive pressure (output) side of the peristaltic pump shall be attached to the inlet side of the flow calibrator (or rotometer) using a combination of Tygon® and polyethylene (or equivalent) tubing. Prior to flow-rate adjustment and sample collection, the sample identification, date, time of initial vacuum reading, and initial vacuum/pressure reading (if applicable) shall be clearly marked on the Tedlar bag.

Flow Rate Adjustment

The rotometer shall be used to adjust the flow rate of the peristaltic pump to allow a flow rate of 200 mL/minute. For VMP wells, this adjustment shall be performed by observing the flow rate

indicated by the ball height and adjusting the peristaltic pump to allow a flow rate of 200 mL/minute *Notes: The initial settings on the pump should be set to allow for the minimum flow possible. It is important to set the flow rate as quickly as possible in order to minimize the amount of additional sample purge.* After setting the sample flow, sample collection shall be immediately initiated. Care shall be taken at this time to avoid unintentionally adjusting (by bumping or handling) the pump speed control.

Sample Collection

After setting the sample flow, the rotometer shall be removed from the sample train and a new, clean, pre-labeled one-liter Tedlar bag shall be connected to the tubing exiting from the output side of the peristaltic pump. A wire tie shall be used, if necessary, to make the connection between the bag and the pump a leak-proof fitting. Immediately open the valve on the Tedlar bag approximately one turn. Based on the flow rate to collect a 1-liter vapor sample, the peristaltic pump shall be allowed approximately five (5) minutes to collect the sample. Total sample collection time, which may exceed five (5) minutes, is dependent on the soil characteristics of the stratum from which the sample is being collected. Upon retrieval of the one-liter sample volume, close the valve on the Tedlar bag, turn off the peristaltic pump, and close the well to the atmosphere. Place the sample bag in a black trash bag or container that will minimize exposure to sunlight.

Duplicate samples shall be collected by repeating the procedure detailed above. The duplicate sample shall be collected immediately after the first sample (original sample) has been collected. Due to the nature of the coarse-adjustment valves that are typically installed on Tedlar bags, the use of a sample splitter is not recommended and will often result in the collection of unequal sample volumes.

Post-Sample Collection

Dismantle the sample train, dispose of all non-dedicated lines used for sample collection. New sample lines at each sample location shall be used, except for dedicated equipment. Non-dedicated, reusable equipment shall be decontaminated according to URS SOP No. 4.

6.0 VENTING

Following sample collection, VMP wells are vented (opened to atmosphere) for 15 minutes. This allows for well stabilization to occur.

7.0 FINAL (STABILIZED) VACUUM/PRESSURE MEASUREMENT

After venting, a final, stabilized vacuum/pressure measurement shall be recorded. A pressure is considered to be stabilized when it does not fluctuate more than 5% in one minute. The manometer shall be allowed a maximum of thirty (30) minutes to stabilize before the vacuum/pressure is recorded. If the manometer does not stabilize within the 30-minute period, the range in which the vacuum/pressure fluctuates over an additional one (1) minute period will be documented. The highest reading within the observed range will also be recorded. (*Please note: If the manometer reading fluctuates between two vacuums, the lowest/weakest vacuum observed will be recorded. If the manometer reading fluctuates between a vacuum and a pressure, the highest pressure observed will be recorded. If the manometer reading fluctuates between two pressures, the highest/strongest pressure observed will be recorded. In all cases, the range in the manometer readings over the additional one-minute period will be recorded.)*

At VMP monitoring locations, the manometer should be turned on, zeroed, and connected to the well as it was for the initial pressure. Once the pressure is stabilized the reading should be taken. The manometer can then be removed and the well can be closed to the atmosphere.

Note: Any monitoring location where water/product is encountered during purge or Tedlar collection, where the requisite volume cannot be purged, or where the well screen is submerged will not have a stabilized pressure collected.

1.0 INTRODUCTION

The purpose of this Standard Operating Procedure (SOP) is to provide a consistent methodology for the screening of soil vapor samples at the Roxana SVE System. This SOP details the necessary procedures to follow in order to ensure that valid total vapor phase hydrocarbons, oxygen, methane and carbon dioxide concentration data is collected and adequately documented. These procedures are applicable to any vapor sample collected at the Roxana site, but are particularly useful for samples collected from vapor monitoring ports (VMPs), SVE wells, and sub-slab (SS) ports that are located throughout the village. Important uses of these data include:

- Evaluation of indoor air or sub-slab methane concentrations
- Screening of indoor air or sub-slab petroleum hydrocarbon concentrations
- Evaluation of the performance of the soil vapor extraction system.
- Ambient air samples can either be collected and analyzed on-location using real-time instrumentation (TVA 1000, GEM 2000, etc), or collected in Tedlar™ sample media and analyzed at a dedicated sample analysis station.

