BASIS OF DESIGN REPORT

VOLUME I

ESSEX/HOPE SITE
JAMESTOWN, NEW YORK

PREPARED FOR
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1.0 INTRODUCTION

This Basis of Design Report has been prepared to present the physical, chemical, and regulatory basis for the design of the remedial action for the Essex/Hope Superfund Site, Jamestown, New York. The remedial approach consists of Alternative 5 as originally developed in the Feasibility Study for the site and depicted in the Record of Decision as the selected remedy.

The components of the remedy are as follows:

- Excavation and offsite disposal of a layer of highly contaminated subsurface soil containing PCBs and trichloroethylene in the area of the north parking lot sump.
- Use of air sparging technology in the area of the north parking lot sump to enhance the reduction of contaminants in the groundwater.
- Collection and treatment of contaminated groundwater through the use of a pump and treat system.
- In-situ vacuum extraction of contaminated subsurface soils above the water table in the areas of the former aboveground storage tanks and the underground storage tanks.
- Installation of an asphalt cap in areas of contamination to enhance surface water run-off and inhibit the infiltration of precipitation.
- Implementation of a long-term monitoring program to determine the effectiveness of the remedial action.

This report also presents the results of the Pre-Design Studies that were conducted in July and August, 1995 to determine the appropriate type, size, and location of various components of the remedy. Some modifications to the selected remedy as originally presented in the feasibility study (O'Brien and Gere, 1993) have been made in light of the data generated by the Pre-Design Investigation.

1.1 Site Background

The Essex/Hope Site is located on a 4.7 acre parcel of land that is currently owned and occupied by Lilly Industries, Inc. at 125 Blackstone Avenue in the City of Jamestown, New York (Figure 1).

The property is bordered by Hopkins Street to the north and Blackstone Avenue to the south and is traversed by an abandoned railroad right-of-way. This site is situated in the center of a steep sided, flat bottom glacially derived valley of silty sand and gravel, which is drained by the Chadakoin River, located 800 feet north of the site.

The site is located in a highly industrialized area of the city that has seen various degrees of industrial use for the past 75 years. Contamination onsite is the result of historical practices conducted at the facility as discussed in the Remedial Investigation (RI) Report dated October 1992.

Essex, owned and occupied the manufacturing facilities at the site from 1982 to 1989, at which time the facilities were sold to Lilly Industrial Coatings, the present occupant. Prior to this period, the facility had been owned and occupied by Essex Chemical Company, Tremco, Inc., Rubbermaid, Inc., and Jamestown Finishing Products, Inc. which all produced various paints, varnishes, and other industrial coatings since approximately the early 1900s. Hope Windows, Inc. currently known as Hopes Architectural Products, Inc., also owned and occupied a portion of the property (known as the Plant 5 building) which was sold to Essex in the mid-1980s.

The following three areas (Figure 2) were identified in the ROD as the focus of remedial efforts.

- North Parking Lot Sump (NPLS) Area located in a parking area on the south side of Hopkins Street and adjacent to the facility formerly known as Plant 5. The subsurface soil proximal to the sump as well as the groundwater in the NPLS Area contain trichloroethylene (TCE) above NYSDEC standards. A smaller area of subsurface soil located south of the sump also contains polychlorinated biphenyls (PCBs) at levels less than 33 mg/kg, dry weight.

- Former Aboveground Storage Tank/Underground Storage Tank (AST/UST) Area located on the east side of the railroad right-of-way. The subsurface soil and groundwater in this area contain ethylbenzene, toluene, and xylene (ETX) residues.

- Previously Closed Underground Storage Tanks (USTs) Area located south of the former Plant 5. The subsurface soil and shallow groundwater in this area contains ethylbenzene, toluene, and xylenes.

1.2 Scope of Pre-Design Activities

The Pre-Design Activities primarily consisted of tasks necessary to provide detail regarding the effectiveness and design of the major remedial components of the selected remedy. These components consist of groundwater pump and treat, soil vapor extraction, and air sparging.

The specific tasks conducted during the Pre-Design Investigation consisted of:

- Test boring drilling to define recovery well installation details.

- Aquifer sieve analysis to define recovery well screen slot size and gravel pack material.

- Installation of five air sparge injection/observation wells and two associated SVE wells.

- Sparge pilot testing in NPLS area.

- Aquifer testing of both shallow and deep waterbearing zones.

- SVE pilot test confirmatory soil sampling in former AST/UST area and former UST area.

- Groundwater sampling of all site monitoring wells.

All work was conducted in accordance with the RD/RA work plan and DEI standard operating guidelines. All groundwater pumped during aquifer testing, purged for groundwater sampling, and removed during well development was discharged to the city sewer system after onsite pretreatment utilizing granular activated carbon canisters. A total of approximately 6,000 gallons of water was pre-treated and discharged to the city sewer system during Pre-Design Activities.

The vapor emissions generated during the combination SVE/sparge testing were collected and treated via granular activated carbon prior to discharge to the atmosphere.

All cuttings generated during well and test boring drilling have been containerized, sampled, and stored onsite pending review of analytical results.

1.3 Report Organization

The following Sections are presented as follows:

- Section 2 - Pre-Design Activity Results
- Section 3 - Remediation Area Basis (current contamination characteristics in areas of concern and attainment areas)
- Section 4 - Remedial Action Description (incorporating Pre-Design Investigation results)
- Section 5 - Remediation Schedule (sequence)

The Basis of Design Report includes accompanying figures and tables illustrating and summarizing data and design criteria. Appendices are also included consisting of the following:

- Appendix A - Boring Logs and Well Construction Diagrams
- Appendix B - Aquifer Pumping Test Data and Calculations
- Appendix C - Pilot SVE/Sparge Test Data and Air Analytical Results
- Appendix D - Laboratory Analyses Results - Soil and Groundwater

2.0 PRE-DESIGN ACTIVITY RESULTS

Figure 3 provides locations for all newly installed monitoring wells and test borings conducted during the Pre-Design Activities. Boring logs for all of the wells and test borings are contained in Appendix A.

2.1 Subsurface Conditions

2.1.1 Geologic Conditions

The Pre-Design investigation drilling activities were concentrated in the NPLS area with the exception of four (4) test borings that were drilled between the former UST area and former AST/UST area. Geologic conditions encountered in the NPLS area were similar to previous descriptions contained in the RI Report and RI Supplement Report.

Underlying ground surface is a continuous deposit of silty, sandy, gravel with occasional clayey fine sand. This unit was found to occur beneath the area down to a depth ranging from 11 to 15.5 feet. The four test borings drilled in other areas encountered but did not fully penetrate this unit to depths of 12 feet. At recovery well location RW-2D, test boring drilling was advanced to a depth of 48 feet. Beneath the silty sand gravel is a fine-grained unit consisting primarily of silt with very fine sand laminations. This unit was present from 11 to 24 feet at the RW-2D location. Previous drilling in the NPLS area has shown this to range from less than 1 to 20 feet thick. The silt grades into a silty, very fine sand to sandy silt lens which extends to a depth of 43 feet. The sand lens grades to a fine to medium sand with little gravel at its base. Beneath the sand lens was a stiff gray silt layer the bottom contact of which was not encountered to a depth of 48 feet.

Grain size (sieve) analysis was conducted on samples from the upper silty sandy gravel deposits from locations RW-1S and RW-2S. The sieve analysis results revealed a non-uniform heterogenous deposit. The sample from RW-1S consisted of 39 percent gravel, 36 percent silt/clay, and 25 percent sand. The sample from RW-2S consisted of 40 percent silt/clay, 35 percent gravel, and 25 percent sand.

At location RW-2D, a sample from the underlying silty fine sand to sandy silt deposit consisted of 67 percent silt/clay, 32 percent sand, and 1 percent gravel, indicating the fine-grained nature of this deposit. Appendix A contains laboratory grain size distribution reports.

In the NPLS area, headspace readings of jarred soil samples were obtained during advancement of test boring and will drilling. At seven locations (RW-1S, RW-2S, RW-2D, SP-1, SP-2, SP-3, and SP-4) the borings were advanced at least to the top of the silt confining layer. At five of the seven locations, significant increases in headspace concentration were observed at the base of the silty sandy gravel and top of the silt layer. Only at locations SP-2 and SP-4 were elevated levels not observed within this zone. This data illustrates the migration of VOCs along the base of the shallow waterbearing zone. Previous investigations during the RI determined the sump in the north parking lot to be the source of the VOCs.

2.1.2 Hydrogeologic Conditions

Previous investigations at the site have identified saturated zones occurring in the shallow silty sandy gravel layer and in the lower very fine sand lens that occurs beneath the silt layer that separates the two units. This silt layer was found to contain an appreciable amount of wet fine sand lenses and appears to act as a leaky confining layer beneath the NPLS area. The silt layer has not been investigated in other areas of the site.

Also, during previous investigations, an additional waterbearing zone was encountered within a glacial till deposit occurring at a depth of approximately 95 feet below ground surface at location MW-7DD in the NPLS area. Groundwater in this zone was encountered within a thin fine sand lens that exhibits low permeability. This waterbearing zone is under confined conditions with a static water level, approximately 3 feet below ground surface.

The Pre-Design Investigation field activities focused primarily on the upper two zones of saturation and the silt layer that separates the two units over most of the site. The upper saturated zone occurs under unconfined conditions as determined through observations made during drilling advancement and groundwater pumping conditions (Section 2.2.1). The unit is considered to terminate at the top of the silt layer. Saturated thickness in the NPLS area ranges from approximately 6 to 8 feet. In other areas of the site, the saturated thickness may reach approximately 10 feet. The grain size analysis conducted on this zone revealed high fines content

(35 to 40 percent) within this waterbearing zone. Figure 4 is a water table contour map for the shallow waterbearing zone. Flow is principally to the northeast with an overall gradient of 0.01. As can be seen, localized variations in gradient and flow occur across the site. In particular, the gradient is shown to steepen along the northern part of the NPLS area and the Hope property to the north. These variations illustrate the non-homogenous nature of this waterbearing zone.

The lower fine sand to sandy silt waterbearing zone was observed to be under confined conditions based upon observations conducted during drilling and pumping test results (Section 2.2.2). Grain size analysis results for this zone revealed an extremely high silt/clay content (67 percent) from RW-2D. Saturated thickness in this zone was found to range from approximately 15 to 30 feet. Figure 5 is a water table contour map for the fine sand waterbearing zone. Groundwater flow in this zone is in an east-northeasterly direction at a gradient of 0.006.

Table 1 summarizes water level data collected during the Pre-Design investigation.

2.2 Aquifer Testing

Aquifer testing was conducted to define hydrogeologic parameters for the shallow waterbearing zone at the RW-1S location. Previous aquifer testing conducted during the RI concentrated on testing of the deep zone (RW-1D) in the NPLS area. Additionally, after completion of the shallow test, a test was conducted on the deep zone at location RW-2D to provide additional information regarding extent of the capture zone for the lower fine sand aquifer. Appendix B contains aquifer testing data and calculations.

2.2.1 RW-1S Test

The test at RW-1S was conducted for a period of 32 hours at a constant rate of 1.05 gpm. The test was initially scheduled to last for 72 hours; however, pumping of the shallow zone significantly dewatered the aquifer in the well vicinity which started to create turbulent conditions in the pumping well vicinity, thereby dictating a shorter test.

Figure 6 is a cone of depression contour map for the RW-1S test at 32 hours. As can be seen, a significant cone of depression was developed for this shallow, unconfined, waterbearing zone. Drawdown effects were observed as far as Hopkins Avenue to the north, MW-12 to the south, to the facility property line to the west, and Plant 5 building to the east. Deep monitoring wells MW-3D, MW-7D, MW-8, MS-11D, and MW-7DD were monitored for water level changes during the shallow test. None of the deep wells indicated drawdown during the test or recovery after the test.

Transmissivitiy and storage values (Theis, 1935) were computed from the Theis non-equilibrium well equation and the modified non-equilibrium formula (Cooper, Jacob, 1946) and are presented in Table 2. These methods were utilized due to the insignificant amount of gravity drainage observed on time drawdown plots of observation wells. As a check on calculations using this method, a distance drawdown analysis was also conducted for nearby observation wells. The distance drawdown results showed excellent correlation with the other methods utilized. Based upon a comparison of calculated transmissivity and storage values for individual observation wells and a comparison of predicted versus observed drawdown utilizing the Theis Well function values, a transmissivity of 400 gpd/ft and storage coefficient of 0.02 best represent conditions in the shallow waterbearing zone in the NPLS area.

2.2.2 RW-2D Test

To supplement the existing aquifer data generated by testing of RW-1D during the RI, deep well RW-2D was pumped at a constant rate of 2.05 gpm for 20 hours. Both shallow and deep surrounding wells were observed for water level change during and after the test. Response to the shallow zone during pumping of the deeper zone was inconclusive due to a significant precipitation event that preceded start of the test. This event caused shallow water levels to rise and masked any drawdown effects in this zone brought about by pumping. The aquifer test conducted at RW-1D during the RI did indicate drawdown within some of the shallow wells during pumping, particularly at MW-3S and MW-11S.

Figure 7 is a drawdown contour map for pumping of RW-2D at 21 hours. The contour map shows a widespread cone of depression brought about by pumping of the confined aquifer. Calculations for aquifer parameters were conducted by the Cooper, Jacob (1946) modified non-equilibrium formula for drawdown and recovery of selected wells. Table 2 summarizes results from this analysis. The aquifer parameters that best represent observed drawdown in the lower fine sand aquifer in the NPLS area are a transmissivitiy of 400 gpd/ft and storage coefficient of 0.0001. These values correlate well with the transmissivity of 300 gpd/ft and storage 0,.0008 estimated for the RW-1D test conducted during the RI.

Evidence of anisotropic conditions in the lower fine sand waterbearing zone are evident when comparing actual drawdown at MW-19D to predicted drawdown at this location. An actual drawdown of 0.16 feet was recorded at the completion of pumping. Utilizing the generated aquifer parameters, a calculated drawdown of 1.97 feet is predicted. This data suggests a higher transmissivity in the lower fine sand zone occurring to the east of the NPLS area, probably due to an increased thickness of the aquifer or a reduced percentage in the amount of fines occurring in the aquifer material. This example indicates the heterogeneity of the deeper aquifer that can cause localized changes in aquifer parameters over relatively short distances.

2.3 Air Sparge Evaluation

Air sparging was evaluated in the NPLS area to determine its effectiveness as a remedial technology for groundwater treatment at the site. Sparge well locations are shown on Figure 8. These locations were modified over those provided in the Feasibility Study. The locations in the feasibility study were in close proximity to the north parking lot sump. Contaminated soils in this area will be excavated during the early stages of remedial construction. The sparge locations were installed north of the NPLS area to determine their effectiveness in areas that won't be excavated. This modification also allowed the pilot test wells to be incorporated into a remediation system should the testing prove successful. Installing the pilot wells in close proximity to the sump would have required their abandonment prior to planned excavation activities.

The objectives of the air sparge pilot test were as follows:

- Determine effectiveness of sparging to enhance groundwater clean-up
- Determine effective radius of sparging
- Determine flow rates and injection pressure to size equipment

A total of five sparge and two soil vapor extraction wells were installed during the Pre-Design Investigation. Figure 8 details pilot sparge system layout. Sparge wells SP-1 through SP-4 were installed with one-foot open intervals at the base of the shallow silty sandy gravel deposit to enable air injection at the base of the shallow waterbearing zone where VOCs have concentrated. The sparge wells were also used as observation points to measure the effects from single or multiple injection points. Well SDO-1 was installed with a one-foot open interval between a depth of 10 to 11 feet as an observation point to the sparging operation in a zone above the base of the gravel unit. Wells VES-1 and VES-2 were vapor recovery wells that were installed to collect vapors that may result from the sparging operation. Additionally, recovery well RW-1 was utilized as a sparge observation point due to its close proximity to the test area.

Several variations of sparge injection were conducted throughout the testing period. Five tests were conducted with SP-1 as the injection point, and all other sparge wells as observation points. One test was conducted utilizing SP-3 as a sparge injection well and all other wells as observation points. A final test was then conducted utilizing SP-1, SP-2, and SP-3 as injection points to observe liberated VOC emissions from multiple injection points. Testing was done at various flow rates and pressures to determine the most optimum operating conditions. Pressure, water level change, and dissolved oxygen readings were measured in observation points. Emissions from the SVE unit were monitored by a PID, Draegar tubes, and air sampling for VOCs by GC. The following subsections describe the results of each of the tests conducted. Table 3 summarizes fieldscreen air analysis results for the pilot sparge testing. Table 4 summarizes laboratory air analysis results. Appendix C contains test data for all of the sparge pilot tests. Graphs of water level change occurring during the various tests are included with the data in Appendix C.

2.3.1 Test No. 1

Test No. 1 consisted of a soil vapor extraction background test to obtain VOC emissions prior to sparge injection. The test was run for a period of 84 minutes with approximately 30 SCFM being withdrawn from SVE-1 and 20 SCFM being withdrawn from SVE-2. The test was started at a vacuum of 90 inches of water on the observation wells and reduced gradually to 52 inches of water by the test conclusion.

PID levels were obtained at three occasions during the test. Levels ranged from 16 to 135 parts per million (ppm) with the levels increasing during test duration (Table 3). Draegar tube samples for TCE (50 ppm detection limit) and PCE (0.10 ppm detection limit) were obtained Between 43 and 52 minutes into the test. Results were negative. Lab air analysis results were taken prior to dilution air (vac wells), prior to carbon (pre-carb), and after carbon (post-carb), as shown on

Table 4. Only one compound, TCE, was detected at 0.787 ppm and 1.09 ppm at the pre-carb and VAC well sample ports, respectively.

2.3.2 Test No. 2

Test No. 2 consisted of a short (21 minute) sparge test on well SP-1 to provide data on flow rates and sparge injection coverage. The test was operated with full injection to determine achievable flow rate and pressure. After 4½ minutes, the injection rate exceeded 20 SCFM at pressure of 7 psi. Dissolved oxygen readings were obtained on two observation wells SP-2 and SDO-1, which are 7 and 11 feet from the injection point, respectively. At both locations DO readings increased from 0.2 mg/l to 0.4 mg/l during the test. Pressure increase was measured at well head location SP-3 using a magnahelic gauge. Pressure was found to increase 1.2 inches of water at a distance of 15 feet two minutes into the test. After an initial increase, the pressure declined to a 0.5 inch overall increase.

Data from the test indicated that oxygen from the injection point was measurable up to 11 feet away. Water level response to sparging was found to be minimum at a point 15 feet from the injection well. This data was used to define subsequent sparge test configurations.

2.3.3 Test No. 3

Test No. 3 was conducted after all sparge wells were redeveloped to determine if the silty nature of the waterbearing zone inhibited response to nearby observation points. Well SP-1 through SP-4 were redeveloped using a hand pump to remove fines from around each well screened opening. The sparge injection test that was conducted for Test No. 2 was then duplicated to determine if redevelopment of the wells increased response. The test was operated for a total of 31 minutes. The first 18 minutes of the test was used to obtain background data with the SVE system only in operation.

The sparge well injected >20 SCFM at a lower pressure (2.1 psi) after development than compared to the 7.0 psi recorded during Test No. 2. Pressure measured at SP-3 increased to 4.3 inches of water in less than 30 seconds before subsiding to a stabilized increase of 1.5 inches of water. Dissolved oxygen readings measured at the recovery well RW-1S (10 feet from SP-1) increased from 4.5 to 5.6 mg/l in less than three minutes. D.O. levels after the initial increase fluctuated between 5.3 to 5.1 mg/l throughout the rest of the test. D.O. levels decreased to 3.8 mg/l approximately one hour after the test ceased.

In summary, redevelopment of the sparge wells increased injection performance and oxygen distribution within the shallow waterbearing zone.

2.3.4 Test No. 4

Test No. 4 was conducted to measure VOC concentration prior to and during air sparging. Additionally, observation of water level change in response to sparging was expanded by the use of pressure transducers in wells SP-2, SP-3, SP-4, and RW-1S. Dissolved oxygen readings were also observed in SP-2 and SP-3.

The test was initiated by operating the SVE unit only for 45 minutes prior to sparging. An air sample of the pre-carb prior to dilution air was obtained to compare with a sample obtained during sparging (Table 4). Air injection was conducted at SP-1 at greater than 20 SCFM at a pressure of 2.1 psi.

Water level response at the observation points indicated that wells SP-3 and RW-1S experienced a decrease in water level in the beginning of the test and then a subsequent rise prior to stabilization. Location SP-3, which is 15 feet from SP-1, decreased during the first minute prior to rising. Location RW-1S which is 11 feet from SP-1 declined during the first 2½ minutes prior to rising. After completion of sparging, SP-3 and RW-1S declined rapidly, indicating the pressure release in this area. Water levels at SP-4 did not change during the test and the recovery cycle. This location was not under the influence of the sparge operation at a distance of 20 feet from the well. Well SP-2, which is 7 feet from the well experienced a steady rise during and after sparging. This well apparently was clogged by prior sparging from nearby SP-1. Response from this well is not indicative of sparge-induced conditions in the aquifer.