2.0 PROCEDURE

The following instruments will be used to screen soil vapor samples:

- TVA-1000 or performance equivalent for volatile organic compounds (VOCs) and methane by flame ionization detector (FID) and for VOCs by photoionization detector (PID)
- LANDTEC GEM-2000 or performance equivalent for oxygen and carbon dioxide.

Immediately prior to use, each instrument will undergo a calibration check. In the event that instrument accuracy is not within 15-percent of the designated calibration check standard concentration, the instrument will be recalibrated. Field personnel will follow applicable instrument operation SOP's and/or manufacturer's recommended procedures for the calibration and operation of the instruments. Calibration data will be documented on the appropriate calibration forms for each instrument.

3.0 REQUIRED MATERIALS FOR SCREENING SAMPLES

The following materials will be used to perform sample screening, either on-site or at a

dedicated sample screening station:

- TVA-1000 and LANDTEC GEM-2000 real-time monitors;
- Calibration gas cylinders, including;
  - Methane in air at concentrations of 50; 500; 5,000, and 32,500 ppmv
  - Isobutylene in air at concentrations of 10, 50 and 1,000 ppmv
  - Hydrocarbon-free air
  - 35 percent by volume concentration CO2
- Regulators for calibration gas cylinders
- SKC sorbent tubes (part # 226-09) used for methane determination
- ¼-inch O.D. Teflon™ or Tygon™ tubing cut to length
- 10-to-1 dilution probe (Thermo Environmental Instruments Part #CR010MR)
- Disposable 4-way plastic valves used to switch the sample between methane and total hydrocarbon analyses.

4.0 CALIBRATION AND QUALITY CONTROL

4.1 Calibration Procedures Applicable to All Field Screening Analyses

Instruments will be calibrated in accordance with applicable SOPs and/or manufacturers recommended procedures at the beginning of the day. If the screening instruments are to be used throughout the work day, a mid-day and end-day calibration check will be performed. Further, the TVA 1000 instrument detectors and associated dilution probe will be bump checked (1-point accuracy check) approximately every two hours in order to document instrument stability. In the event that a bump check indicates a deviation greater than ± 15percent from the designated bump-gas concentration, a full instrument calibration will be performed. Due to negligible (<5-percent) instrument drift throughout the day, the LANDTEC GEM-2000 will not undergo bi-hourly bump checks. Instead, calibration accuracy checks will be conducted at approximately midday, and again at the conclusion of the sample event.

As stated above, calibration of the Landtec GEM-2000 and TVA-1000 will be performed in accordance with applicable SOPs and/or manufacturer recommended procedures. However, the wide range of petroleum hydrocarbons and methane concentrations present at the site (i.e., greater than four orders-of magnitude) may be outside of the linear range of the TVA-1000 FID.

To meet a primary data quality objective of the project (i.e., to quickly and accurately determine whether a potentially explosive condition is present at a sampling location), the FID calibration will be based on a calibration standard that is approximately 10% of the lower explosive limit (LEL) for methane (5,000 ppmv). However, additional QC procedures will be implemented to ensure quality data for both hydrocarbon and methane concentrations.

The linearity of instrument response will be verified by using 50 ppmv, 500-ppmv methane standards. If significant non-linear response (i.e., greater than 15% relative root mean square error) is observed, a nonlinear calibration curve will be developed. The relative response factor for isobutylene (which is used here as a surrogate for petroleum vapors) will be determined by using a 1,000 ppmv (nominal) isobutylene calibration standard. (1,000 ppmv is approximately 10% of the LEL for gasoline.)

Calibration shall be considered adequate when check standards are within +/- 15%. If the calibration check standards are outside that range, a second check standard will be run and if the check standard fails again, the instrument will be recalibrated and data obtained since the last check standard was successfully run will be flagged as estimated values.