Dissolved oxygen readings at SP-3 suggest that this location was receiving oxygen from air injection at SP-1. Levels started at 6.3 mg/l prior to sparging. D.O. levels decreased initially to 5.75 mg/l prior to rising to 5.95 mg/l by 17 minutes. At the completion of sparging, D.O. levels dropped abruptly to 5.3 mg/l within two minutes of test termination. This sudden drop appears related to the stopping of air injection at SP-1, 15 feet away.

D.O. levels at SP-2 decreased steadily throughout the test supporting the assumption that SP-2 was clogged during the test and did not respond to sparging.

The air emission sample conducted during sparging (Table 4) increased TCE levels from 0.86 ppm prior to sparging to 1.65 ppm. Tetrachloroethylene was also detected at 0.01 ppm during sparging compared to <0.05 ppm prior to sparging.

In summary, Test No. 4 illustrated that sparging in the NPLS area has an effective radius of at least 15 feet, based upon D.O. levels and water level change. Sparging effects apparently did not extend to a depth of 20 feet based upon the non-response at SP-4. TCE concentrations in air emissions were shown to nearly double when sparging was conducted as opposed to non-sparging conditions.

2.3.5 Test No. 5

Test No. 5 was designed to determine response to sparging at various flow rates and injection pressures. Sparging was done at SP-1 for a period of 75 minutes. Air emission sampling was conducted at a reduced flow rate (8 SCFM) to compare with sampling conducted at >20 SCFM injection rate. Water levels and D.O. measurements were conducted in accordance with the previous test. Additionally, Draegar tube sampling was also conducted during the test.

Air was initially injected into sparge well SP-1 at 14 SCFM for 25 minutes. Water levels at SP-2, SP-3, SP-4, and RW-1S all showed a sudden drop in water level for the first 2½ minutes. The drop ranged from 0.12 feet at SP-4, which is 20 feet from the injection point, to 0.05 feet at SP-2, 7 feet from the injection point. Water levels in each well gradually stabilized during the remaining 22 minutes at this rate.

At 25½ minutes, the air flow at SP-1 was reduced to 8 SCFM. This caused a sudden rise in water level at observation wells SP-2, SP-3, and RW-1S. The rise ranged from 0.10 feet at SP-3 (15 feet from injection point), to 0.22 feet at SP-2 (7 feet from injection point). Well SP-4, which is 20 feet from the injection point, showed only a slight rise resulting from this change. After the initial rise at SP-2, SP-3, and RW-1S, the water level in each of these wells declined towards original static level. The 8 SCFM rate was utilized for 8 minutes.

The final flow rate at SP-1 was greater than 20 SCFM for 43 minutes. This change in injection rate caused the water levels in all four wells to drop suddenly. The closest wells (SP-2 and RW-1S) showed the sharpest and fastest decline. Decline in both of these wells was greater than 0.3 feet and occurred within the first two minutes. At SP-3, the decline occurred within the first one to two minutes, but only approximately to 0.15 feet. The water level change at SP-4 declined steadily for the first 14 minutes to a level of 0.15 feet lower than the previous rate.

After the initial decline, the water level at SP-2 rose steadily through the remainder of the test to a level approximately 0.15 feet higher than the last level at the previous rate. The water levels at the remaining three wells stabilized or rose slightly during the remainder of the test.

Recovery of water levels were also recorded after shutoff of the unit. All wells revealed a rise in water levels during the first one to two minutes after test shut down. The riser ranged from over one feet in the nearest well (SP-2) to approximately 0.10 feet in the farthest well (SP-4). After the abrupt rise, water levels in SP-2, SP-3, and RW-1S revealed equilibrium conditions approximately 12 minutes after shut down. Well SP-4 continued to decline until approximately 30 minutes when it reached relatively stable conditions.

In summary, the injection of air into the shallow waterbearing zone creates significant displacement of water that causes sudden and abrupt changes in water level surrounding the injection well. These changes appear relatively complex and are not readily quantifiable. These changes were found to occur to at least 20 feet from the injection point for flows of 12 and greater than 20 SCFM. The flow rate of 8 SCFM did not appear to extend to 20 feet, but changes were observed at the observation point 15 feet from the injection well.

An air emission sample was taken during the 8 SCFM flow period to determine if VOC concentrations are significantly different than previous sampling at a higher injection rate. Concentrations of TCE and PCE were 1.66 and 0.007 ppm, respectively. These values are essentially the same as those obtained from the air sample taken during higher injection flow rate.

Draegar tube samples for TCE (50 ppm) and PCE (0.100 ppm) were also obtained during the higher flow rate period during the test. Results for this sampling were negative.

2.3.6 Test No. 6

Test No. 6 involved sparging from well SP-3 at various flow rates to determine effects from a different injection point. Detailed dissolved oxygen readings were also obtained at two observation points to determine air circulation within the aquifer. Water levels were measured at three observation points (SP-2, SP-3, and SP-4) to determine hydraulic changes in the aquifer due to sparging. An air emission sample was also obtained during sparging of SP-3 to compare concentration with that at SP-1. Figure 9 depicts water level and dissolved oxygen changes throughout the sparge test at SP-3.

Sparging was initiated at a flow of 12.0 SCFM for a period of 33 minutes. As with the previous tests, a sudden drop in water level was apparent at all wells. At SP-1 (15 feet from sparge injection well) the water level dropped 0.47 feet within the first minute. At SP-2 (22 feet from the injection point) the water level dropped 0.15 feet within the first three minutes. At SP-4 (35 feet from injection point) the water level dropped 0.08 feet within the first five minutes. Water levels at SP-2 and SP-4 then began to rise and then stabilize by 12 minutes into the test. The nearest observation point, SP-1 recorded water levels that fluctuated during this step before stabilizing at approximately 24 minutes into the step.

The second flow rate was 13.5 SCFM which was conducted for 30 minutes. Water levels in all three observation wells again dropped suddenly after the new rate was selected. The levels dropped 0.5 feet at SP-1 to approximately 0.1 at SP-4. The water levels at SP-1 and SP-4 partially recovered and stabilized between five and seven minutes after increasing the flow rate. The water level at SP-2 steadily rose during the remainder of the flow rate.

Flow was increased to >20 SCFM for seven minutes at the end of the test; however, this increase did not appear to affect the trend in water levels at the observation points.

After completion of sparging, the water levels were observed to rise at all three locations. Most of the rise occurred at SP-1 where water level went up 0.6 feet during the first minute. Water levels at the three wells began to stabilize three to five minutes into recovery.

Dissolved oxygen levels were observed at location SP-1 and RW-1S, 15 and 16 feet from the injection well, respectively. Figure 9 depicts DO concentration change during the SP-3 test.

Oxygen levels were observed to increase at both locations during the first three to seven minutes of the test. D.O. levels at SP-1 went from 2.3 to 2.9 mg/l within the first three minutes of the test. The D.O. level peaked at 3.0 mg/l nine minutes into the test, then steadily declined back to 2.35 mg/l by the end of the first step. D.O. levels at RW-1S rose from 2.35 to 2.60 mg/l seven minutes into the test. D.O. levels at this location then steadily decreased to a level of 1.6 mg/l by the end of the first step.

During the second step, D.O. levels increased initially at each location. At SP-1 the D.O. level went from 2.35 to 2.70 mg/l within one minute of air injection increase. At RW-1S, D.O. levels went from 1.60 to 1.80 mg/l within the first three minutes of increased air injection. The D.O. levels then remained relatively stable throughout the remainder of the step. During the final step (15 SCFM), D.O. levels were found to increase abruptly at SP-1 to 3.05 mg/l. The D.O. levels remained elevated throughout this period. At RW-1S, the levels remained relatively unchanged at approximately 1.8 mg/l throughout this rate. After sparging was terminated, the D.O. levels at SP-1 dropped suddenly to 1.75 mg/l. The levels at RW-1S remained the same after sparging at 1.8 mg/l. One hour after sparging however, the level at RW-1S dropped to 1.6 mg/l.

In summary, an increase in D.O. is apparent from sparging at SP-3 for a distance of approximately 15 feet from the injection point. Water level response to sparging was observed up to 35 feet from the injection point. Significant water level response was observed 22 feet from the injection point.

An air emission sample was obtained during the first step of SP-3 injection. The results were similar to the other sparge air analysis. TCE levels were slightly higher at 1.79 ppm. PCE level was detected at 0.008 ppm. One additional compound, ethylbenzene was detected at 0.19 ppm at this location.

A PCE Draegar tube sample was obtained during the second step of SP-3 injection. Sample results were negative.

2.3.7 Test No. 7

Test No. 7 involved injecting air into multiple sparge points (SP-1, SP-2, and SP-3) to determine VOC concentrations under this condition. The test was run for 95 minutes with an air emission sample obtained prior to the end of testing. Air injection was a total of approximately 13 SCFM or about 4 SCFM for each injection point. The air emission results were slightly lower than previous results. TCE was detected at 1.48 ppm. No other VOC compounds were detected.

2.3.8 Summary

The sparge pilot tests conducted in the NPLS area have demonstrated that this technology is achievable and will enhance remediation of the shallow groundwater through removal of VOCs. Specifically, the testing has determined the following:

- Air injection into shallow groundwater and collection within the vadose zone is achievable without significant limitations caused by site conditions.
- VOC concentrations of air emissions from these units were shown to nearly double when sparging was conducted as opposed to non-sparging conditions.
- The effective radius based upon increase in D.O. levels was found as far as 15 feet from the sparge injection point at injection rates from 8 to 20 SCFM.
- Water level changes due to sparging were found as far as 35 feet from injection point.
- Injection rates varying from 4 to 20 SCFM did not significantly affect VOC concentrations in the air emission samples.

The effectiveness of sparging is anticipated to be further enhanced by pumping of the shallow waterbearing zone. Pumping of this zone will create groundwater flow towards the pumping well which will draw contamination upward from the top of the silty clay layer. The air sparge wells will inject air into the aquifer around well RW-1S as groundwater is drawn toward the well from within the capture zone thereby liberating VOCs prior to groundwater extraction.

2.4 SVE Pilot Test Confirmatory Sampling

To provide a check on the effectiveness of the pilot SVE testing being conducted in the former AST/UST area and former UST area, two soil borings were drilled and sampled within each treatment area and compared to previous analytical results. The borings were located adjacent to previous boring locations to provide a relative comparison of constituent concentrations. In the former AST/UST area, the locations chosen were those exhibiting the highest level of VOCs in soil samples. In the former UST area, the location selected were those adjacent to two previous sample borings drilled during ERM's site assessment activities in 1988. Table 5 summarizes laboratory results for the recent sampling and previous sampling at these locations. A discussion regarding the results of this comparison is provided in Section 3.2.3.

2.5 Groundwater Sample Results

Table 6 summarizes groundwater sample results for the shallow and deep monitoring wells. Tables 7 and 8 summarize groundwater analytical results for the pumping wells, RW-1S and RW-2D. Both inorganic and organic parameters are provided. Isocencentration contour maps for total chlorinated VOCs for both the shallow and lower fine sand waterbearing zones are provided in Figures 10 and 11. Figure 12 provides a summary of total ethylbenzene, toluene, and xylene concentrations for the shallow monitoring wells at the facility. A complete discussion of the groundwater sample results and comparison to previous data is discussed by area in Section 3.1.

3.0 REMEDIATION AREAS BASIS

This section describes the database and rationale used to develop the major design components for the selected remedial option. The present database on contaminant characterization and hydrogeologic conditions has been developed based upon various site investigations conducted form 1988 through the 1995 Pre-Design Investigation. The Remedial Action Objectives (RAOs) for the selected remedy include:

- Prevent ingestion of groundwater containing chlorinated VOCs, specifically TCE in concentrations exceeding Standard, Criteria, and Guidance (SCGs) levels.

- Prevent incidental ingestion of soils containing aromatic hydrocarbons such as ETX within the Former AST/UST Area and Previously Closed USTs Area, and prevent dermal adsorption of residues.

- Reduce site-related residues of TCE and ETX in groundwater, utilizing state/Federal groundwater standards as defined in the SCGs or background levels as cleanup goals.

- Reduce site-related residues of TCE and ETX in subsurface soils, utilizing cleanup goals of 1 ppm per individual VOC and/or 10 ppm aggregate total VOCs.

- Control and abate migration of contaminated groundwater from the site to the degree necessary to address groundwater goals.

- Prevent inhalation of VOCs emitted into the air through the volatilization of chemicals from contaminated soil or groundwater at concentrations that present a total carcinogenic risk factor (CRF) greater than 10^{-4} to 10^{-6} or a Health Index (HI) greater than 1.

- Prevent the release of VOCs from soil to groundwater that would result in groundwater concentrations exceeding SCGs.

3.1 Groundwater Contamination Characteristics

Groundwater chemical characteristics are summarized herein for the purposes of engineering design related to compatibility of materials and equipment, as well as to define specific remediation areas.

3.1.1 North Parking Lot Sump (NPLS) Area

Figure 10 is an isoconcentration map depicting total chlorinated VOC compounds in the shallow waterbearing zone for the most recent sampling round. Total chlorinated VOC concentrations ranged from 2 to 695,720 μg/l for the NPLS area. Concentrations at wells MW-7S revealed an increase from 57 to 430 μg/l, whereas wells MW-11S and MW-12 indicated decreasing total chlorinated VOCs (106 to 33 μg/l and 1,948 to 559 μg/l, respectively). The remaining wells had values relatively consistent with the prior sampling round. Offsite downgradient shallow wells revealed an increase at MW-14S and MW-15S (1,985 from 1,601 μg/l and 216 from 6 μg/l, respectively). MW-16S did not detect chlorinated VOCs for either round. TCE concentrations in the north parking lot sump area ranged from an estimated value of 2 μg/l to 640,000 μg/l. TCE values in the NPLS area were, in general, consistent with the prior sampling round with the exception of MW-7S which registered an increase in TCE concentration from 30 to 220 μg/l. The offsite downgradient wells in the shallow zone (MW-14S, MW-15S, and MW-16S) revealed an increase in TCE concentration to 140 μg/l from 6 μg/l from the previous sample round at MW-15S and an increase to 920 μg/l from 450 μg/l at MW-14S. At MW-16S, TCE was nondetectable from the most recent and prior sample round.

Vinyl chloride was detected at 3 of 6 shallow monitoring wells in the NPLS area at concentrations ranging from 8 to 1,900 μg/l. At MW-12 the concentration decreased from 420 to 230 μg/l. Other vinyl chloride values were relatively consistent with past sample results. The offsite downgradient wells revealed a decrease in vinyl chloride from 290 to 170 μg/l at MW-14S and nondetectable levels at MW-15S and MW-16S.

Toluene, ethylbenzene, and xylene parameters are of secondary concern in the NPLS area. The only well with detectable levels of constituents occurred at MW-3S which detected toluene (140 μg/l) and total xylenes (580 μg/l). Previous sample rounds also did not detect widespread extent of these constituents in the NPLS area.

Based upon a comparison of the most recent sample event and the prior sample event, the chlorinated VOC plume exhibited greater concentrations along its eastern extent at locations MW-7S and MW-15S and a decrease in concentrations along western sample points MW-11S and MW-12. Otherwise, the plume has maintained its previous configuration of a narrow north-south traversing area with a maximum lateral extent of only approximately 50 feet onsite.

Figure 11 is an isoconcentration map of chlorinated VOCs in the lower fine sand zone for the NPLS area. Total VOC concentrations were found to decrease in all NPLS deep wells except MW-8 where chlorinated VOCs were detected at 48 μg/l, up from 37 μg/l in February of 1992.

The configuration of the chlorinated VOCs in deep groundwater is similar to that in the shallow aquifer except that the concentrations in the deep zone are significantly less than the shallow. Downgradient, the chlorinated VOC concentrations also are less than the previous sampling round. At MW-14D, total chlorinated VOCs dropped from 38 to 14 μg/l. At MW-15D, total chlorinated VOCs dropped from 313 μg/l to 61 μg/l.

Along the eastern portion of the site at MW-19D, 412 μg/l of chlorinated VOCs was detected. Of this concentration, 410 μg/l was vinyl chloride. Previous results in this area revealed a total chlorinated VOC concentration of 104 μg/l with only 6 μg/l being vinyl chloride.

The total chlorinated VOC concentration in the well installed beneath the deep waterbearing zone into the glacial till (MW-7DD) was found to be 5 μg/l, all of which was TCE. Previous sampling results detected 24 μg/l of total chlorinated VOCs.

In summary, groundwater in the lower fine sand waterbearing zone reveals a similar configuration as the shallow waterbearing zone in the NPLS area. Concentrations in the lower fine sand zone are significantly less than the shallow zone. The extent of VOC constituents in the deep zone is adequately defined with the existing well network.

Groundwater samples collected from the deeper glacial till well (MW-7DD) have revealed progressively diminishing concentrations of chlorinated VOCs since the First Sample Round in February 1992. Table 9 summarizes lab data for MW-7DD showing the decreasing trend. A possible explanation for this trend is that the original VOC constituents detected in groundwater from this well were introduced through well installation practices. Subsequent sampling rounds have indicated decreasing concentrations due to a lack of a continual source of contaminants into this zone.

PCB analysis was also conducted for all NPLS wells. Only well MW-3S detected PCBs (Aroclor-1254) at a concentration of 730 μg/l. Previous sampling at this well detected 240 μg/l of PCBs. Semi-volatile constituents were not sampled during the Pre-Design Investigation. Previous sampling detected minor concentrations of naphthalene (31 μg/l), 2-Methylnaphthalene (30 μg/l), Bis-C2-ethylhexylphthalate (95 μg/l), and other constituents at trace values. Details regarding semivolatile concentrations in groundwater are contained in the R.I. Report.

3.1.2 Former AST/UST Area

The principal VOC constituents in this area consist of toluene, ethylbenzene, and xylene. At well MW-2 total VOC concentration remained relatively unchanged (124,650 μg/l) compared to the last sample round (122,430 μg/l) in February 1992. The constituents of VOCs at this location consist of: toluene (99,000 μg/l), total xylenes (21,000 μg/l), ethylbenzene (4,100 μg/l), 1,2-dichloroethene (370 μg/l), and vinyl chloride (180 μg/l). Vinyl chloride previously was not detected at this location.

At well location MW-4, 9,350 μg/l of total VOCs were detected. The previous sample round (July 1992) at this location detected 35,230 μg/l Total VOCs. The constituents detected during the most recent sample round consisted of toluene (6,700 μg/l), total xylenes (2,200 μg/l), and ethylbenzene (450 μg/l).

The ethylbenzene, toluene, and xylene characteristics of groundwater in the AST/UST area is not apparent in downgradient wells with the possible exception of well MW-3S.

Of secondary concern in the AST/UST area are concentrations of semi-volatile constituents in shallow groundwater. Groundwater sampling during the Pre-Design Investigation did not include semi-volatile constituents. Previous sampling has detected naphthalene at concentrations of 94 μg/l at MW-4 and 320 μg/l at MW-2. Bis(2-ethylhexyl)phthalate was also detected at concentrations of 94 μg/l at MW-4 and 60 μg/l at MW-2. Other semi-volatile constituents were detected in this area at low to trace concentrations. The RI report contains a detailed summary of this information.

3.1.3 Former UST Area

The principal constituents historically detected in this area have been ethylbenzene, xylene, and toluene. Well MW-20, which is immediately downgradient of the former UST area, detected 22,100 μg/l Total VOCs. Previous sampling (March 1993) in this area detected 11,178 μg/l Total VOCs. The recent analysis revealed a significant increase in total xylenes to 20,000 μg/l from 8,000 μg/l. Other wells (MW-1 and MW-13) nearby the former UST area did not detect VOC compounds that were associated with this area. Additionally, downgradient wells MW-19S and MW-18 did not detect VOC compounds indicative of this area. Delineation of VOC constituents in this area was previously conducted during Remedial Investigation Activities that included sampling Hope monitoring wells HW-7, HW-8, HW-9, and cone penetrometer groundwater sampling activities.

3.2 Soil Contamination Characteristics

Information regarding soil contamination characteristics was defined during the Remedial Investigation Process. The Pre-Design activities obtained information on soil contaminant characteristics only for comparative purposes to determine effectiveness of the SVE pilot testing in the former AST/UST area and UST areas. The following subsections describe available data for each of the three main remediation areas.

3.2.1 NPLS Area

The primary constituents detected in subsurface soils were TCE and PCBs. In this area of the site, the source of these constituents was considered to be the sump area. Figure 13 depicts previous RI soil sampling activities in the NPLS area and maximum concentrations of TCE and PCBs at each location.

Contaminants occurring in this area appear to have been discharged through the sump and into the shallow water table. Overlying soils above the water table do not exhibit the concentration levels of VOCs that occur beneath the water table. Specifically, the highest levels of contamination occur at the top of a silty clay confining layer which separates the upper and lower waterbearing zones. In the area of the sump, this occurs at a depth of approximately 14 to 16 feet. This material is a source of groundwater contamination in the NPLS area. The extent of the

PCB-contaminated soil is estimated based upon the existing data (Figure 13). Based upon the historical information available, soil boring data, and groundwater data, the areas of greatest contamination in the silty clay layer occur within and adjacent to the sump in the north parking lot.

3.2.2 Former AST/UST Area

A source of VOCs consisting primarily of ethylbenzene, toluene, xylene (ETX) and other VOCs commonly associated with petroleum-derived compounds was identified in the vicinity of MW-2 as a result of a soil boring program conducted during RI field activities. Analysis of subsurface soils in this area revealed total VOC concentrations ranging from less than detectable (<0.01 ppm) to 360 ppm. Immediately east of this area, two soil samples were obtained from a testing boring (B-10) sample from the 0- to 2-foot interval and one from the 6- to 8-foot interval, and analyzed for xylenes. The 0- to 2-foot samples exhibited a xylene concentration of 2,700 ppm and the 6- to 8-foot sample did not exhibit elevated concentrations. No trichloroethylene (TCE) was exhibited in the soil samples collected from this location. Based on this data, it appears that the elevated surface concentrations are the result of a localized surface spill.

To provide an indication on the effectiveness of the Pilot VES Study in this area, soil borings were drilled and sampled adjacent to previously drilled borings B-12 and B-14 during the Pre-Design Investigation. Samples were obtained from these borings and analyzed for VOCs to compare to previous results. Table 5 includes comparison data for the former AST/UST area. At location TB-12, the lab analysis revealed non-detectable levels for VOC constituents. Previous sampling in this area detected 15 mg/kg of ethylbenzene, 66 mg/kg of toluene, and 73 mg/kg of total xylenes. Based upon this sample location, the SVE system has been effective in reducing soil VOC levels.

At TB-14, a reduction in VOC concentration was not as apparent. Ethylbenzene was detected at 16 mg/kg initially, and 11 mg/kg during the Pre-Design Studies. Toluene was initially detected at 34 mg/kg and 29 mg/kg during the Pre-Design Studies. Total xylenes were previously detected at 120 mg/kg and at 180 mg/kg during the Pre-Design Studies. The increase in xylenes at TB-14 may, in part, be due to the heterogenuity of soil conditions in this area.

In summary, the SVE pilot testing in the former AST/UST area has shown limited success on reducing soil VOC concentrations. An expanded vacuum system will provide an effective means for VOC removal throughout this remediation area.

3.2.3 Former UST Area

Analysis of soils collected from excavations adjacent to the side walls of the five USTs during the RI revealed the presence of ETX at maximum concentrations of 1,000, 410, and 3,600 mg/kg, respectively. Prior to the RI, two soil borings were drilled and sampled in this area and identified ethylbenzene at a concentration of 200 mg/kg.

During the Pre-Design activities, two borings were drilled and sampled in the approximate locations of the site assessment test borings to provide an indication on the effectiveness of the pilot SVE testing conducted in this area. Table 5 compares results of this testing to the previous soil boring data.

At location TB-3, total xylenes were detected at 30 mg/kg and ethylbenzene was detected at 3.8 mg/kg. Previous sampling at SB-3 did not detect ethylbenzene and did not analyze for xylenes. Results from this location indicate that VOCs are still detected above site RAOs. Due to the fact that xylene was not initially analyzed, a conclusion on the effectiveness of SVE at this location cannot be made.

At location TB-4, only 0.310 mg/kg of ethylbenzene and 1.8 mg/kg of total xylenes were detected. Previous data indicated that 200 mg/kg of ethylbenzene was present in this area. Total xylenes were not analyzed. Based upon the results at the TB-4 location, the SVE unit appears to have been effective in removing VOCs from the subsurface. Construction of a full scale SVE system in this area should effectively reduce soil VOC concentrations to RAO levels.

3.3 Areas of Attainment

Table 10 provides the soil and groundwater Remedial Action Objectives (RAOs) for this project. The areas of attainment for the soil RAOs include the identified areas of the former AST/UST area and the former UST area as shown on Figure 14. These areas represent sources of VOC contamination as determined during the RI and previous investigations as well as the data collected during the Pre-Design Investigation.

In the NPLS area, subsurface soils 7 to 8 feet beneath the water table were found to contain PCBs and TCE in exceedance of the RAOs. Due to the nature of disposal through the north parking lot sump, the overlying soils predominantly do not exceed RAOs for soil. This area is interpreted to be point source discharge to groundwater. Accordingly, no soil area of attainment has been established in the NPLS area. The RAOs for the NPLS area will be addressed through groundwater.

The groundwater area of attainment will be a network of monitoring wells that occur downgradient of the three source areas of contamination (NPLS, former AST/UST, and former UST areas). Details regarding monitoring of the attainment areas will be developed in the Remedial Action and Performance Monitoring Plan prior to submittal of final design package.

4.0 REMEDIAL ACTION DESCRIPTION

Figure 14 depicts a plan view of the proposed remedial action elements. The remedial action consists of groundwater pumping and treatment utilizing five shallow water table wells and two deep wells, combination soil vapor extraction and air sparging in source areas of groundwater/soil contamination, and removal of north parking lot sump and related subsurface soils containing elevated levels of PCBs and TCE. Additionally, the former UST area, former AST/UST area, and the north parking lot sump area will be capped with an asphaltic cover and graded to minimize infiltration in areas containing BNAs and VOCs. The following subsections describe each element of the prepared remedy.

4.1 NPLS Decommissioning and Soil Excavation

The former NPLS sump and surrounding soils will be excavated. The concrete sump, grating, piping, and aggregate within the excavation area will be removed and disposed of offsite at a suitable treatment, storage, and disposal (TSD) facility. The soil excavation will be implemented to remove the zone of PCB contamination in the silty clay layer approximately 12 to 14 feet below ground surface. Soils containing PCBs above the RAO (10 ppm) shall be targeted for removal. Approximately 100 CY of PCB soils will be removed from within the proposed excavation area. Concurrent with removal of the PCB-contaminated soils will be removal of VOC-contaminated soils, primarily trichloroethylene.

The area of the proposed excavation is shown on Figure 15. This area encompasses the soil borings with PCBs above the RAOs for soil (soil borings 6 and 7) in addition to the highest concentrations of TCE contamination. The excavation is anticipated to be performed using steel sheet pile wall bracing to prevent undercutting of the electrical transformer, the plant building foundations, and the western property line. A continuous sheet pile wall, approximately 30 x 45 feet in plan dimensions, will be installed prior to excavation. The detailed wall design will be prepared prior to construction. An alternative excavation method utilizing large diameter shaft (caisson) drilling to remove contaminated soil will also be evaluated. The selection of the excavation method will be based upon cost effectiveness. This determination will be made prior to the final design phase.

The sequence of activities, assuming an open excavation using sheet pile bracing, would be as follows:

1. Decommission the sump, including removal of piping, sealing cut pipe ends, and removal of standing water.

2. Setup of temporary water storage and treatment system, including a frac tank (18,500 gallons), transfer pump, and dual activated carbon adsorbers. Discharge shall be to the existing onsite sewer within the plant building directly south of the excavation.

3. Location and removal of abandoned utilities and relocation of active utilities within the excavation area.

4. Installation of sheet pile wall for excavation bracing.

5. Construction of temporary soil stockpile area liners and water collection sump adjacent to the excavation.

6. Installation of groundwater dewatering wellpoints in the confined aquifer underlying the silty clay layer. The well points will be pumped prior to and during the excavation to lower the confined aquifer potentiometric surface to below the proposed floor of the excavation. Groundwater will be discharged to the temporary storage and treatment system.

7. Excavation of unsaturated zone soils (0 to 6 feet BGS) and placement in a prepared onsite stockpile (Number 1).

8. Excavation of saturated zone soils above the silty clay layer (6 to 12 feet BGS) and placement in a prepared onsite stockpile (Number 2). The stockpiles shall be temporarily covered and drained water shall be collected in a sump and pumped to the onsite temporary treatment system.

9. Excavation of the PCB-contaminated silty clay soils and placement in waste storage containers onsite. The sump materials shall also be placed in the waste container.

10. Quick-turnaround chemical analyses of the soil stockpiles for waste constituents, including RCRA characteristics, and submittal of waste profile sheets for disposal approval at suitable TSD facilities.

11. Backfill of the excavation with clean stockpiled soils, or imported clean backfill if the stockpiled soils are RCRA characteristic. The backfill shall be placed in 1-foot thick layers and compacted to achieve a firm, stable fill.

12. Removal of the dewatering system and the sheet pile walls.

13. Offsite transportation and disposal of the sump materials, PCB-contaminated soils, and if needed, the stockpile Number 2 soils, at an approved TSDF.

14. Demobilization of the temporary water storage and treatment facility.

Upon demobilization of the excavation support facilities, the NPLS area final cover and groundwater collection and air sparging systems shall be installed.

4.2 Cap and Cover

A surface cap consisting of asphalt pavement shall be placed over the NPLS area, the underground storage tank area, and the AST/UST area. The extent of the cap is shown on Figure 16.

The purpose of the cap is as follows:

1. Prevent the risk of contaminant exposures by dermal contact and particulate inhalation.

2. Minimize the potential for leaching of semi-volatile organic soil contaminants into the groundwater.

3. Improve the efficiency of soil vapor extraction (SVE) in the SVE treatment areas by minimizing the leakage of air into the vacuum extraction wells.

The asphalt cap shall consist of a standard light-duty roadway pavement including an aggregate subbase, asphaltic concrete base, and a surface wear course. Minor soil excavation and grading will be required in the treatment areas to place the cap. Excavated materials will be temporarily stockpiled and either used for backfill in the NPLS area excavation, or hauled offsite for disposal at a suitable non-RCRA TSD facility.

Each of the capped areas will be sloped to convey runoff into local stormwater drainage channels and catch basins.

4.3 Groundwater Collection System

Table 11 summarizes the details for the proposed groundwater extraction system. Four (RW-1S, RW-1D, RW-2S, and RW-2D) of the seven wells have been installed. Well RW-3S will require installation in the former AST/UST area and wells RW-4S and RW-5S will require installation in the former UST area. The three shallow recovery wells to be installed will be constructed of four-inch stainless steel screen and riser. Each shallow well will be drilled to the top of the clayey silt confining layer. Anticipated depth will be 16 to 18 feet. Each well will be constructed of ten feet of 0.01-inch continuous wire wound slotted screen. All three wells will be drilled by hollow stem augers or drive casing drilling methods. The wells will be installed in accordance with the installation procedures utilized for Pre-Design Activities (DEI SOPs 16, 17, and 18).

Based upon the pumping tests conducted during the RI and Pre-Design Activities, each shallow well is anticipated to provide at a constant rate, approximately 0.50 to 1.0 gallons per minute (gpm). Each deep well is anticipated to produce a constant rate of approximately 2 to 3 gpm. Total flow for the extraction system is estimated to range between 6 to 14 gallons per minute. A capture zone analysis map for the shallow wells is provided on Figure 17. The capture zones shown are based upon a yield of 1 gpm, transmissivity of 400 gpd/ft, and a storage coefficient of 0.02 as determined during the Pre-Design Investigation aquifer testing.

Figure 17 provides a capture zone delineation for the deep well based upon each deep well pumping 2 gpm and a transmissivity of 400 gpd/ft and storage coefficient of 0.0001, as determined from RI and Pre-Design Investigation pumping.

4.4 Combination SVE/Air Sparge Systems

Combination SVE/sparge systems are proposed throughout all of the constituent source areas to enhance groundwater treatment by in-situ methods. In the former UST area and former AST/UST area, the SVE systems will provide a dual role by treating the vadose zone soils which primarily contain toluene, ethylbenzene, and xylene constituents. The air sparge technology is considered to be favorable in the two tank farm areas because of the shallow nature of contamination and characteristics of VOC constituents. In the NPLS area, the air sparge operation will be utilized to assist removal of chlorinated VOCs which are found to occur at the top of the silty clay confining layer. Vadose zone treatment in this area is of secondary concern. Figure 18 depicts SVE and sparge well construction details.

Because the treatment areas occur in three distinct locations separated by hundreds of feet and facility production buildings, three separate SVE/sparge units will be utilized. This approach allows for maximum flexibility for treatment cycles, flow rates, pressure, etc. and less complications that a single unit.

Based upon the SVE pilot testing conducted (O'Brien and Gere, 1993), the effective radius of treatment was found to range from 25 to 30 feet under operating vacuums ranging between 50 to 68 inches of water.

The sparge testing conducted in the NPLS area revealed an effective radius of 15 feet. Typically, injection flow rates per sparge point will range from 3 to 7 SCFM under an injection pressure of 3.0 to 3.5 psi. Variations in the three areas may occur; however, the sparge systems proposed are capable of operating over a wider range of conditions. Each individual well can be regulated to provide optimum conditions for sparging. The following subsections describe details for each of the combination SVE/sparge systems.

Based upon existing information, it is assumed that treatment of off gas will be required prior to discharge to the atmosphere for each of the SVE/sparge units. If, however, VOC emission levels drop signficaintly during remediation, treatment of off gas emission may not be further required. The Remedial Action Air Monitoring Plan will provide further details regarding emission concentration levels requiring treatment prior to discharge.

4.4.1 Former AST/UST Area

In the former UST area, seven SVE wells are proposed for the entire system. The well configuration is shown on Figure 19. Well spacing ranges from 22 to 30 feet between locations to provide adequate overlap and enhanced recovery. The well locations are designed to treat soil contamination as well as to collect all vapors created from air sparging. All wells will be two-inch diameter PVC wells screened within the vadose zone. Screened intervals will be approximately 3 to 8 feet below existing grade. Total flow from the system is anticipated to range between 150 to 220 SCFM under an operating vacuum of 7 in Hg or less. All piping from the system will be PVC and will be run underground to the combination SVE/air sparge unit as located on Figure 19.

The sparge system for the former AST/UST area is designed to enhance treatment of groundwater contamination which will ultimately reduce groundwater pump and treat duration. The system consists of five sparge wells which will inject air into the underlying shallow waterbearing zone. The injected air will provide treatment via two methods: volatilization of contaminants with resultant capture by overlying SVE system, and biodegradation of contaminants via increase in O_2 levels. Each well injects air at a controlled rate so that spreading of VOC contaminants does not occur. Injection pressures for each well will be approximately 3 to 3.5 psi with each well injecting approximately 3 to 7 SCFM for a total flow of approximately 25 SCFM for this area. All piping for the sparge system in the former AST/UST area will be run underground to the sparge unit. Each sparge well will consist of two-inch diameter PVC as shown on Figure 18. Screen slot size will be 0.01 inch for this area. Each well will be installed flush with existing grade.

The SVE/sparge unit will be an integrated system with automated timer and automatic shut-off for SVE failure, high condensate tank level, and high temperature setting. The unit will be housed in a weatherproof, sound-resistant enclosure. The unit will be operated by a controller with auto/manual operation, 24-hour timer, and system reset switches.

Emissions for the system will be routed through a carbon adsorption system prior to discharge to the atmosphere. The carbon system will consist of a Calgon Carbon Vapor Pac (1,800 lbs. activated carbon) or equivalent system that will be mounted adjacent to and outside of the enclosure. During the early stages of operation, a thermal oxidizer may be utilized in lieu of a carbon bed until emission levels subside. This determination will be made based upon the cost-effective use of carbon based upon the initial emission concentrations from the unit.

4.4.2 Former UST Area

In this area, four sparge and nine SVE wells are projected for vadose zone and groundwater treatment. The plan view for the system is provided as Figure 20. The spacing for the configuration of the system is distorted due to the elongated nature of the tank farm and the presence of adjacent Plant 5 building. The sparge well configuration in this area does not allow for overlap due to the constraints caused by the building and underground tanks. However, the air injection treatment will still be effective due to the induced gradients that will be created by the two shallow recovery wells in this area. These gradients will cause the majority of groundwater from this area to migrate through the sparge locations prior to collection by the groundwater recovery system.

The SVE wells will be screened within the vadose zone from approximately 3 to 8 feet. Well construction details will be similar to those in the former AST/UST area except that the SVE wells in this area may not have to be flush mount construction. If the location of the wells does not interfere with normal plant operations, all piping in this area will be above ground. If the well locations are found to interfere with normal plant operations, piping and wells will then be located beneath the ground. Anticipated extraction rates per well range from 15 to 25 SCFM. Total extraction rate is anticipated to be approximately 200 SCFM at an operating vacuum of 7 in Hg or less.

The four sparge wells will be installed to the base of the shallow waterbearing zone (approximately 16 foot depth). Each well will be two-inch in diameter with a one-foot screen on sparge tip at the base of the well (Figure 18). The injection rates per sparge well will range from 3 to 7 SCFM at an injection pressure of approximately 3.5 psi. Total injection rates for the system in this area will range from approximately 20 to 25 SCFM. All piping for the sparge unit will be two-inch PVC.

The combination SVE/sparge system will be an integrated unit with the same features as described for the former AST/UST area system. Emissions from the system will be treated with activated carbon (Calgon Carbon Vapor Pac or equivalent). As in the case of the former AST/UST area, a thermal oxidizer may be utilized initially in lieu of carbon if VOC loading exceeds practical carbon adsorption capabilities.

4.4.3 NPLS Area

The combination SVE/sparge system in this area is designed primarily to enhance treatment of groundwater by in-situ methods prior to recovery and treatment via the groundwater extraction system. Specifically, the sparge wells are designed to treat the top of the silty clay confining layer, which has been shown to be a source of VOCs in the NPLS area. The plan view of the Sparge/SVE system is included on Figure 21. A total of nine SVE and nine sparge wells are proposed for this area. Two of the SVE and four of the five sparge wells have already been installed in this area for the purpose of conducting a pilot study. Logs for these wells are included in Appendix A.

Flow rates for the SVE wells are anticipated to range from 15 to 20 SCFM. Total flow from the system is expected to be in the range of 100 SCFM at an operating vacuum of 7 in Hg or less. The sparge wells will inject between 5 to 7 SCFM at an injection pressure of 3.5 psi. Total injection flow from the sparge until will range from 25 to 35 SCFM. All installed wells will be flush-mount construction. All piping for the SVE/sparge system will be run underground to the treatment unit. The treatment will consist of four Calgon Carbon Ventsorb or equivalent canisters connected two in series and two parallel.

4.5 Wastewater Management

All water extracted from the recovery wells will be piped to a centralized treatment area as shown on Figure 21. The majority of the piping runs will be run underground except for sections through production buildings or otherwise shown. Water from the treatment system is intended to be discharged to the City of Jamestown public sewer system, contingent upon the successful application for a discharge permit.

4.5.1 Discharge Requirements

Preliminary discussions have been undertaken with the Jamestown Board of Public Utilities (BPU) concerning discharge of treated wastewaters into the public sewer.

The City of Jamestown Sewer Use Ordinance, Amended June 12, 1989, contains provisions for discharge of wasterwater into the sewer. Article VI of the ordinance requires a Class I Permit for discharge of industrial wastewaters. Discharge limitations are included for various inorgainc substances as summarized on Table 12. Additionally, federal pre-treatment standards must be met for organic constituents. Concurrently with submittal of this report, DEI will initiate the Sewer Use Permit Application for obtaining an Industrial Wastewater Discharge Permit. The final Pre-treatment Standard will be provided by the BPU after submittal of the permit application.

4.5.2 Wastewater Treatment

Treatment options are being evaluated to determine the most efficient cost-effective method of meeting POTW discharge effluent limitations. Present technologies being considered are carbon adsorption, air stripping, or a combination carbon adsorption/air stripping system. Based on preliminary evaluations, activated carbon adsorption has been determined to be the preferred treatment method. Based upon the range of groundwater pumping rates considered, the system will be required to treat and discharge up to 25,000 gallons per day.

Condensate water from the SVE Systems will be collected in a separator tank at each unit. Each unit will not operate when the tank is full. Water from each condensate tank will be drained or pumped manually into storage drums which will be transferred to groundwater treatment system for treatment prior to discharge to the POTW. It is anticipated that each SVE unit will accumulate on average, less than 40 gallons per month of condensate.

4.6 Remedial Action Operations

Figure 22 is a process flow and instrumentation diagram for the selected remedial action. The remediation system consists of a centralized groundwater treatment system that will collect water from all seven wells. Three separate SVE/sparge systems are provided for each of the remediation areas. This approach allows flexibility for treatment and is less complex technically and easier to construct. Details regarding operation cycles, flow rates, vacuum and pressure settings will be provided in the operations and maintenance manual.

5.0 GENERAL SEQUENCE OF CONSTRUCTION ACTIVITIES

The initial construction activities will involve site preparation work such as field surveying, mobilization of equipment and personnel, and installation of temporary wastewater storage and pretreatment facility for the NPLS excavation. Upon completion of site preparation, the NPLS excavation will commence. No other site work is envisioned during this task. After completion of excavation, the excavated area will be backfilled, contaminated materials that were excavated will be disposed offsite and the groundwater collected from the excavation will be pretreated via activated carbon and then discharged to the city sewer system (pending approval).