4.2 Analysis of Concentrated Samples Utilizing a Dilution Probe

Because samples will need to be analyzed which are above the measurement range of the FID or which may not have sufficient oxygen content to analyze reliably, dilution of some samples will be required prior to analysis. The 10:1 dilution probe will be calibrated using the 32,500 ppmv methane standard. Calibration of the dilution probe is considered complete when the FID response to this standard is within ± 15-percent of 3,250 ppmv.

The critical orifice in the dilution probe is density-dependent. As it will be calibrated using a 3.25% methane standard that has a density of 98.6% that of air, samples that have a density significantly different from that will be subject to some level of deterministic error. Samples that have extremely high hydrocarbon or methane concentrations have the potential to have significantly varying densities, which can introduce significant error when the analysis relies on the dilution probe. For example, error in excess of 10% will be present at concentrations of methane above 40% (if significant concentrations of petroleum hydrocarbons are not present).

Because the average density of petroleum hydrocarbon vapors is variable, the error is not as readily quantified for elevated concentrations petroleum hydrocarbons. Assuming an average density of 2.5 times that of air (i.e., density equivalent to isopentane), error in excess of 10% will be present at concentrations of petroleum hydrocarbon above 17% (if significant concentrations of methane are not present).

The density error associated with methane and heavier hydrocarbons have the potential to offset

each other. Because the average density of measured hydrocarbon will not be known, data associated with an estimated error greater than 10% due to the presence of hydrocarbon or methane will be flagged as estimated, rather than corrected for an assumed density. As the concentrations at which significant error is introduced are well above project action levels, estimated concentrations at these ranges are considered adequate to meet project data quality objectives.

4.3 Analysis of Samples Utilizing a Charcoal Scrubber Tube to Filter Heavy Hydrocarbons

Use of the sorbent tube to screen out hydrocarbons other than methane affects the function of the FID instrument by lessening the flow of air through the detector. Preliminary testing indicates that a 25% to 30% reduction in instrument response occurs over the linear calibration range of the instrument. To calibrate the instrument for use of the sorbent tube, the 50, 500 and 5,000-ppmv methane standards will be run with the sorbent tube to determine the relative response of the instrument to methane passed through the sorbent tube. The relative response factor (RRF) for each calibration standard will be calculated as:

$$RRF = \frac{FID_{sorb}}{FID_{raw}};$$

Where;

RRF = relative response factor;

FIDsorb = Instrument response with sorbent tube; and FIDraw = Instrument response to calibration standard without sorbent tube

The average RRF shall be used as a correction factor for samples analyzed using the sorbent tube. It is not necessary to correct instrument response (other than multiplying the displayed value by 10) when using the 10:1 dilution probe in conjunction with the sorbent tube. When using the dilution probe, the majority (approximately 90-percent) of the sample that is analyzed is actually dilution air that does not pass through the sorbent tube.

5.0 SAMPLE SCREENING

Most soil vapor samples collected in Tedlar ™ bags will be screened at a fixed location using the instrumentation noted above. The fixed location facilitates the use of the instrumentation, allows for a more stable environment in which to screen the samples, and provides adequate space in which to perform the screening and complete the associated documentation. However, to allow rapid screening of indoor air and sub-slab soil vapor, such samples can be

analyzed on site, using the same field instrumentation. The calibration of these instruments, as outlined in Section 4.0, will be performed in such a way that instrument response is most accurate in the concentration range that corresponds to project action levels.

The TVA-1000 has been configured with a switching device (disposable valve) to allow sample to be passed through an SKC carbon sorbent tube to remove petroleum hydrocarbons (i.e., site data indicate that the remainder will be primarily methane).

5.1 Procedures for Sample Screening On Site

- Screen air sample with LANDTEC Model GEM-2000 landfill gas analyzer. Quickly document oxygen and carbon dioxide concentrations on the appropriate sample screening data sheet;
- Screen sample with the TVA 1000 PID instrument and quickly document the concentration on the appropriate data sheet; and
- Set the TVA-1000 to sample through the SKC sorbent tube used in conjunction with the FID.