The next construction activity will be the installation of the various treatment systems for soil and groundwater. These include the groundwater treatment system and the SVE/sparge systems for the former UST area, former AST/UST area, and the NPLS area. Specific activities will include recovery well and sparge/SVE well installation, installation of piping (underground and aboveground) from the various wells to the treatment units, and installation of treatment units and process controls. After installation is complete, a short prove-out period will then be conducted to ensure proper operation of the system and piping prior to capping of the remediation areas.

After the prove-out period is completed, the capping of the remediation areas will then be conducted. Once capping is completed, formal start-up of the system will be undertaken. Further details regarding sequence of work will be provided in the Construction Work Plan for the site.

6.0 REFERENCES

Cooper, H. H., Jr., and C. E. Jacob, "A generalized graphical method for evaluating formation constants and summarizing well-field history" Transactions. American Geophysical Union 27 (1946): 526-34.

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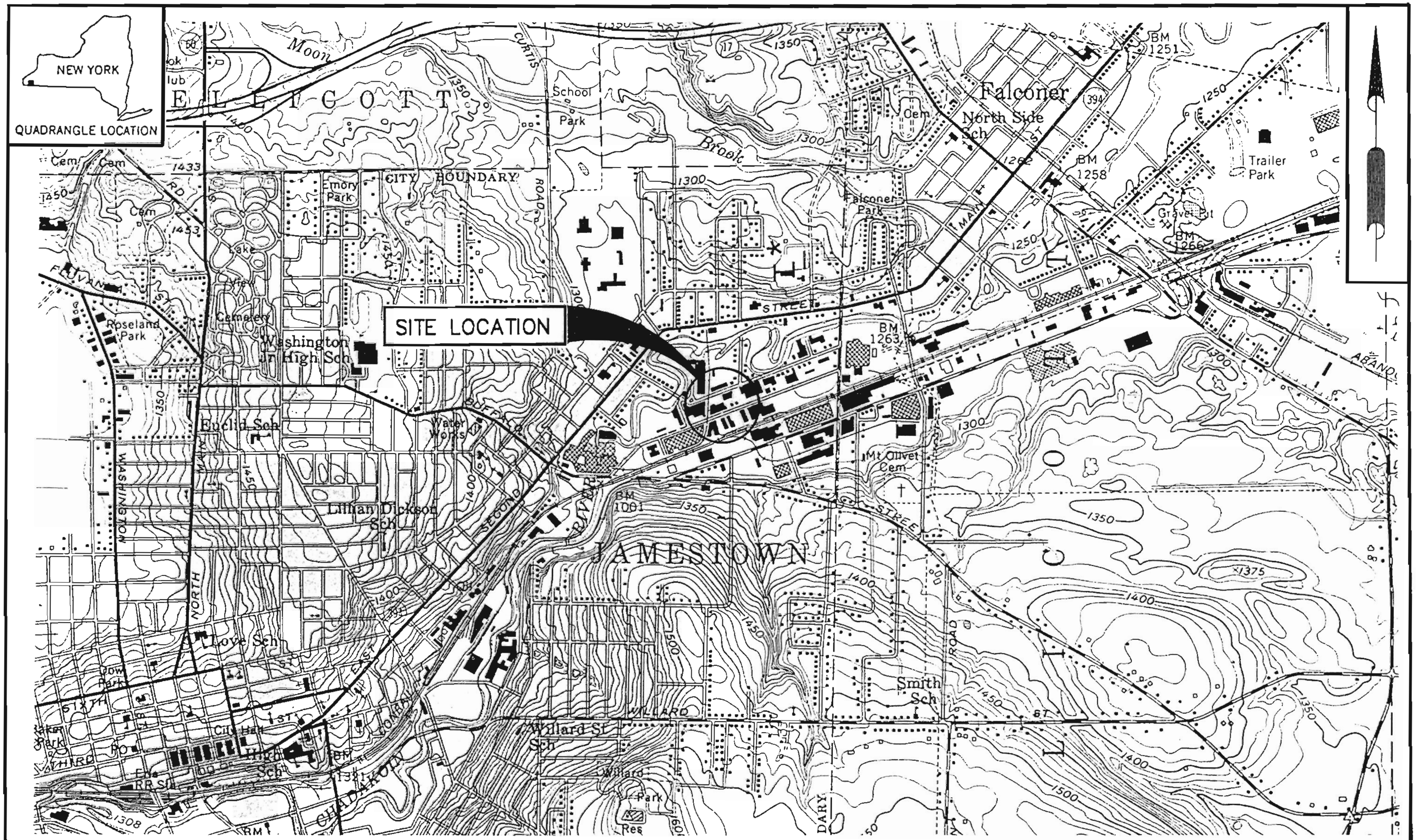
Theis, C. U., 1935. "The Relation Between Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Groundwater Storage: American Geophysical Union Transactions, Vol. 16, p. 519-524.

FIGURES



BASE MAP IS A PORTION OF THE JAMESTOWN, NY U.S.G.S. QUADRANGLE. 7.5 MINUTE SERIES. PHOTOREVISED 1979. CONTOUR INTERVAL 10 FEET.

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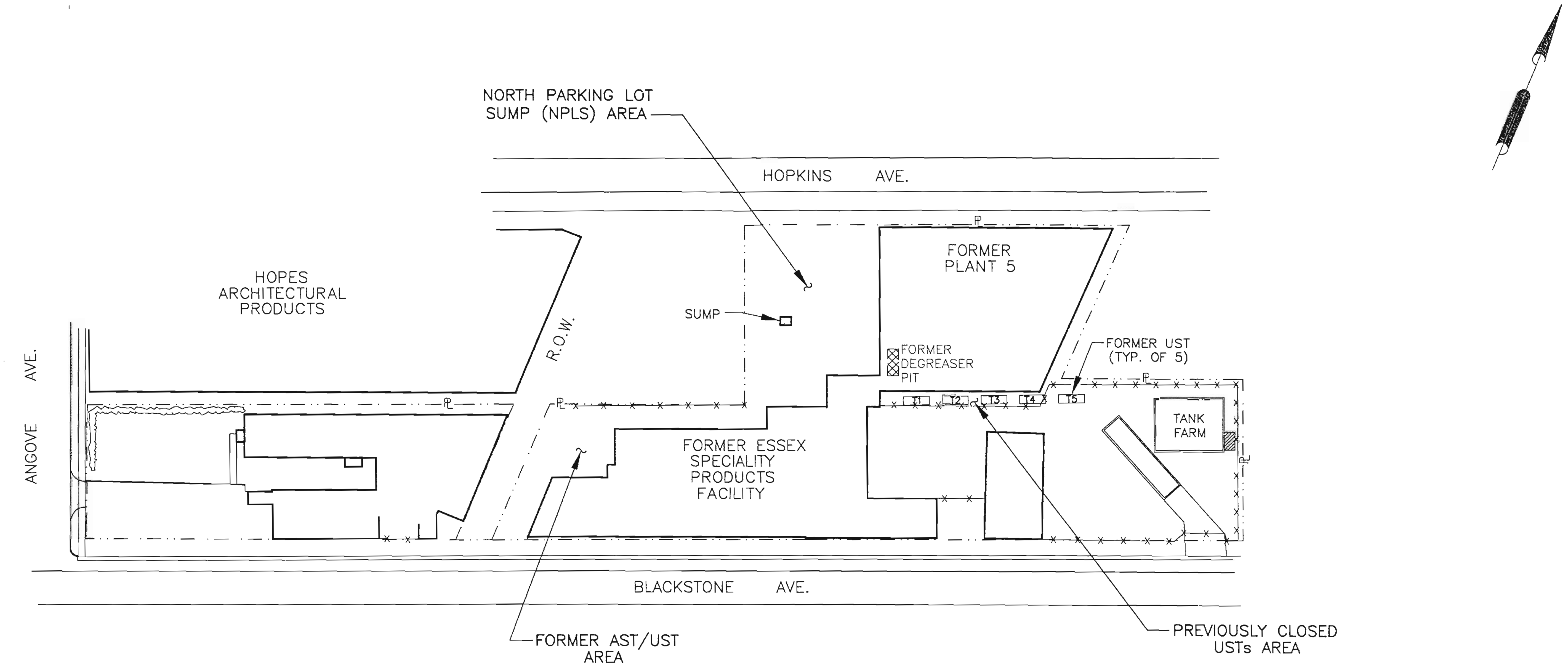
Dow Environmental

SITE LOCATION MAP

ESSEX/HOPE SITE	JAMESTOWN, NY
CLIENT: ESSEX SPECIALTY PRODUCTS, INC.	JOB NUMBER: 7138-400
SCALE: AS SHOWN	FIGURE NUMBER 1
	REV 0



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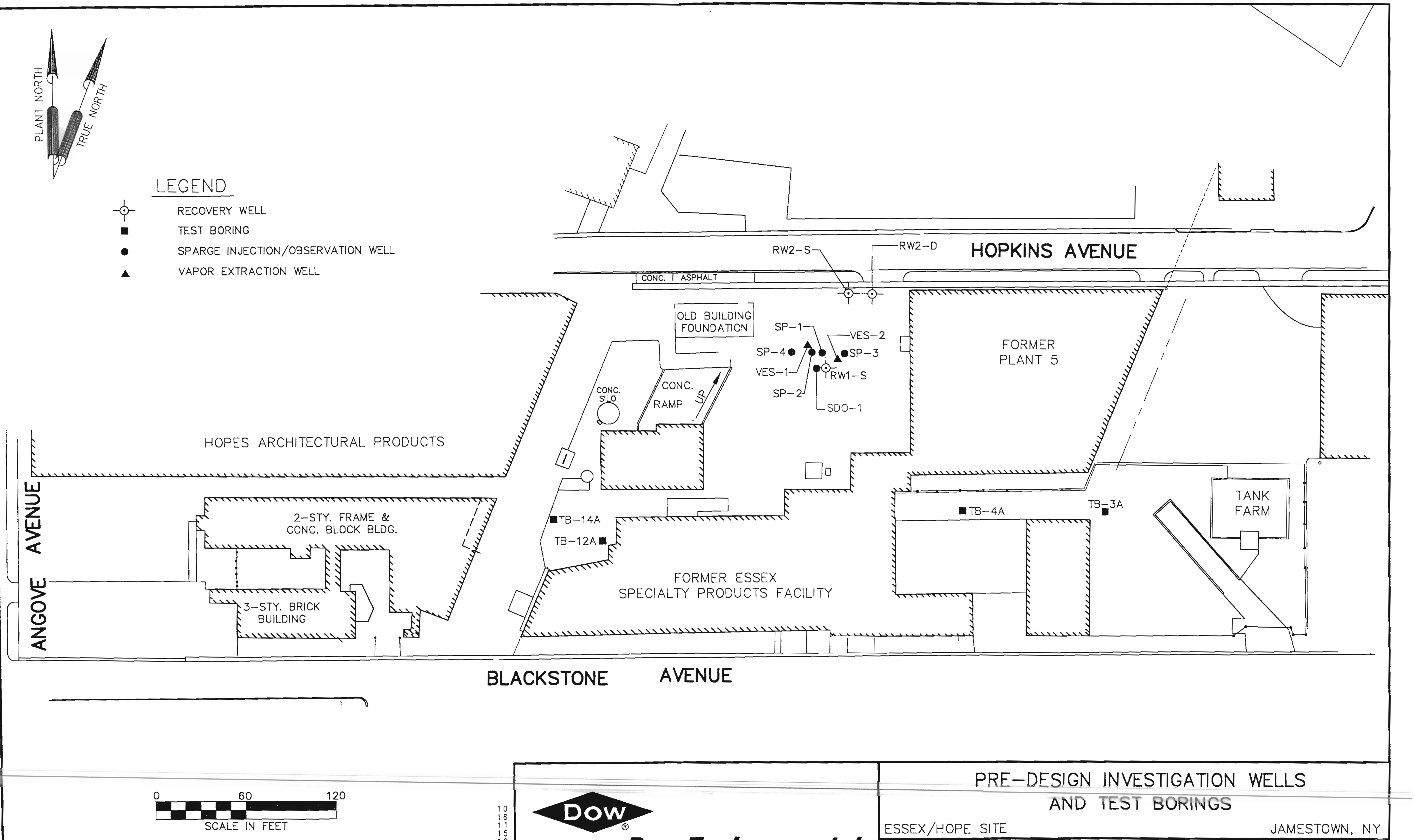
Dow Environmental

SITE PLAN WITH AREAS OF CONCERN

ESSEX/HOPE SITE
JAMESTOWN, NY
CLIENT: ESSEX SPECIALTY PRODUCTS, INC.
JOB NUMBER: 7138-400
SCALE: AS SHOWN
FIGURE NUMBER 2
REV 0

FILE: \SHARED\ESSEX-H\7138-039



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Dow Environmental

PRE-DESIGN INVESTIGATION WELLS AND TEST BORINGS

ESSEX/HOPE SITE JAMESTOWN, NY

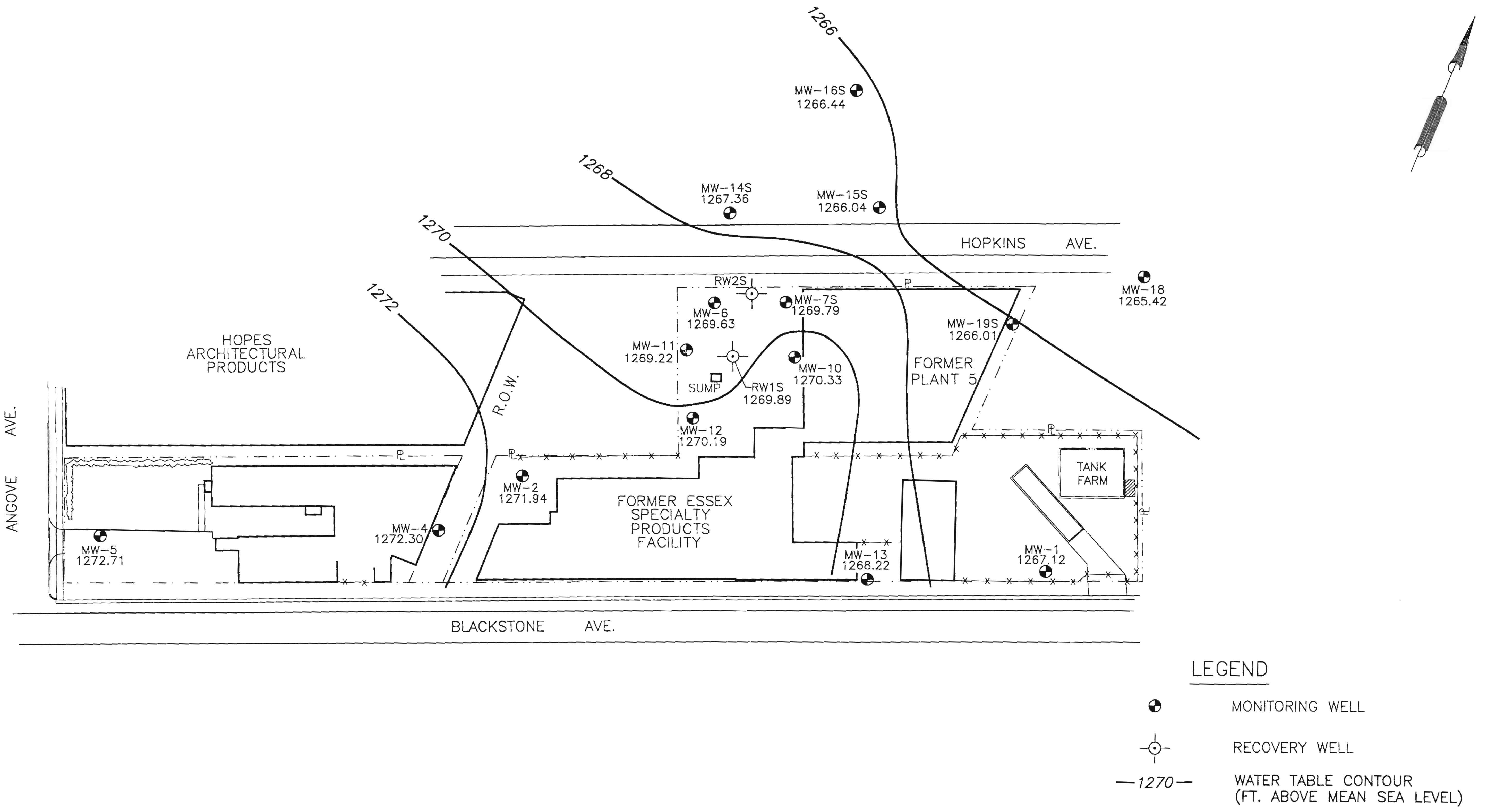
CLIENT: ESSEX SPECIALTY PRODUCTS, INC.

JOB NUMBER: 7138-400

SCALE: AS SHOWN

FIGURE NUMBER 3

REV 0



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SCALE IN FEET

FILE: \SHARED\ESSEX-H\7138-025

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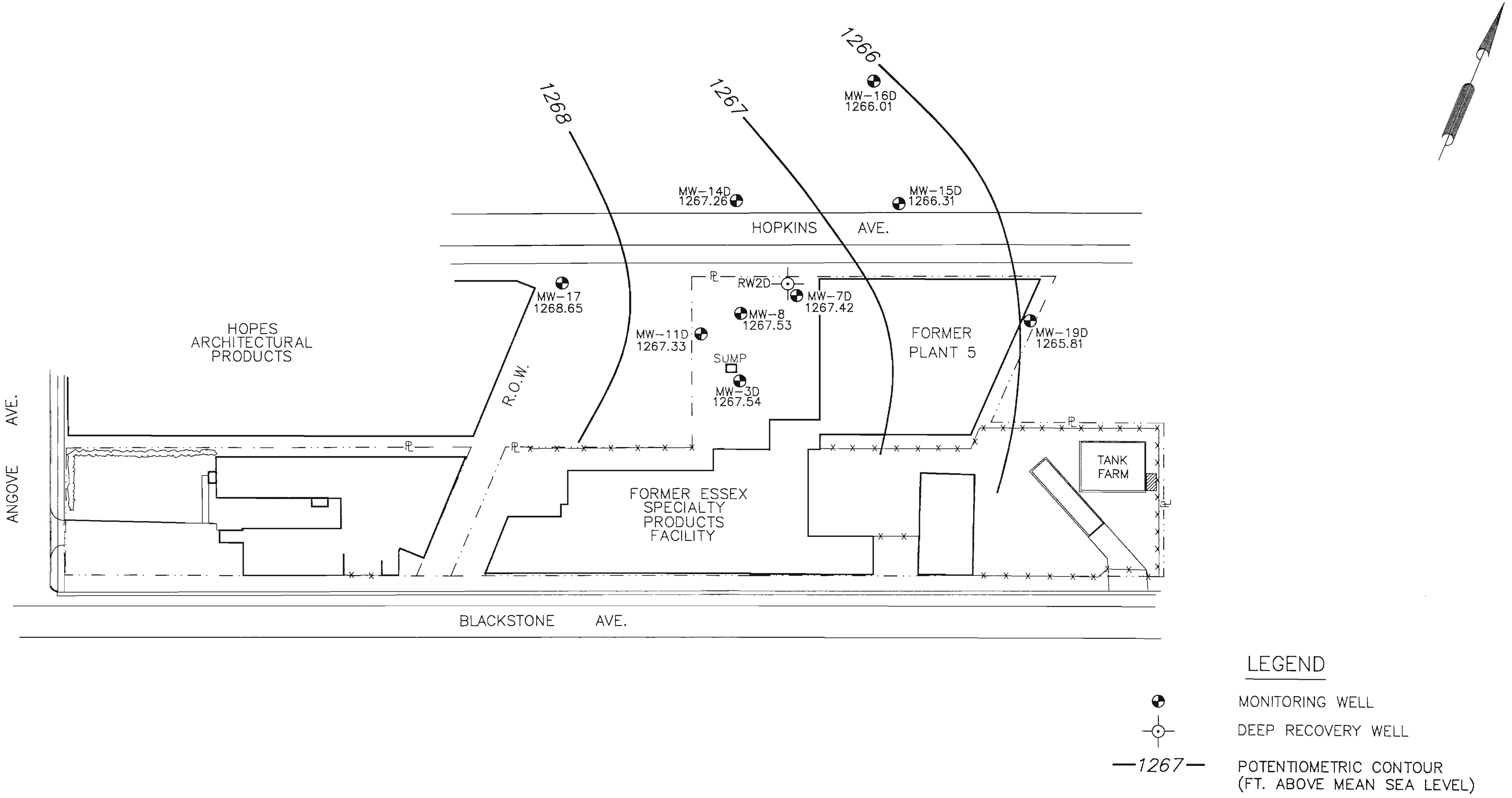
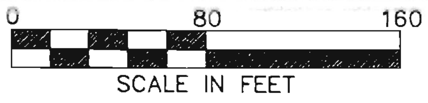
Dow Environmental

SHALLOW WATER TABLE CONTOUR MAP
AUGUST, 1995

ESSEX/HOPE SITE		JAMESTOWN, NY	
CLIENT: ESSEX SPECIALTY PRODUCTS, INC.		JOB NUMBER: 7138-400	
SCALE: AS SHOWN	FIGURE NUMBER 4		REV 0





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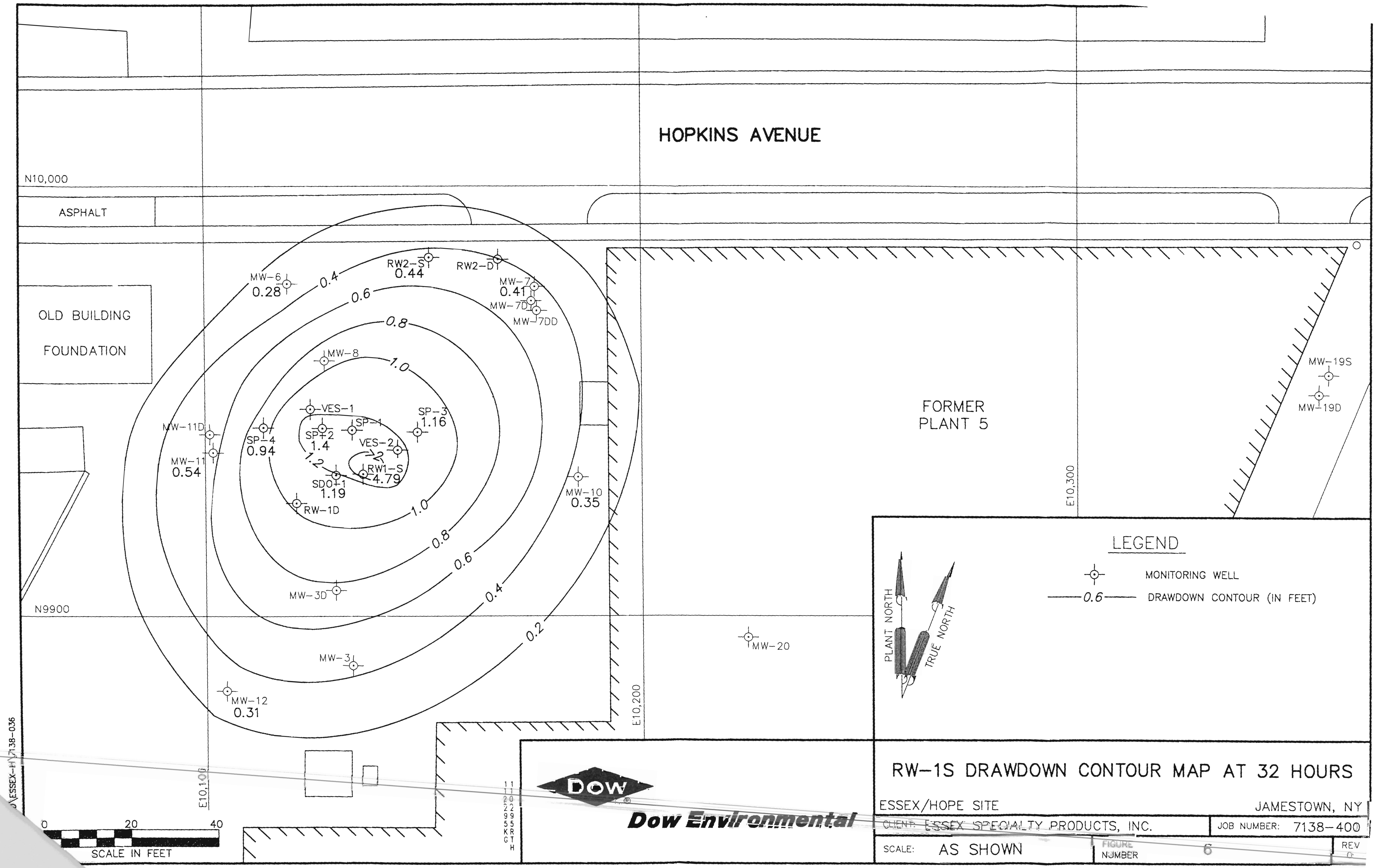
POTENTIOMETRIC CONTOUR MAP LOWER FINE SAND WATER BEARING ZONE – AUGUST, 1995			
ESSEX/HOPE SITE		JAMESTOWN, NY	
CLIENT: ESSEX SPECIALTY PRODUCTS, INC.		JOB NUMBER: 7138-400	
SCALE: AS SHOWN	FIGURE NUMBER 5		REV 0



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RW–1S DRAWDOWN CONTOUR MAP AT 32 HOURS

ESSEX/HOPE SITE JAMESTOWN, NY

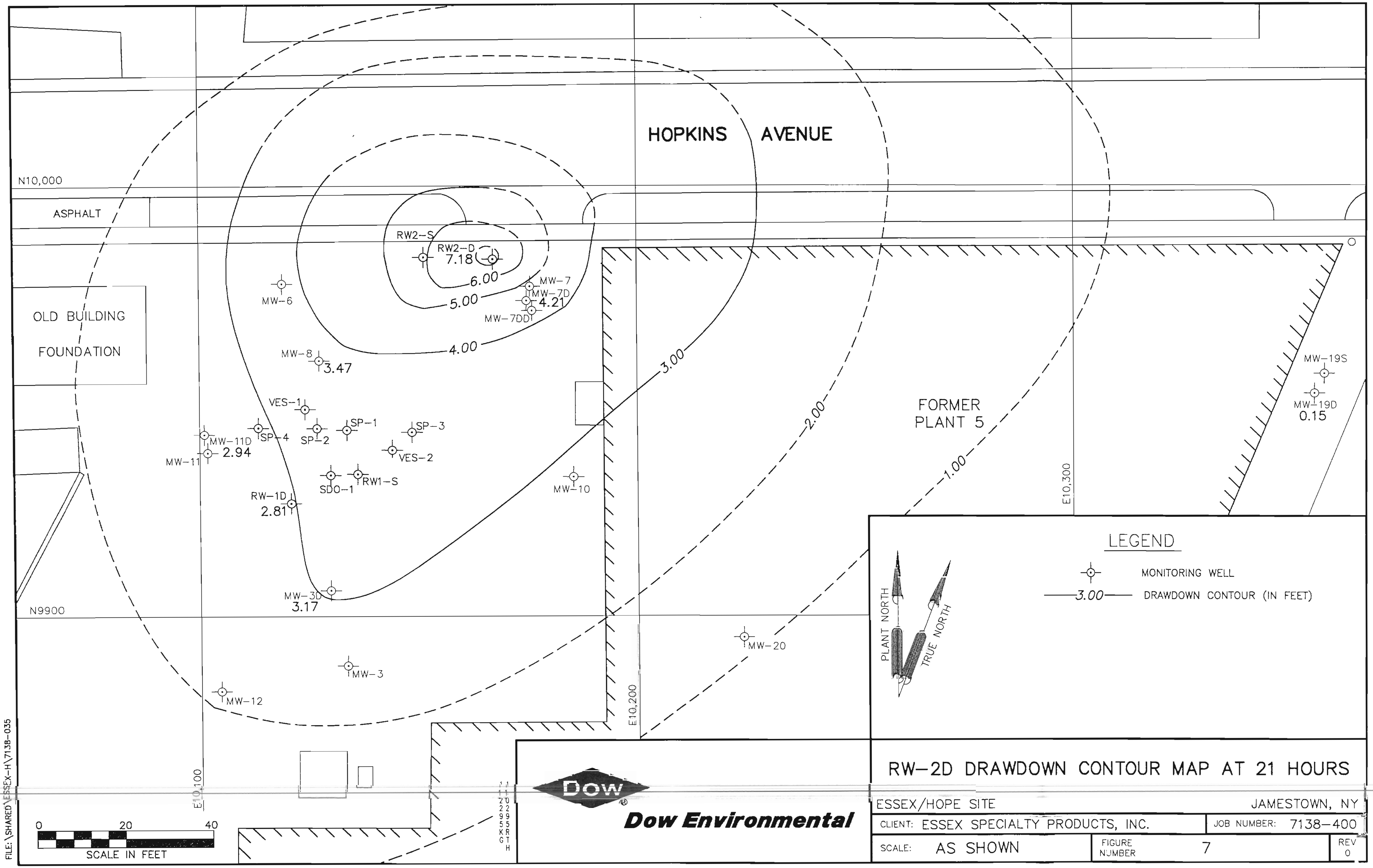
CLIENT: ESSEX SPECIALTY PRODUCTS, INC.

JOB NUMBER: 7138–400

SCALE: AS SHOWN

FIGURE NUMBER 6

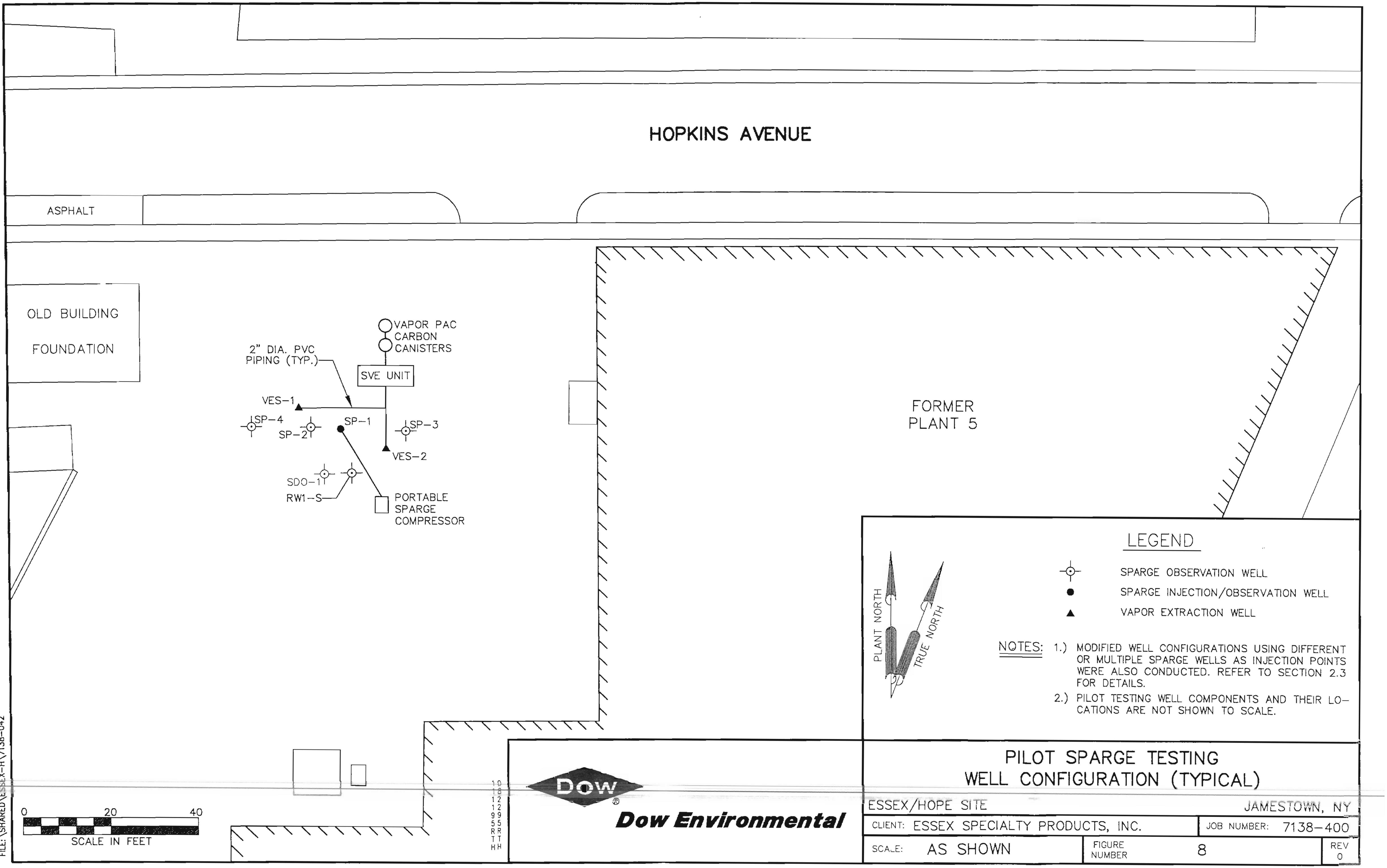
REV 0



Dow Environmental

RW–2D DRAWDOWN CONTOUR MAP AT 21 HOURS

ESSEX/HOPE SITE		JAMESTOWN, NY
CLIENT: ESSEX SPECIALTY PRODUCTS, INC.		JOB NUMBER: 7138–400
SCALE: AS SHOWN	FIGURE NUMBER 7	REV 0



LEGEND

⌖	SPARGE OBSERVATION WELL
●	SPARGE INJECTION/OBSERVATION WELL
▲	VAPOR EXTRACTION WELL

NOTES:
1.) MODIFIED WELL CONFIGURATIONS USING DIFFERENT OR MULTIPLE SPARGE WELLS AS INJECTION POINTS WERE ALSO CONDUCTED. REFER TO SECTION 2.3 FOR DETAILS.
2.) PILOT TESTING WELL COMPONENTS AND THEIR LOCATIONS ARE NOT SHOWN TO SCALE.

DOW
Dow Environmental

PILOT SPARGE TESTING
WELL CONFIGURATION (TYPICAL)

ESSEX/HOPE SITE JAMESTOWN, NY
CLIENT: ESSEX SPECIALTY PRODUCTS, INC.
JOB NUMBER: 7138-400
SCALE: AS SHOWN
FIGURE NUMBER 8
REV 0

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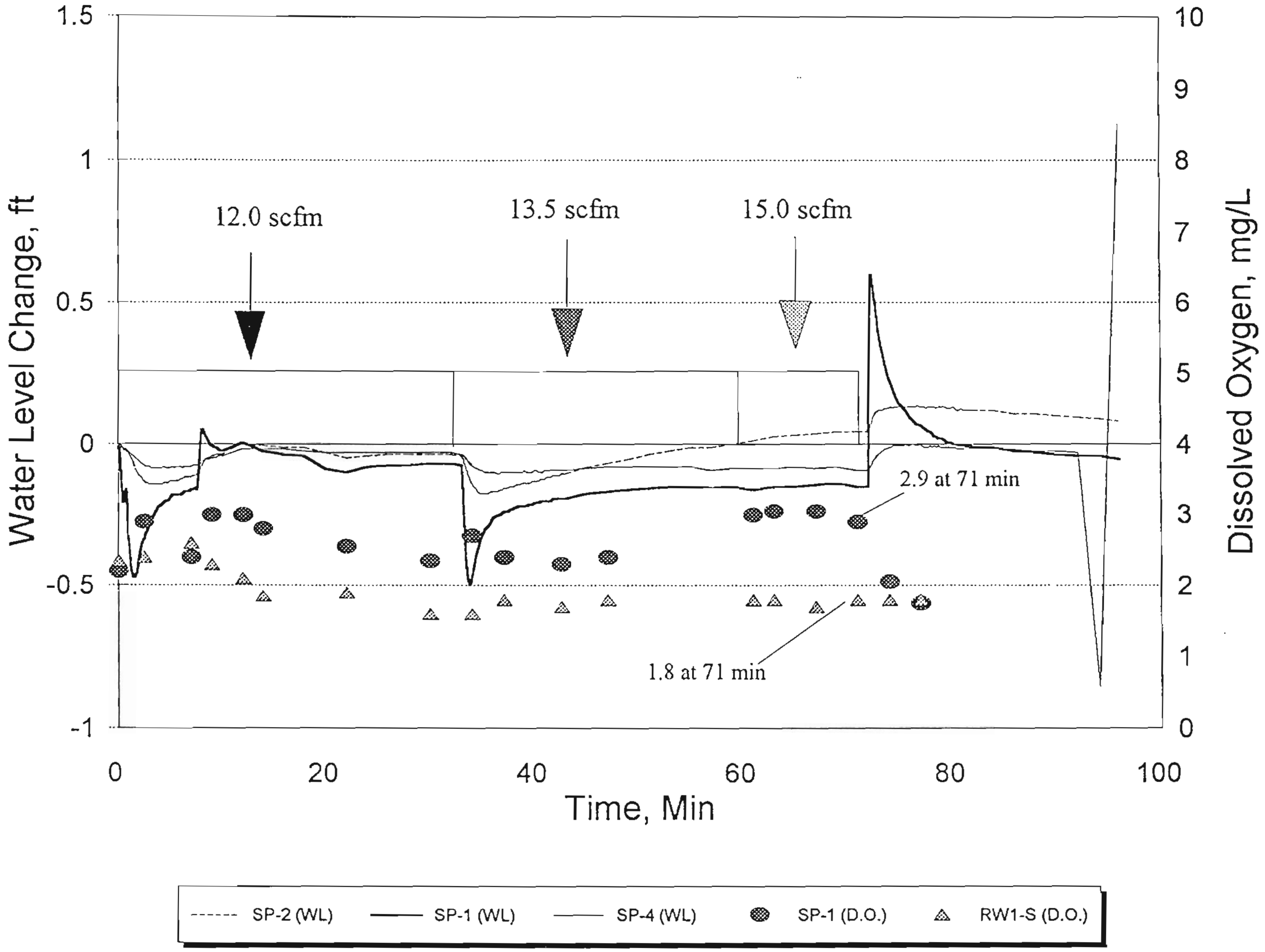

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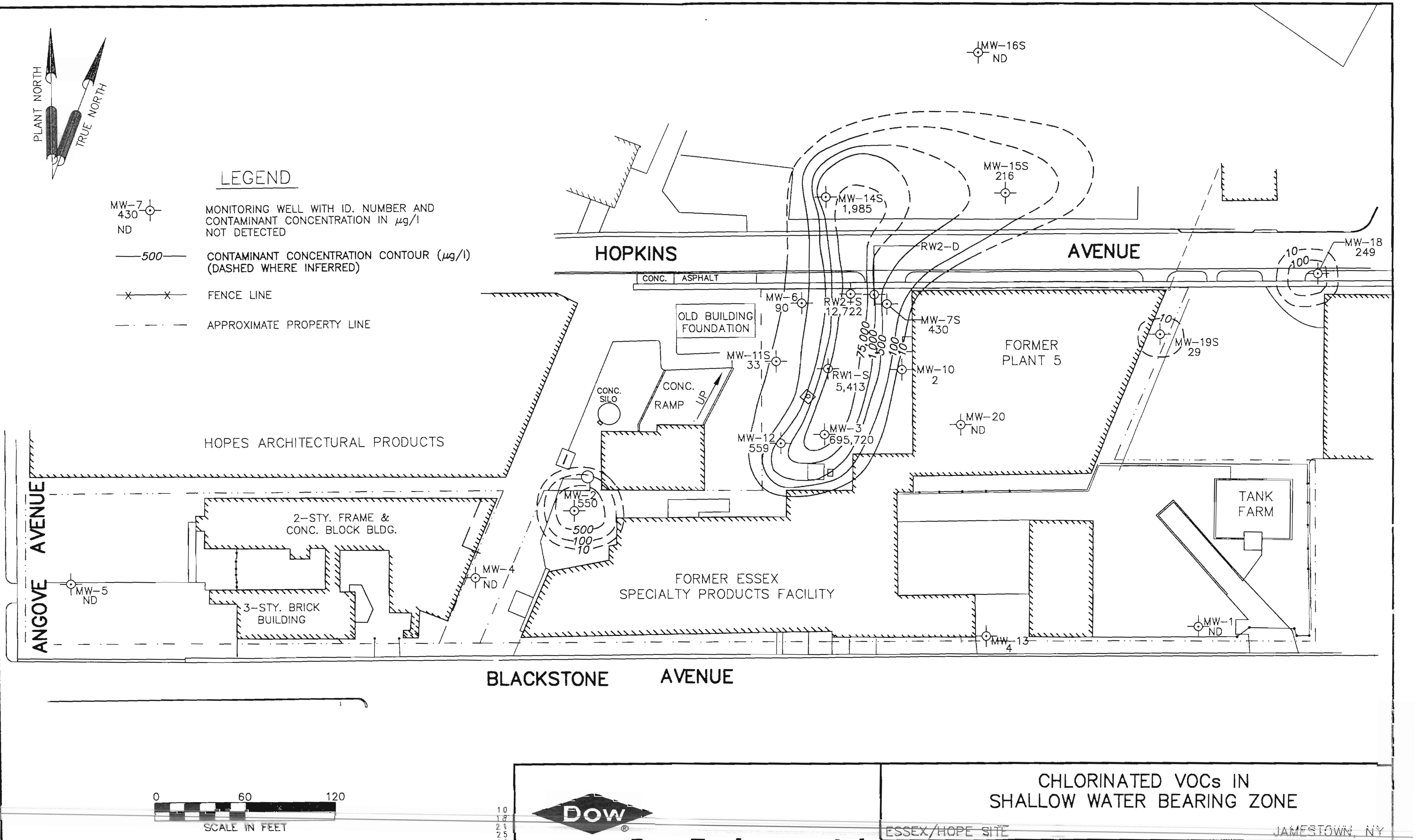
Dow Environmental