Calculate the methane concentration as;

$$C_{meth} = FID / F_{RRF};$$

Where

C_{meth} = methane concentration (ppmv); and

FID = FID reading (ppmv)

- Switch the TVA-1000 to sample without the sorbent tube. Screen the sample with the TVA-1000 and quickly record the vapor concentration by FID on the appropriate data sheet; and
- The hydrocarbon concentration portion of the FID response should be calculated as;

$$HC = C_{raw} - C_{meth};$$

Where

HC = hydrocarbon concentration (ppmv); and

C_{raw} = FID reading without sorbent tube (ppmv)

5.2 Procedures for Sample Screening at a Dedicated Sample Analysis Station

The sampling instrumentation for the dedicated sample analysis station has been configured such that the TVA-1000 can be operated with a 10:1 dilution valve, if concentrations are outside the operational range of the FID (i.e., if there is insufficient oxygen to support the FID flame or if the sample is above the linear range of the instrument).

- Open the valve on the Tedlar™ bag sample approximately one turn and attach to the inlet of the LANDTEC Model GEM-2000 landfill gas analyzer. Quickly document oxygen and carbon dioxide concentrations on the appropriate sample screening data sheet (attached);
- If the oxygen concentration in the sample is less than 16-percent, configure the TVA-1000 for use with a 10-to-1 dilution probe. The dilution probe will allow for the sample to be screened by FID without flameout associated with low oxygen concentration samples. The dilution probe must be separately calibrated and should be used for sample analysis by FID only;
- Set the TVA-1000 to sample through the SKC sorbent tube. Record the reading as the methane concentration. If the 10-to-1 dilution probe is used, the displayed concentration (FID) must be multiplied by 10;
- Switch the TVA-1000 to sample without the sorbent tube. Immediately connect the sample bag to the TVA-1000 probe inlet and quickly record the vapor concentration by FID on the appropriate data sheet. If the 10-to-1 dilution probe is used, the displayed concentration (FID) must be multiplied by 10; and
- The hydrocarbon (HC) concentration portion of the FID response should be calculated as:

$$HC = C_{raw} - C_{meth}.$$

5.3 Procedures Applicable to All Sample Screening

Because concentrations of hydrocarbons in some samples are elevated, the carbon in the sorbent tube can be saturated with hydrocarbon relatively quickly. Therefore, the following protocols are in place to assure quality data:

- The sorbent tube will be replaced at least every 10 samples;
- The sorbent tube will also be replaced, if breakthrough is observed (readily apparent) or

if concentrations do not go to zero after sample is removed from analyzer inlet; and
Associated sample lines (Teflon™ or Tygon™ tubing), valves, etc. will be replaced if concentrations do not return to zero after sample is removed from analyzer inlet.

6.0 CONCLUSION

The screening of soil gas samples must be conducted in an organized and precise manner. The resultant data will be valid only if proper procedure and associated QA/QC is followed. It is imperative that personnel conducting the sample screening strictly adhere to the protocol detailed above. Because the samples are collected in 1-liter bags, the samples must be removed from the instrument inlets as soon as a stable reading can be documented. Failure to do so will result in an inadequate amount of sample volume to complete all the screening parameters. Larger bags cannot be used due to time constraints during sample collection.

1.0 INTRODUCTION TO THE DWYER DIGITAL MANOMETER

The Dwyer Series 475 Mark III Digital Manometer is used by personnel in the field to measure vacuum/pressure at wells throughout the Village of Roxana. Personnel responsible for using a manometer are required to read the manufacturer's instruction manual and be trained in the operation of the instrument.

2.0 ZEROING THE MANOMETER

The manometer is zeroed before each measurement. This is done by either depressing the "zero" button located on the front of the manometer, or adjusting the knob ("zero adjust knob") on the top of the manometer (depending on which model is being used) while both positive and negative connections are open to the atmosphere. The "zero" button will automatically zero the instrument. The knob must be turned either clockwise (more positive) or counterclockwise (more negative) depending upon whether the manometer is reading positive or negative.

3.0 VACUUM / PRESSURE MEASUREMENT

The manometer shall be set on the "inches of water column" unit setting which can be done by depressing the "E/M" button and scrolling until "in/H2O" is found.

The positive fitting of the manometer shall be connected to the appropriate vacuum measurement fitting located on the well. The negative fitting on the manometer shall remain open to the atmosphere. The vacuum/pressure is immediately read and recorded to the nearest hundredth of an inch (or tenth of an inch if using 0-200 manometer) of water. The manometer can then be removed from the vacuum measurement fitting.

4.0 MAINTENANCE AND CALIBRATION

If the "low bat" indicator is lit on the manometer display, the battery needs to be replaced. A weak battery can cause improper operation or inaccurate measurements. The battery is changed by unscrewing the flathead screws located on the bottom of the manometer and removing the battery plate. The 9 volt alkaline battery will slide out and can then be unclipped from the wiring. Install a fresh battery and secure the battery plate. When replacing the cover, be sure the rubber

sealing gasket is properly seated in the gasket channel of the endcap. Note the endcap will only fit one way.

In the event that the manometer comes in contact with water or other conditions which cause the display to either not power on, or to read incorrectly, the manometer should be sent back to the manufacturer for calibration.

Exceeding the range of the manometer will not damage it or affect calibration if the maximum pressure is not exceeded. Exceeding the maximum pressure will cause permanent damage to the sensor and may rupture the housing and/or cause injury. The maximum pressure is shown on the rear label of the manometer.

Manometers should be sent back to the manufacturer or certified calibration agency every six (6) months for calibration following the "Manometer Calibration Schedule." Calibration and maintenance records as well as calibration certificates are maintained on site.

1. Objective

This document defines the standard operating procedure for calibration and maintenance of field instruments frequently used during environmental field activities. This Standard Operating Procedure (SOP) gives descriptions of the most common used of these instruments and field procedures necessary to calibrate and maintain these field instruments. Other related SOPs are listed below:

- SOP No. 4 – Decontamination
- SOP No. 8 – Field Reporting and Documentation.

2. Equipment

The following equipment is required during field instrument calibration and maintenance activities.

- Latex/Nitrile gloves
- Site logbook
- Field data sheets
- Equipment Calibration Record forms
- Distilled/deionized water
- Decontamination equipment
- Health and Safety Equipment
- Field Instrument Operations Manual
- Calibration gases for Air Monitoring Equipment
- Calibration solutions for Water Monitoring Equipment.

3. Type of Field Instruments Commonly used during Environmental Investigations

The following are some of the more commonly used instruments during environmental investigations.

- Photoionization Detector (PID)
- Multi-gas Meter (usually includes Explosimeter, Hydrogen Sulfide detector, Oxygen sensor, and Carbon Monoxide meter)
- RAM

- Groundwater Level Indicator
- Petroleum/Groundwater Interface Probe
- Groundwater pH, Temperature, Conductivity Meter.

4. Maintenance

Maintenance of field instruments should be performed on all field instruments on a regular basis to ensure instruments are in proper working order at all times and to prolong the instruments life. General maintenance such as regular cleaning of the instrument, battery checks and replacement, and ensuring the instrument is handled and stored properly can easily be performed by URS employees. Other maintenance items such as sensor repair, annual calibrations and repair of a malfunctioning piece of equipment should be performed by the instrument manufacturer or licensed dealer and should not be performed by URS employees. Contact the manufacturer to determine where the instrument should be submitted for these maintenance tasks. The vast range of instruments available for use by the environmental professional have an equally vast maintenance regime and therefore maintenance guidelines specified in manual for each piece of equipment should be referred to and followed at all times.

5. Calibration

Due to the vast number of field instruments available, various parameters potentially monitored, and the wide range of functions potentially performed by each instrument, a description of the calibration of every type of instrument available is not feasible. However, a generalized SOP for general types of field equipment calibration is presented and should be followed while performing calibrations of field instruments.

Air Monitoring Instruments (PID, Multigas Meters, Hydrogen Sulfide Detectors, etc.)

- Turn the instrument on. The on/off switch may be a toggle switch, knob, or button to be depressed depending on the type and brand of instrument being used.
- Allow the instrument to "warm up" and progress through the startup diagnostic routine.
- Apply the calibration gas (isobutylene, methane, multi-gas mixtures, etc.) to the instrument to get an initial instrument reading.
- Record the initial reading on the proper equipment calibration field form and in the site logbook. Also record the calibration standard and concentration of that standard on the field form and in the logbook.

- If the initial reading is greater than +/-5% of the calibration standard proceed with instrument calibration as specified in the equipment operator's manual. If the initial reading is within this +/- 5% window of the calibration gas standard, the instrument should be considered calibrated and additional calibration is not required at this time. At periodic intervals throughout the day the calibration of the instrument should be check and re-evaluated.
- Apply the calibration gas and proceed as directed in the operator's manual.
- After calibration is complete, record the final calibrated reading on the field equipment calibration forms and in the field logbook. At periodic intervals throughout the day the calibration of the instrument should be check and re-evaluated.