SP-3 SPARGE PILOT TEST RESULTS

ESSEX/HOPE SITE — JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS, INC.		JOB NUMBER: 7138-400	
SCALE: MULTIPLE	FIGURE NUMBER 9		REV 0



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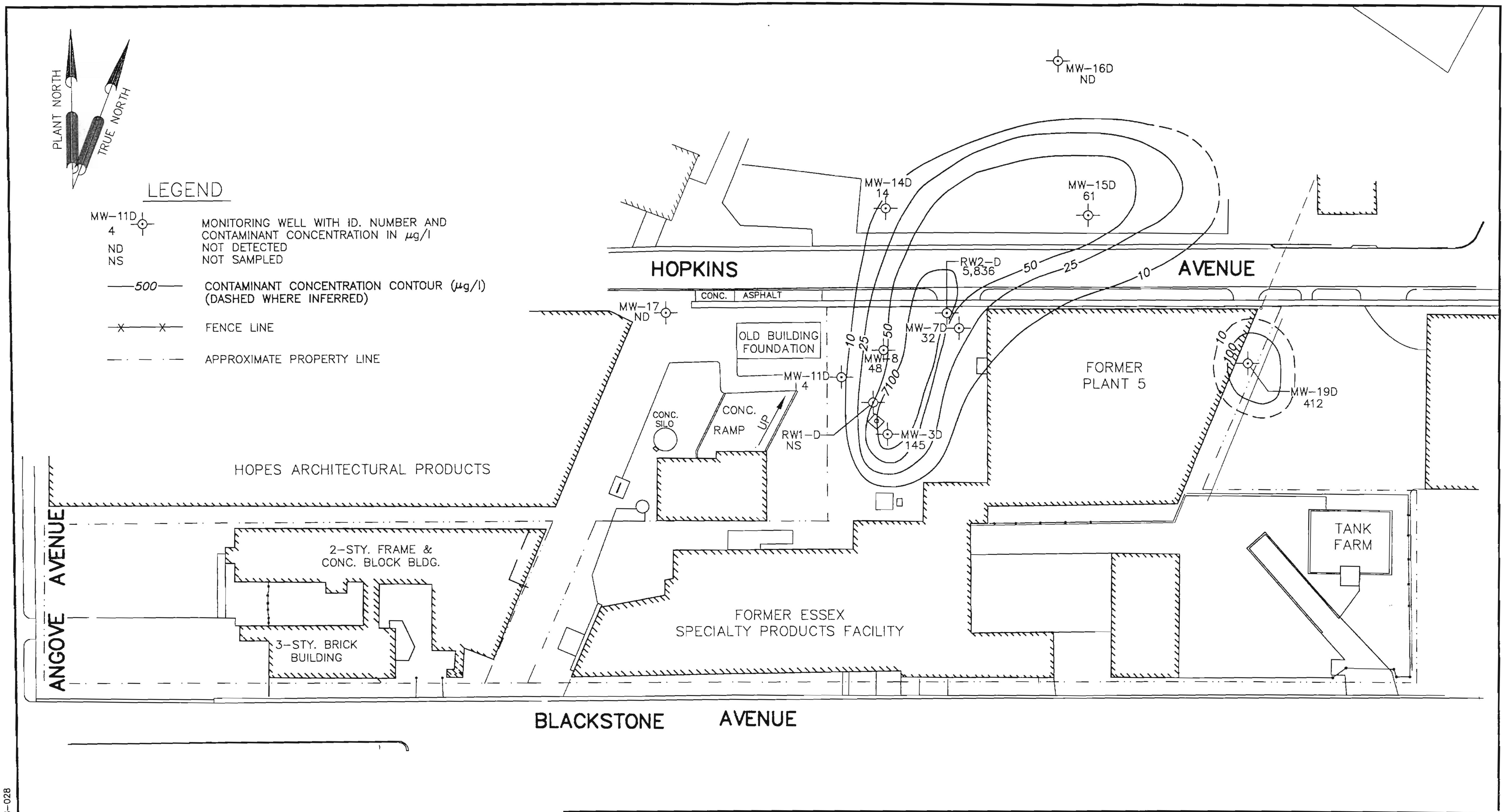
CHLORINATED VOCs IN SHALLOW WATER BEARING ZONE

ESSEX/HOPE SITE JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS, INC.	JOB NUMBER: 7138-400
SCALE: AS SHOWN	FIGURE NUMBER 10	REV 0



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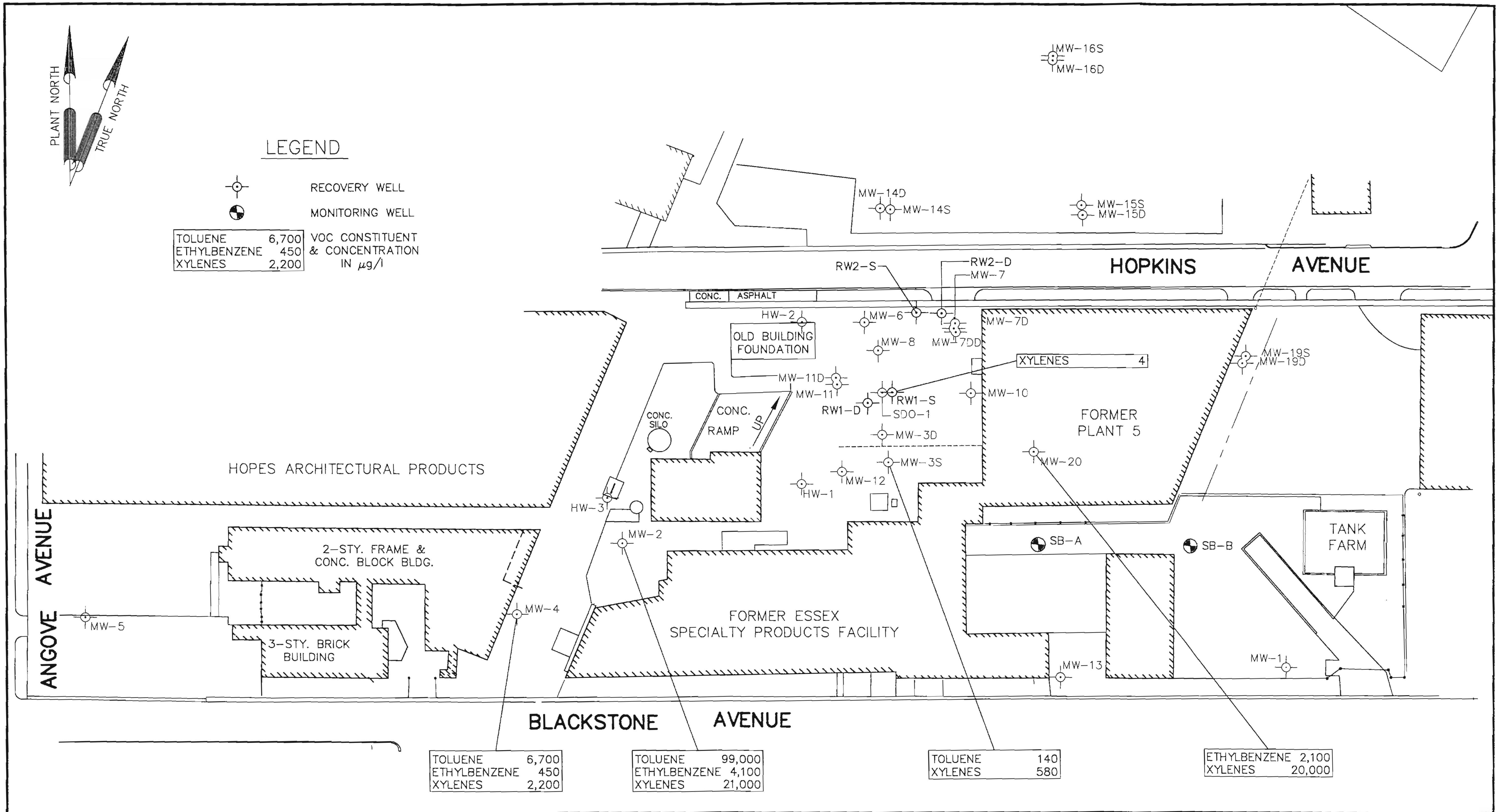
CHLORINATED VOCs IN
LOWER FINE SAND WATER BEARING ZONE

ESSEX/HOPE SITE
JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS, INC.
JOB NUMBER: 7138-400

SCALE: AS SHOWN
FIGURE NUMBER 11
REV 0



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10 18 11 15 99 55 RR TT HH

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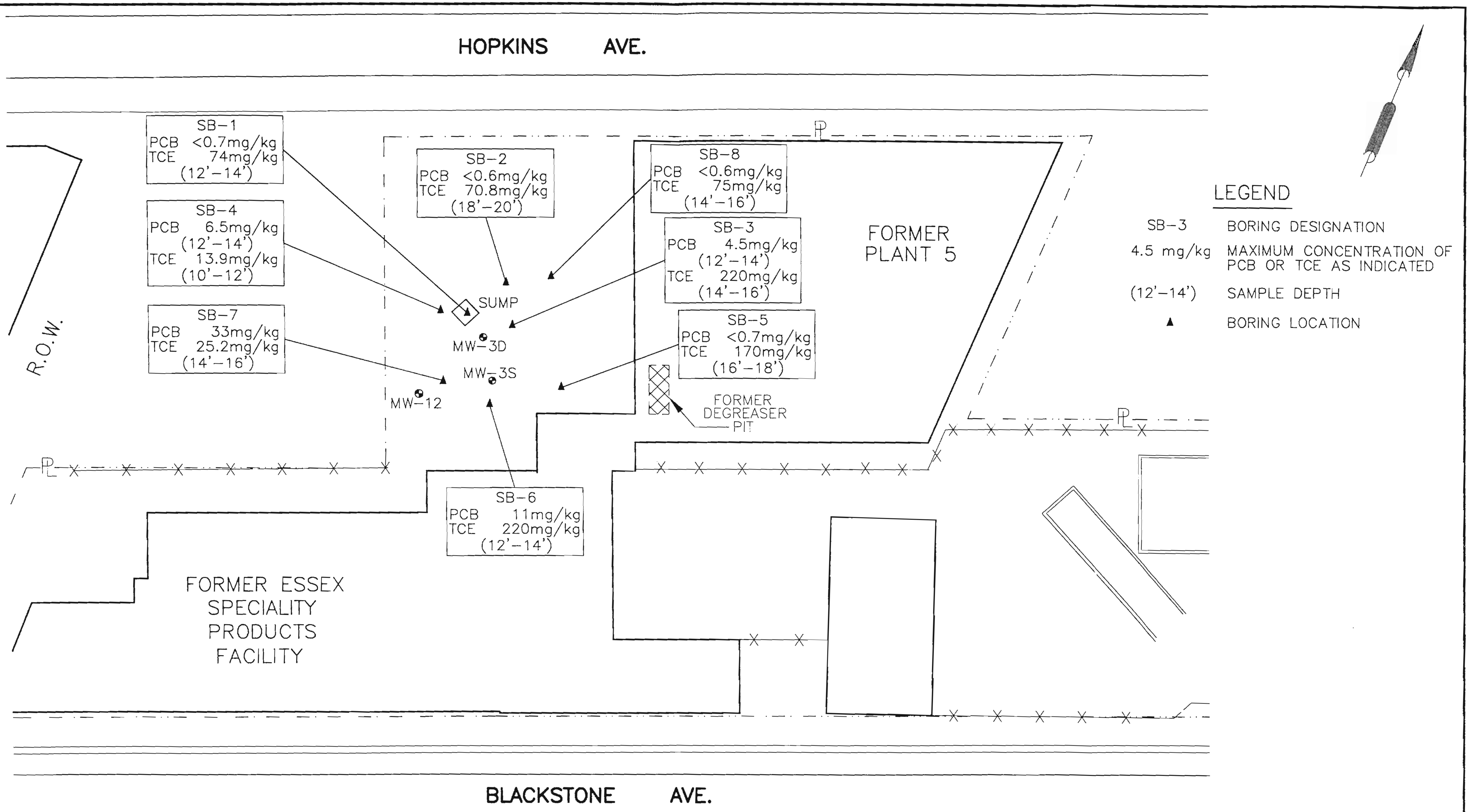
ETHYLBENZENE, TOLUENE, AND XYLENE GROUNDWATER CONCENTRATIONS – AUGUST, 1995 SAMPLING ROUND

ESSEX/HOPE SITE JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS, INC.
JOB NUMBER: 7138-400

SCALE: AS SHOWN
FIGURE NUMBER 12
REV 0



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SCALE IN FEET

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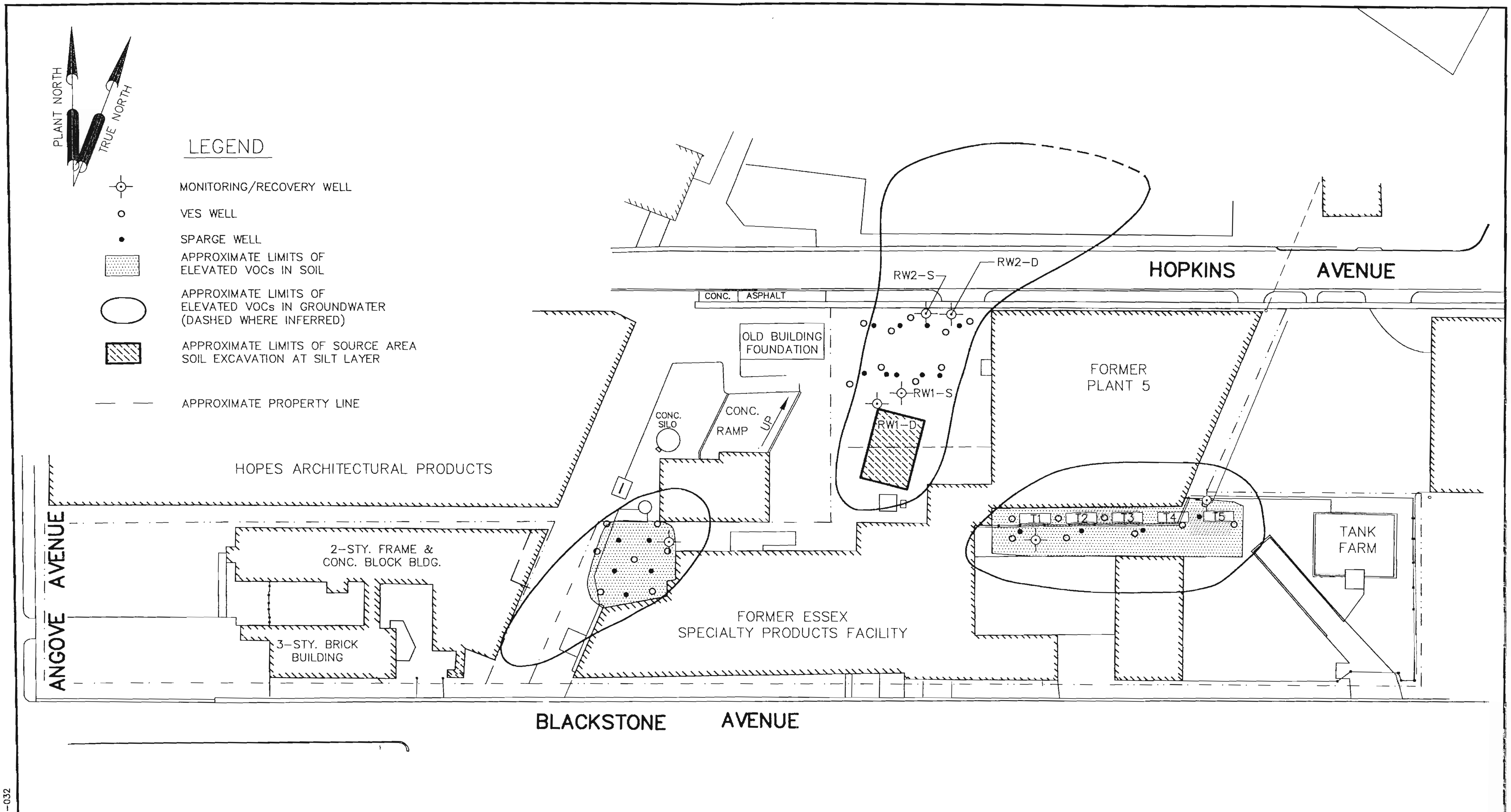
Dow Environmental

PCB/TCE CONCENTRATIONS
TOP OF SILT LAYER – NPLS AREA

ESSEX/HOPE SITE JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS JOB NUMBER: 7138-400

SCALE: AS SHOWN FIGURE NUMBER 13 REV 0



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SCALE IN FEET

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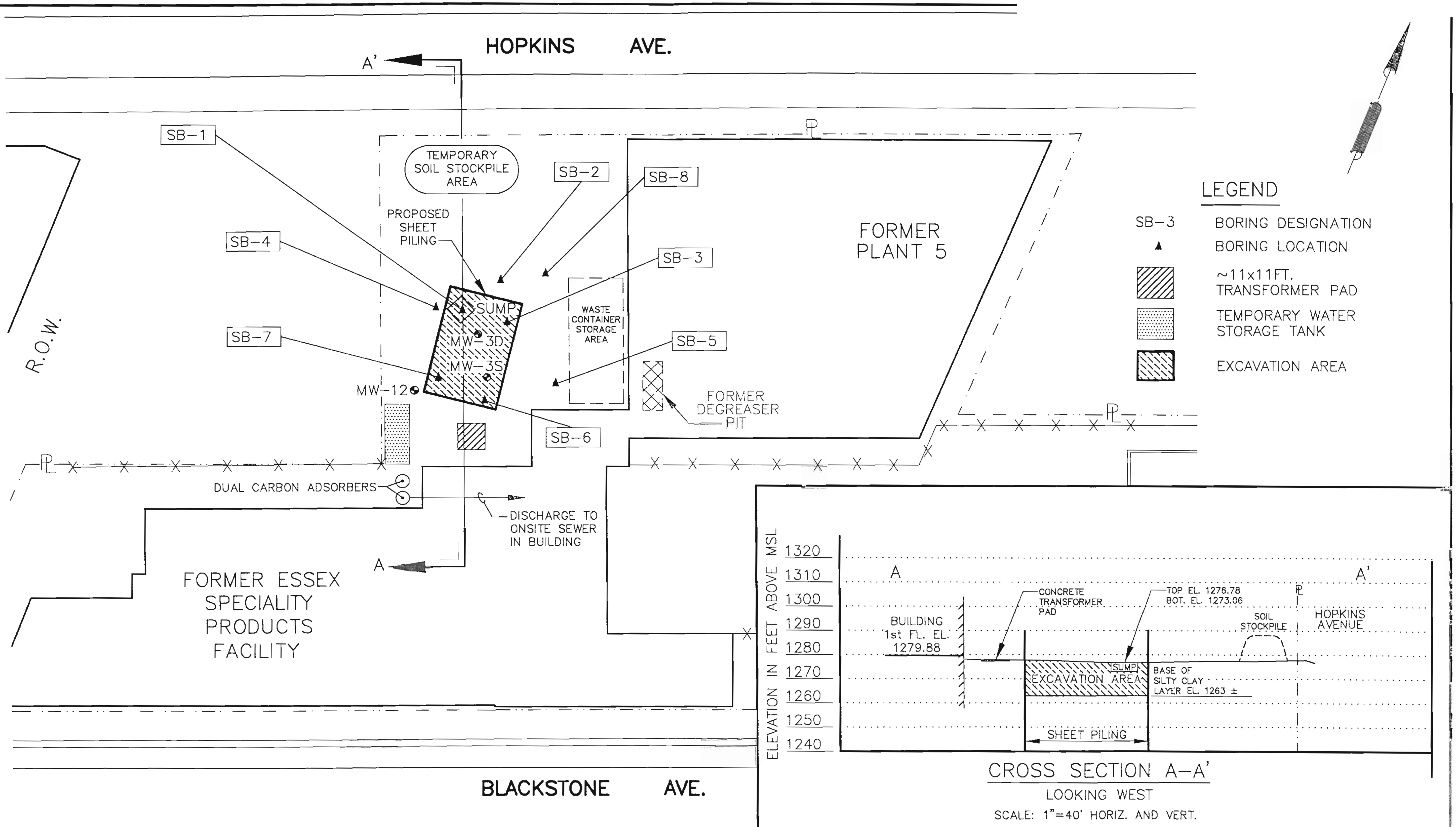
Dow Environmental

APPROXIMATE LIMITS OF ELEVATED VOCs AND SOURCE AREA SOIL EXCAVATION

ESSEX/HOPE SITE — JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS, INC.
JOB NUMBER: 7138-400
SCALE: AS SHOWN
FIGURE NUMBER 14
REV 0



CROSS SECTION A-A'

LOOKING WEST

SCALE: 1"=40' HORIZ. AND VERT.