Groundwater Parameter Instruments (pH, Temperature, Electrical Conductivity, Turbidity, etc.)

Frequently one instrument will have multiple sensors for measuring various parameters in water. Sensors for temperature, electrical conductivity and turbidity require scheduled calibrations by the equipment manufacturer or authorized service center and should not be performed in the field. The sensor for pH analysis should be calibrated daily in the field prior to use.

- Turn the instrument on. The on/off switch may be a toggle switch, knob, or button to be depressed depending on the type and brand of instrument being used.
- Allow the instrument to "warm up" and progress through the startup diagnostic routine.
- Apply pH 7 and pH 4 buffers solutions as instructed by the instrument prompts or the operator's manual.
- Adjust the reading of the instrument to correlate to the corresponding buffer solution being applied.
- Record reading in the field logbook and on proper field calibration forms.
- Dispose of used buffer solution and reseal buffer solution containers for future use.

Water Level Indicator and Petroleum/Water Interface Probe

Field calibration of this instrument is not required. Rather a series of field checks to ensure the instrument is in proper working order will be described.

- Turn the instrument on. The on/off switch is usually a knob located on the side of the reel in which the measuring tape is rolled onto.

- Push the "test" button to ensure that the batteries are in working order. If the batteries are working, an audible tone will be heard and a visible light located on the side of the real will illuminate.
- Immerse the sensor probe in potable water to ensure the audible tone is heard and visible light illuminates when the electrical circuit is completed when the probe enters the water. Make an observation of where the water level is at on the probe when the circuit is completed. Repeat this step several times to familiarize yourself with this contact point. By performing this step, the chance of submersing the probe to a greater depth than necessary is reduced. Over submersion of the probe will result in a greater amount of the probe and measuring tape to be cleaned and decontaminated prior to collection of another groundwater measurement.
- After collection of every water level measurement, decontaminate all portions of the water level meter or petroleum/water interface probe that came in contact with the groundwater as outlined in SOP No. 4 – Decontamination.

6. Decontamination

Small instruments and equipment will be cleaned according to SOP No. 4 – Decontamination and the generalized procedures stated below:

a. Rinse with potable water to remove the gross contamination

b. Scrub with brush using Alconox soap (or equivalent) and distilled water solution

c. Rinse with distilled water.

Decontaminated equipment should be wrapped in aluminum foil or placed in plastic bags between uses and during storage.

1. Introduction and Types of Contamination

This document defines the standard procedure for decontamination. This SOP serves as a supplement to the project Work Plan Addendum and is intended to be used together with several other SOPs. Other related SOPs are listed below:

- SOP No. 8 - Field Reporting and Documentation
- SOP No. 10 - Groundwater Level Measurements
- SOP No. 11 - Groundwater Sampling
- SOP No. 20 – Monitoring Well Development and Purging
- SOP No. 21 - Monitoring Well Installation
- SOP No. 26 - Sample Control and Custody Procedures
- SOP No. 28 - Soil Sampling
- SOP No. 31 - Surface Water Sampling
- SOP No. 32 - Sediment Sampling.

Site and/or Sample Cross-Contamination

The overall objective of multimedia sampling programs is to obtain samples that accurately depict the chemical, physical, and/or biological conditions at the sampling site. Extraneous contaminants can be brought onto the sampling location and/or introduced into the medium of interest during the sampling program (e.g. using sampling equipment that is not properly or fully decontaminated). Trace quantities of contaminants can consequently be captured in a sample and lead to false positive analytical results and, ultimately, to an incorrect assessment of the contaminant conditions associated with the site. Decontamination of sampling equipment (e.g., all non-disposable equipment that will come in direct contact with samples) and field support equipment (e.g., drill rigs, vehicles) is, therefore, required prior to, between, and after uses to ensure that sampling cross-contamination is prevented, and that on-site contaminants are not carried off-site.

2. Procedure

2.1 Equipment List

The following is a list of equipment that may be needed to perform decontamination:

- Brushes

- Wash tubs
- Buckets
- Scrapers, flat bladed
- Hot water - high-pressure sprayer
- Sponges or paper towels
- Alconox detergent (or equivalent)
- Potable tap water
- Laboratory-grade deionized or distilled water
- Garden-type water sprayers.