FILE: \SHARED\ESSEX-H\7138-044

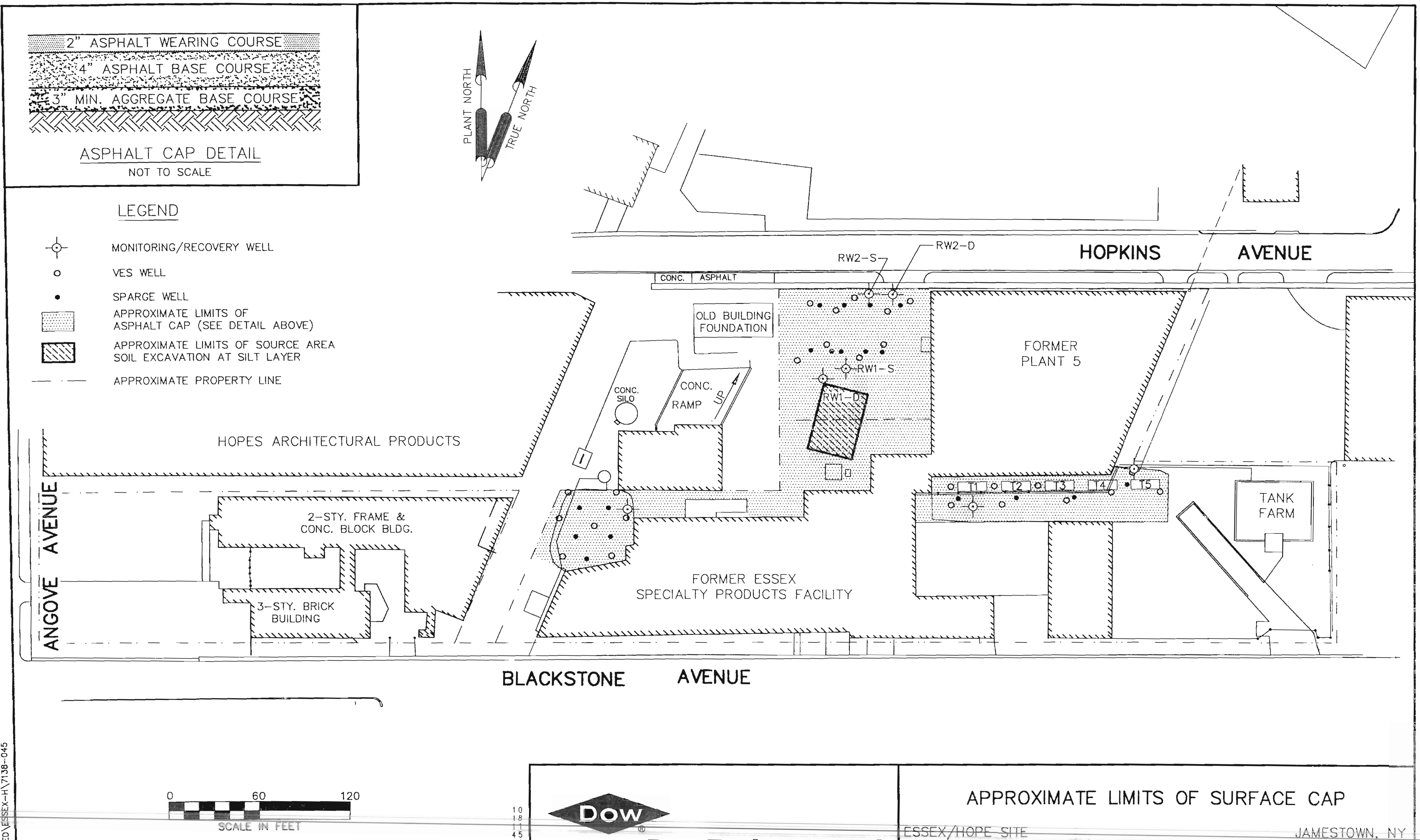
Dow Environmental

NPLS SOIL EXCAVATION AND SUMP REMOVAL

ESSEX/HOPE SITE JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS JOB NUMBER: 7138-400

SCALE: AS SHOWN FIGURE NUMBER 15 REV 0



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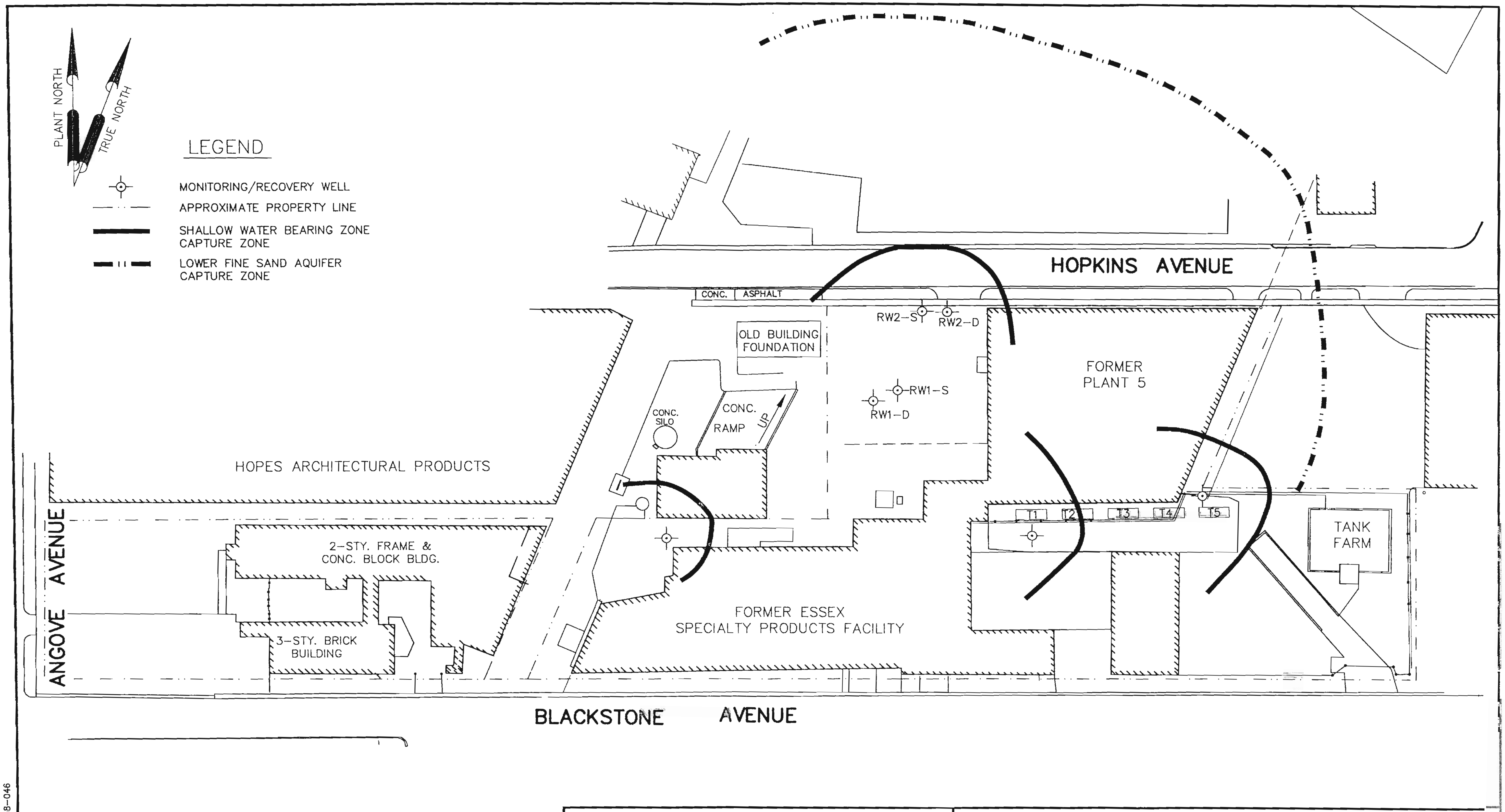
Dow Environmental

APPROXIMATE LIMITS OF SURFACE CAP

ESSEX/HOPE SITE JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS, INC.		JOB NUMBER: 7138-400	
SCALE: AS SHOWN	FIGURE NUMBER 16		REV 0



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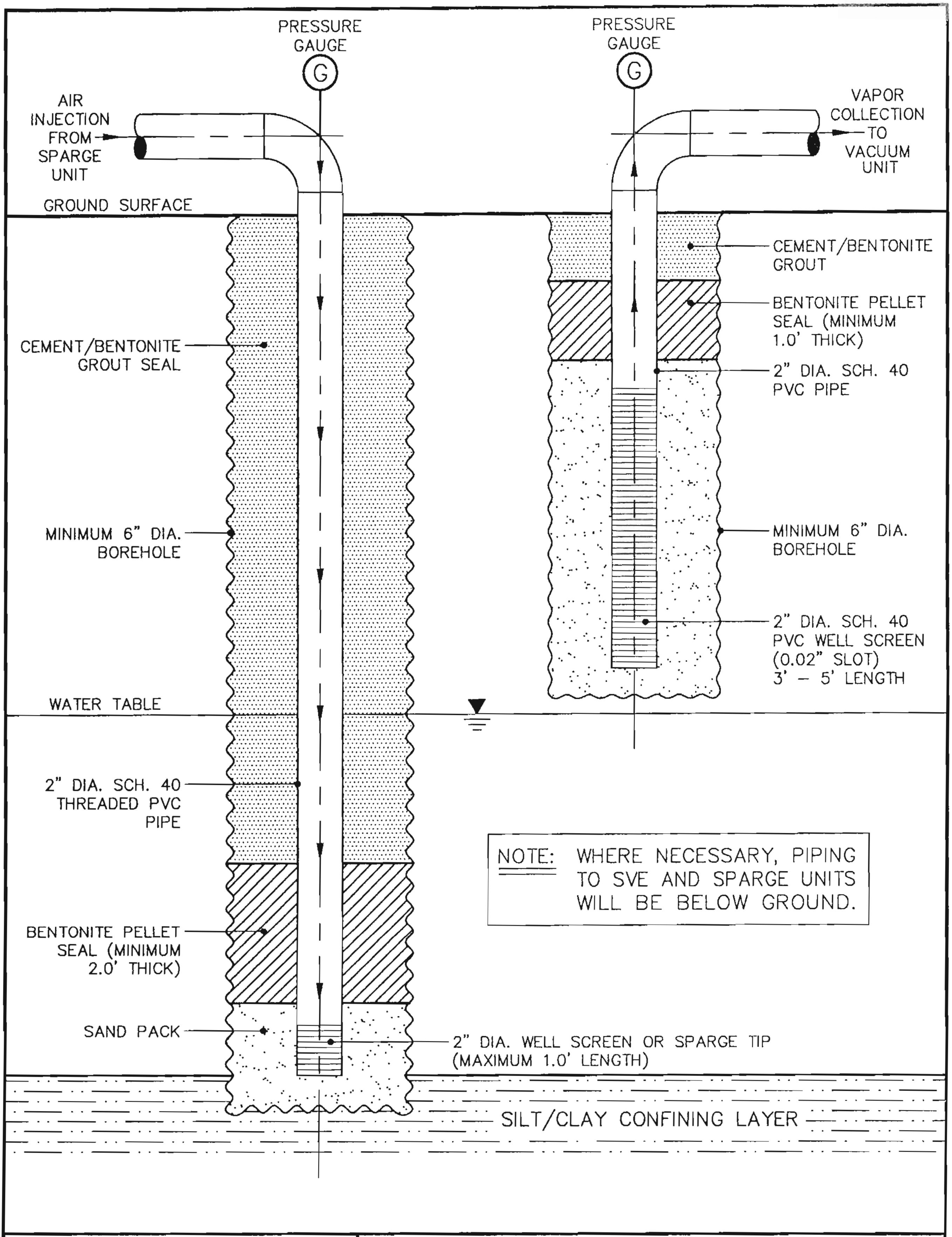
CAPTURE ZONE ANALYSIS MAP
SHALLOW WATER BEARING ZONE AND LOWER FINE SAND AQUIFER

ESSEX/HOPE SITE
JAMESTOWN, NY

Dow Environmental

CLIENT: ESSEX SPECIALTY PRODUCTS, INC.		JOB NUMBER: 7138-400	
SCALE: AS SHOWN	FIGURE NUMBER 17		REV 0



NOTE: WHERE NECESSARY, PIPING TO SVE AND SPARGE UNITS WILL BE BELOW GROUND.

FILE: \SHARED\ESSEX-H\7138-041

Dow Environmental

SVE/SPARGE WELL CONSTRUCTION DETAILS

ESSEX/HOPE SITE	JAMESTOWN, NY
CLIENT: ESSEX SPECIALTY PRODUCTS	JOB NUMBER: 7138-400
SCALE: NONE	FIGURE NUMBER 18
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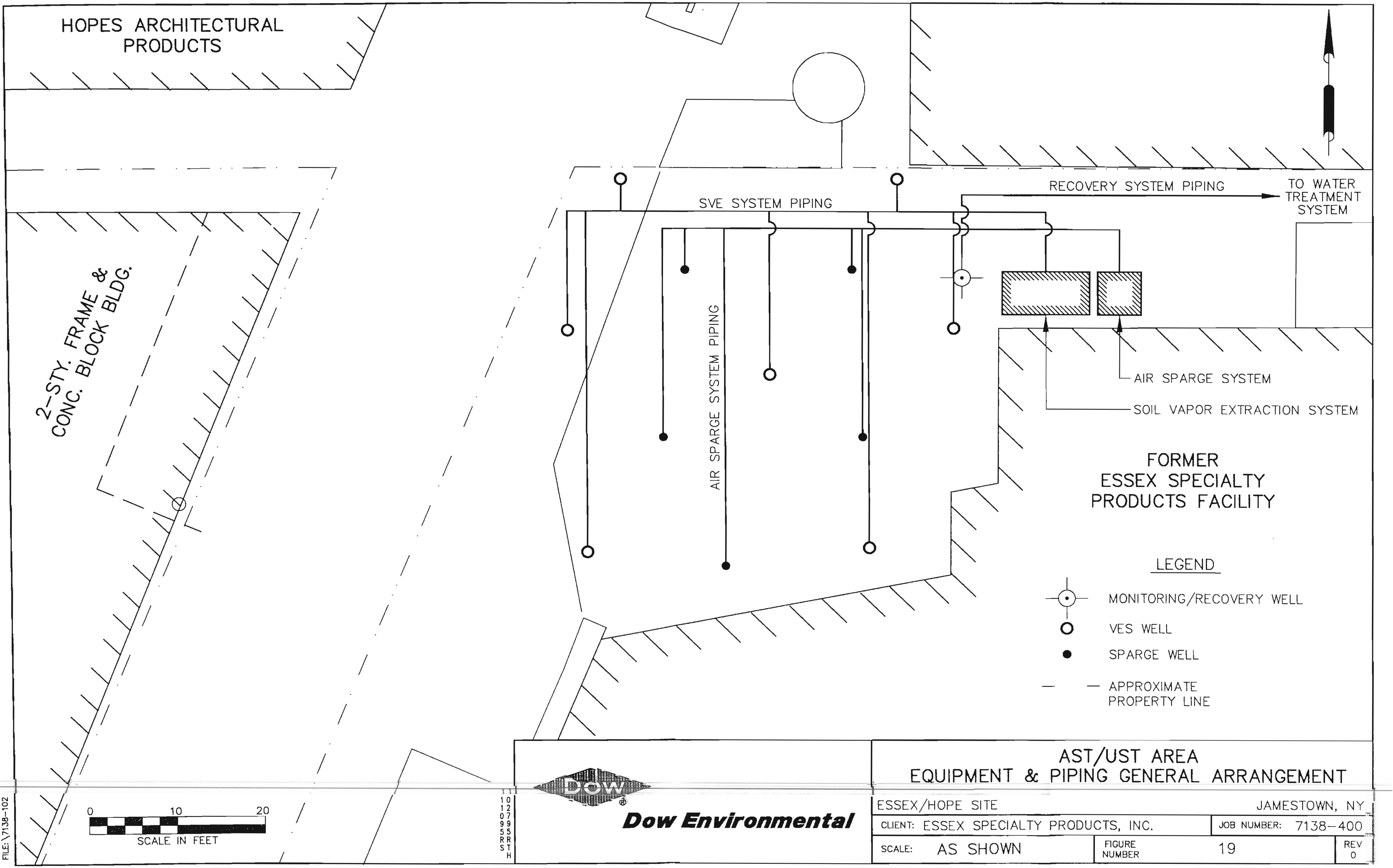
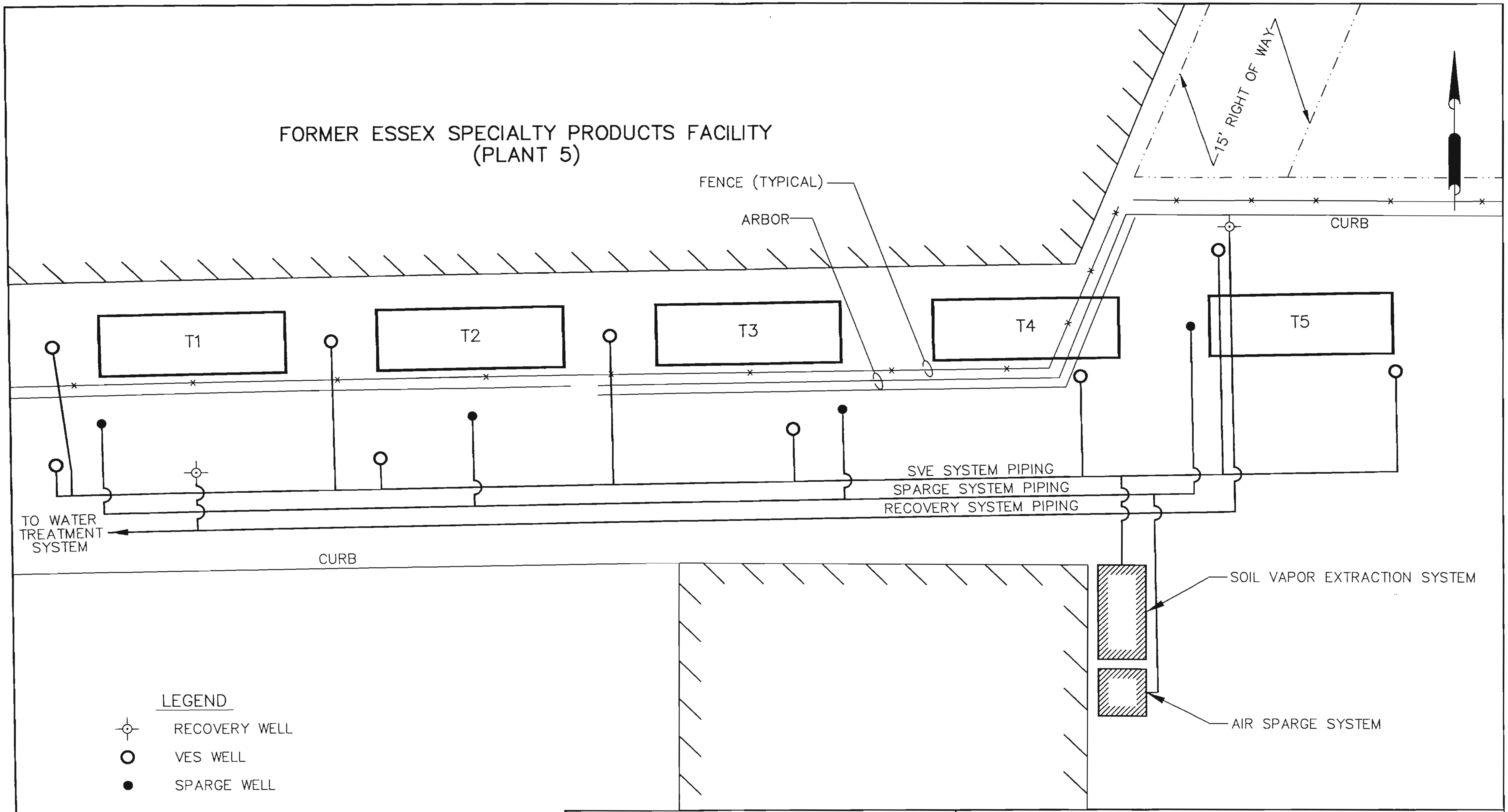


FILE: \7138-102

Dow Environmental

AST/UST AREA EQUIPMENT & PIPING GENERAL ARRANGEMENT

ESSEX/HOPE SITE	JAMESTOWN, NY
CLIENT: ESSEX SPECIALTY PRODUCTS, INC.	JOB NUMBER: 7138-400
SCALE: AS SHOWN	FIGURE NUMBER 19
	REV 0