2.2 Decontamination

2.2.1 Personnel

A temporary personnel decontamination line will be set up around each exclusion zone. If contamination is not encountered, a dry decontamination station may be established which consists of discarding of disposable personal protective equipment (PPE).

If real-time monitoring instruments indicate that contamination has been encountered (i.e. action levels are exceeded requiring an upgrade from initial PPE levels), a complete personnel decontamination station will be established.

The temporary decontamination line should provide space to wash and rinse boots, gloves, and all sampling or measuring equipment prior to placing the equipment into a vehicle. A container should be available to dispose of used disposable items such as gloves, tape, or tyvek (if used).

The decontamination procedure for field personnel will include:

1. Glove and boot wash in an Alconox solution
2. Glove and boot rinse
3. Duct tape removal
4. Outer glove removal
5. Coverall removal

6. Respirator removal (if used)
7. Inner glove removal

2.2.2 Sampling Equipment

The following steps will be used to decontaminate sampling equipment:

- Personnel will dress in suitable safety equipment to reduce personal exposure as required by the HASP.
- Gross contamination on equipment will be scraped off at the sampling or construction site.
- Equipment that cannot be damaged by water will be placed in a wash tub containing Alconox or low-sudsing nonphosphatic detergent along with potable water and scrubbed with a bristle brush or similar utensil. Equipment will be rinsed with tap water in a second wash tub followed by a deionized or distilled water rinse.
- Equipment that may be damaged by water will be carefully wiped clean using a sponge and detergent water and rinsed with deionized or distilled water. Care will be taken to prevent equipment damage.
- Rinse and detergent water will be replaced with new solutions between borings or sample locations.

Following decontamination, equipment will be placed in a clean area or on clean plastic sheeting to prevent contact with contaminated soil. If the equipment is not used immediately after decontamination, the equipment will be covered or wrapped in plastic sheeting or heavy-duty trash bags to minimize potential contact with contaminants.

2.2.3 Drilling and Heavy Equipment

Drilling rigs will be decontaminated at a decontamination station located near a central staging area. The decontamination station may consist of a temporary or permanent structure capable of collecting all decontamination fluids. Mobile decontamination trailers may be used to decontaminate heavy equipment at each site. The following steps will be used to decontaminate drilling and heavy equipment:

- Personnel will dress in suitable PPE to reduce personal exposure as required by the HSP.
- Equipment showing gross contamination or having caked-on drill cuttings will be scraped with a flat-bladed scraper at the sampling or construction site.

- Equipment that cannot be damaged by water, such as drill rigs, augers, drill bits, and shovels, will be washed with a hot water, high-pressure sprayer then rinsed with potable water. Care will be taken to adequately clean the insides of the hollow-stem augers and backhoe buckets.

Following decontamination, drilling equipment will be placed on the clean drill rig and moved to a clean area. If the equipment is not used immediately, it should be stored in a designated clean area.

2.2.4 Equipment Leaving the Site

Vehicles used for activities in non-contaminated areas shall be cleaned on an as-needed basis, as determined by the Site Safety Officer, using soap and water on the outside and vacuuming the inside. On-site cleaning will be required for very dirty vehicles leaving the area. Construction equipment such as trucks, drilling rigs, backhoes, trailers, etc., will be pressure washed before the equipment is removed from the site to limit exposure of off-site personnel to potential contaminants.

2.2.5 Wastewater

Liquid waste water from decontamination, well development and purging will be containerized and left at the site where it originated, unless otherwise specified.

3. Documentation

Sampling personnel will be responsible for documenting the decontamination of sampling and drilling equipment. The documentation will be recorded with waterproof ink in the sampler's field notebook with consecutively numbered pages. The information entered in the field book concerning decontamination should include the following:

- Decontamination personnel
- Date and start and end times
- Decontamination observations
- Weather conditions.

4. Quality Assurance Requirements

Equipment rinsate samples of the decontaminated sampling equipment may be taken to verify the effectiveness of the decontamination procedures. The rinsate sampling procedure will include rinsing deionized water through or over a decontaminated sampling tool (such as a split spoon)

and collecting the rinsate water into the appropriate sample bottles. The rinsate sampling procedure, including the sample number, will be recorded in the field notebook.

APPENDIX G Federally Enforceable State Operating Permit