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Dow Environmental

UNDERGROUND STORAGE TANK AREA EQUIPMENT & PIPING GENERAL ARRANGEMENT

ESSEX/HOPE SITE	JAMESTOWN, NY
CLIENT: ESSEX SPECIALTY PRODUCTS, INC.	JOB NUMBER: 7138-400
SCALE: AS SHOWN	FIGURE NUMBER 20
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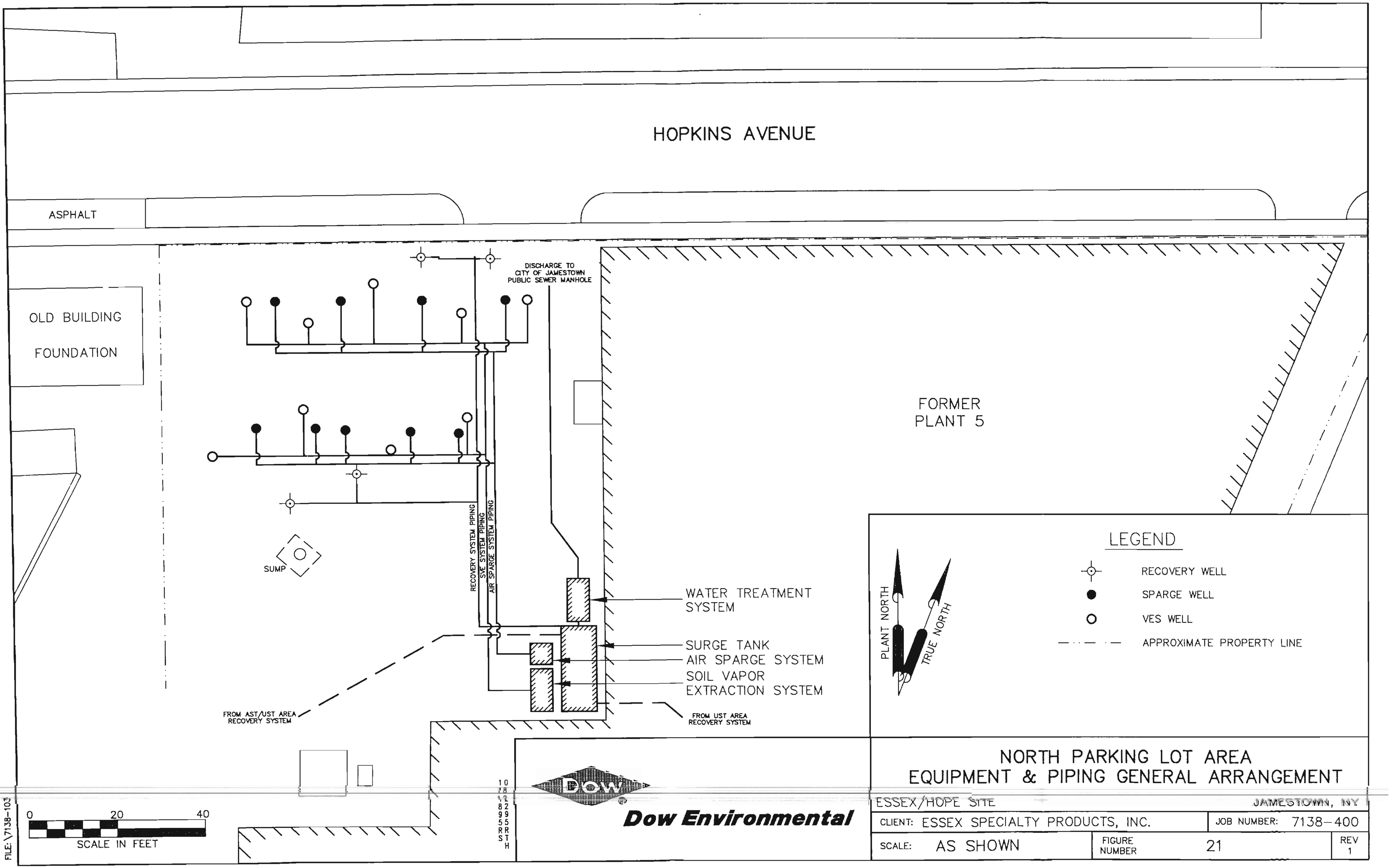


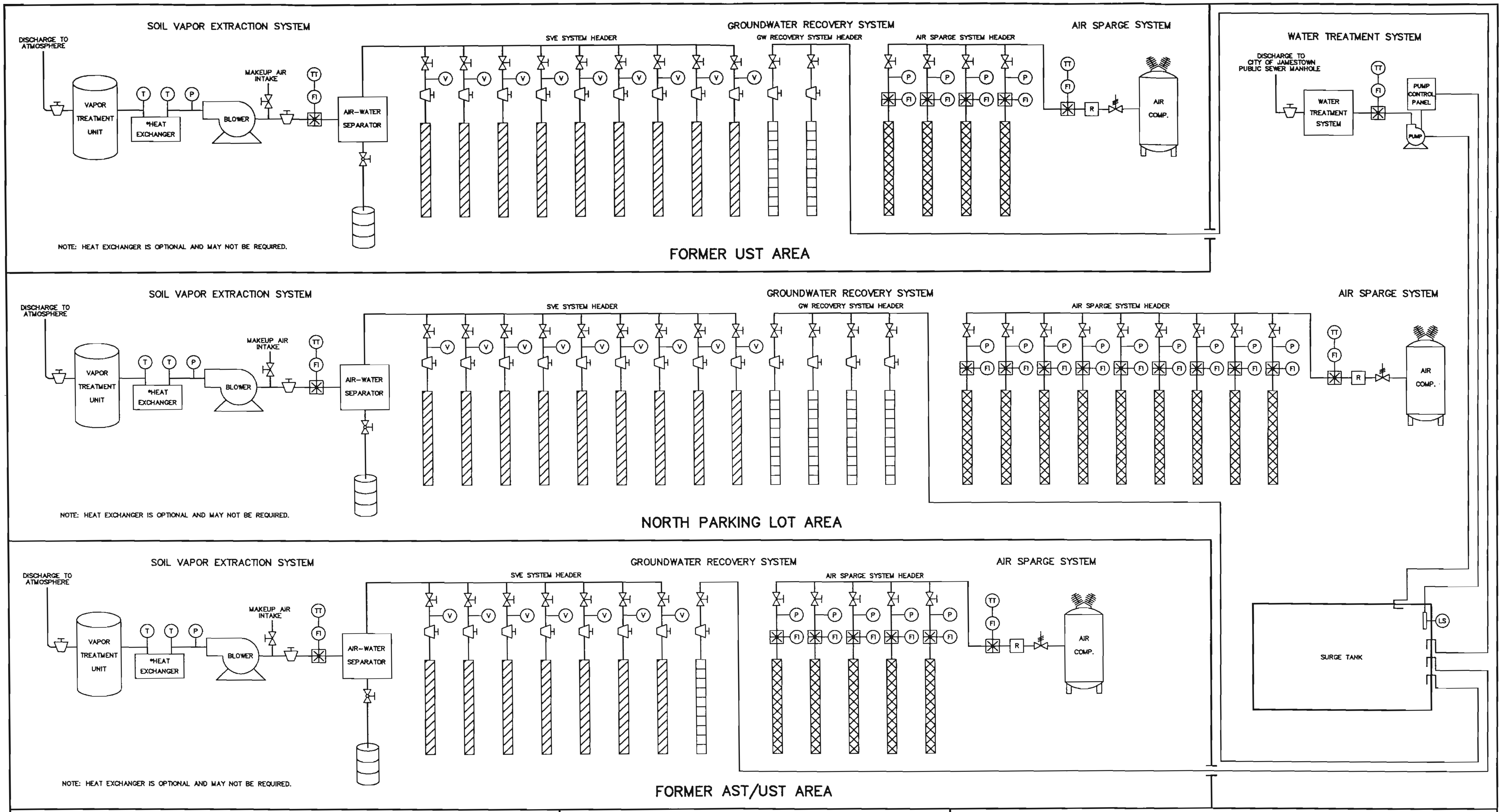
Dow Environmental

NORTH PARKING LOT AREA
EQUIPMENT & PIPING GENERAL ARRANGEMENT

ESSEX/HOPE SITE JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS, INC. JOB NUMBER: 7138-400

SCALE: AS SHOWN FIGURE NUMBER 21 REV 1



LEGEND

▨ — VAPOR EXTRACTION WELL

▤ — RECOVERY WELL

☒ — AIR SPARGE WELL

— PRESSURE RELIEF VALVE

— CONTROL/SHUTOFF VALVE

— SHUTOFF VALVE

☒ — FLOW METER

— SAMPLE COCK

R — REGULATOR

Ⓥ — VACUUM GAUGE

Ⓣ — TEMPERATURE GAUGE

Ⓟ — PRESSURE GAUGE

(FI) — FLOW INDICATOR

(TT) — TOTALIZER

(LS) — LEVEL CONTROL SWITCH

11895RS

FILE: \7138-100

DOW

Dow Environmental

GENERAL PROCESS FLOW AND INSTRUMENTATION DIAGRAM

ESSEX/HOPE SITE JAMESTOWN, NY

CLIENT: ESSEX SPECIALTY PRODUCTS

JOB NUMBER: 7138-400

SCALE: NOT TO SCALE

FIGURE NUMBER 22

REV 1

TABLES

TABLE 1

WATER LEVEL ELEVATIONS
AUGUST 1995
Page 1 of 2 Pages

Well No.	Measuring Point Elevation (ft.-MSL)	Date	Depth of Water (ft.)	Water Level Elevation (Ft.-MSL)
MW-1	1280.48	8/7/95	13.36	1267.12
MW-2	1279.81	8/7/95	7.87	1271.94
MW-3S	1280.58	8/10/95	12.51	1268.07
MW-3D	1276.99	8/9/95	9.45	1267.54
MW-4	1281.02	8/7/95	8.72	1272.30
MW-5	1280.91	8/7/95	8.20	1272.71
MW-6	1277.44	8/9/95	7.81	1269.33
MW-7S	1277.37	8/8/95	7.58	1269.74
MW-7D	1277.63	8/8/95	10.21	1267.42
MW-7DD	1277.47	8/8/95	2.76	1274.71
MW-8	1277.27	8/9/95	9.74	1267.53
MW-10	1278.11	8/10/95	7.78	1270.33
MW-11S	1277.46	8/9/95	8.24	1269.22
MW-11D	1277.52	8/9/95	10.19	1267.33
MW-12	1280.06	8/10/95	9.87	1270.19
MW-13	1278.12	8/7/95	9.90	1268.22
MW-14S	1280.25	8/8/95	12.89	1267.36
MW-14D	1280.01	8/8/95	12.75	1267.26
MW-15S	1279.55	8/8/95	13.51	1266.04
MW-15D	1279.46	8/8/95	13.15	1266.31
MW-16S	1279.32	8/8/95	12.88	1266.44

TABLE 1

WATER LEVEL ELEVATIONS
AUGUST 1995
Page 2 of 2 Pages

Well No.	Measuring Point Elevation (ft.-MSL)	Date	Depth of Water (ft.)	Water Level Elevation (Ft.-MSL)
MW-16D	1279.05	8/8/95	13.04	1266.01
MW-17	1278.53	8/7/95	9.88	1268.65
MW-18	1275.59	8/7/95	10.17	1265.42
MW-19S	1276.82	8/7/95	10.81	1266.01
MW-19D	1276.21	8/7/75	10.40	1265.81
MW-20	1278.64	8/9/95	3.68	1274.96
RW-1S	1276.94	8/2/95	7.05	1269.89
RW-1D	N/A	8/2/95	9.18	----
RW-2S	N/A	8/2/95	7.65	----
RW-2D	N/A	8/2/95	9.65	----

TABLE 2

AQUIFER PERFORMANCE TEST RESULTS

Observation Well	Analysis Method	Transmissivity (gpd/ft)	Storage Co-efficient
RW-1S Pumping Test (Shallow Waterbearing Zone)			
SP-4	Theis	550	0.005
MW-11	Theis	600	0.015
SP-3	Cooper/ Jacob	440	0.013
SP-3	Theis	600	0.002
SP-3, MW-11, and MW-12	Distance Drawdown	400	0.02
RW-2D Pumping Test (Lower Fine Sand Waterbearing Zone)			
MW-11D	Calculated recovery	330	1.3×10^{-4}
MW-11D	Cooper, Jacob Drawdown	450	6.6×10^{-5}
MW-11D	Residual Drawdown	350	---
MW-3D	Cooper, Jacob Drawdown	500	4.9×10^{-5}
MW-7D	Cooper, Jacob Drawdown	430	5.8×10^{-4}
RW-1D	Cooper, Jacob Drawdown	450	9.0×10^{-5}

TABLE 3

FIELD SCREENING AIR SAMPLING RESULTS SVE/SPARGE PILOT TESTING

Page 1 of 3 Pages

Test No.	Injection Well	Test Time (Min.)	Flow Rate (SCFM)	Pre-Carb PID Reading (ppm Equiv.)	PCE Draegar Tube Sample (0.1 mg/kg)	TCE Draegar Tube Sample (50 mg/kg)
1	---	5	SVE only	16	---	---
1	---	23	SVE only	43	---	---
1	---	43	SVE only		negative	---
1	---	52	SVE only		---	negative
1	---	73	SVE only	135	---	---
2	SP-1	6	>20	124	---	---
2	SP-1	17	>20	89	---	---
3	---	0.00	SVE only	32	---	---
3	SP-1	2	>20	0	---	---
3	SP-1	7	>20	11	---	---
4	SP-1	9	>20	65	---	---
4	SP-1	25	>20	48	---	---
4	SP-1	96	>20	32	---	---
5	N/A	9	SVE only	11	---	---
5	SP-1	8	14	16	---	---
5	SP-1	24	14	11	---	---
5	SP-1	36	>20	11	---	---
5	SP-1	60	>20	---	negative	negative
5	SP-1	70	>20	16	---	---
6	N/A	0.00	SVE only	0	---	---

TABLE 3

FIELD SCREENING AIR SAMPLING RESULTS
SVE/SPARGE PILOT TESTING
Page 2 of 3 Pages

Test No.	Injection Well	Test Time (Min.)	Flow Rate (SCFM)	Pre-Carb PID Reading (ppm Equiv.)	PCE Draegar Tube Sample (0.1 mg/kg)	TCE Draegar Tube Sample (50 mg/kg)
6	SP-3	4.5	12	22	---	---
6	SP-3	15.5	12	16	---	---
6	SP-3	22	12	22	---	---
6	SP-3	30	12	22	---	---
6	SP-3	44	13.5	16	---	---
6	SP-3	50	13.5	---	negative	negative
6	SP-3	63	>20	11	---	---
7	---	0.00	SVE only	22	---	---
7	SP-1, SP-2, and SP-3	3	12	11	---	---
7	SP-1, SP-2, and SP-3	8	12	11	---	---
7	SP-1, SP-2, and SP-3	13	12	11	---	---
7	SP-1, SP-2, and SP-3	17	15	16	---	---
7	SP-1, SP-2, and SP-3	25	15	5	---	---
7	SP-1, SP-2, and SP-3	34	15	5	---	---
7	SP-1, SP-2, and SP-3	39	17	0	---	---

TABLE 3

FIELD SCREENING AIR SAMPLING RESULTS
SVE/SPARGE PILOT TESTING
Page 3 of 3 Pages

Test No.	Injection Well	Test Time (Min.)	Flow Rate (SCFM)	Pre-Carb PID Reading (ppm Equiv.)	PCE Draegar Tube Sample (0.1 mg/kg)	TCE Draegar Tube Sample (50 mg/kg)
7	SP-1, SP-2, and SP-3	47	17	0	---	---
7	SP-1, SP-2, and SP-3	53	17	0	---	---
7	SP-1, SP-2, and SP-3	62	17	0	---	---
7	SP-1, SP-2, and SP-3	67	>20	0	---	---
7	SP-1, SP-2, and SP-3	75	>20	0	---	---
7	SP-1, SP-2, and SP-3	80	>20	0	---	---
7	SP-1, SP-2, and SP-3	95	12.5	0	---	---

TABLE 4
LABORATORY AIR ANALYSIS RESULTS
SVE/SPARGE PILOT TESTING

Test Number	1	1	1	4	4	5	6	7
Date	7/26/95	7/26/95	7/26/95	7/27/95	7/27/95	7/27/95	7/28/95	7/28/95
Time	14:35	14:35	14:35	14:00	14:55	18:40	09:23	12:52
Sample Location	Pre-Carb	Post-Carb	VAC Wells	VAC Wells	Pre-Carb	VAC Wells	VAC Wells	VAC Wells
Sparge Operation	NO	NO	NO	NO	YES	YES	YES	YES
Sparge Insertion Point	- -	- -	- -	- -	SP-1	SP-1	SP-3	SP-1, SP-2, SP-3
Flow Rate (scfm)	- -	- -	- -	- -	>20	8	12	15
Units	(ppmv)	(ppmv)	(ppmv)	(ppmv)	(ppmv)	(ppmv)	(ppmv)	(ppmv)
Parameters								
ETHYLBENZENE	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	0.19	< 0.07
TRICHLOROETHENE	1.086	< 0.005	0.787	0.862	1.659	1.639	1.790	1.481
TETRACHLOROETHENE	< 0.005	< 0.005	< 0.005	< 0.005	0.010	0.007	0.008	< 0.005

<# indicates not detected at laboratory detection limit

Analysis conducted by CG for EPA 601/602 compounds. Only those compounds detected are shown.

Appendix C contains laboratory analysis sheets.

The Pre-carb sample location indicates a sample point prior to carbon treatment but after dilution air addition.
The Post-carb sample location indicates a sample taken of emissions after carbon treatment.
The VAC sample location indicates a sample taken prior to carbon treatment and prior to dilution air addition..

TABLE 5
SVE PILOT TESTING CONFIRMATORY SOIL SAMPLES

Sample Boring	**TB-3A**	**SB-3**	**TB-4A**	**SB-4**	**TB-12A**	**12**	**TB-14A**	**14(1)**
Sample Depth	**4' - 6'**	**4' - 6'**	**6' - 8'**	**6' - 8"**	**6' - 8'**	**4' - 6'**	**8' - 10'**	**8' - 10'**
Collection Date	**7/95**	**1988**	**7/95**	**1988**	**7/95**	**8/89**	**7/95**	**8/89**
Parameters	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
ETHYLBENZENE	3.8	<0.03	0.310	200	<1.4	15	11	16
trans-1,2-DICHLOROETHENE	< 1.4	NA	< 1.4	NA	< 1.4	< 1.2	< 1.4	< 1.1
TRICHLOROETHENE	< 1.4	NA	< 1.4	NA	< 1.4	< 1.2	< 1.4	< 1.1
TOLUENE	< 1.4	<0.03	< 1.4	<6	<1.4	66	29	34
METHYLENE CHLORIDE	< 1.7	<0.03	< 1.6	<6	<1.6	< 1.2	<1.6	< 1.1
XYLENES (total)	30	NA	1.8	NA	<1.4	73	180	120

All results provided in mg/kg (part per million)
<# indicates not detected at laboratory detection limit
Volatile organic analysis conducted by U.S. EPA SW-846 Methods 8240 or 8260
NA = Not Analyzed
Only compounds detected are shown. Additional compounds sampled for not detected are provided on laboratory data sheets in Appendix D.

TABLE 6
GROUNDWATER ANALYTICAL RESULTS
ORGANIC COMPOUNDS

Volatile Organic Compounds	MW1	MW2	MW-3S	MW-3D	MW4	MW-5	MW-6	MW-7S	MW-7D
VINYL CHLORIDE	< 10	180	1,900	47	< 500	< 10	< 10	< 10	< 10
CARBON DISULFIDE	< 10	< 500	< 1000	< 10	< 500	< 10	< 10	< 10	< 10
1,1-DICHLOROETHENE	< 10	< 500	150	< 10	< 500	< 10	< 10	< 10	< 10
1,2-DICHLOROETHENE (total)	< 10	370	53,000	27	< 500	< 10	42	210	7
2-BUTANONE	< 10	< 500	< 1000	< 10	< 500	< 10	< 10	< 10	< 10
TRICHLOROETHENE	< 10	< 500	640,000	71	< 500	< 10	48	220	25
TETRACHLOROETHENE	< 10	< 500	670	< 10	< 500	< 10	< 10	< 10	< 10
TOLUENE	< 10	99,000	140	< 10	6,700	< 10	< 10	< 10	< 10
ETHYLBENZENE	< 10	4,100	< 1000	< 10	450	< 10	< 10	< 10	< 10
XYLENES (total)	< 10	21,000	580	< 10	2,200	< 10	< 10	< 10	< 10
Total VOCs	**0**	**124,650**	**696,440**	**145**	**9,350**	**0**	**90**	**430**	**32**

Polychlorinated Biphenyls	MW1	MW2	MW-3S	MW-3D	MW4	MW-5	MW-6	MW-7S	MW-7D
AROCLOR-1254	< 1	< 1	730	< 1	< 1	< 1	< 1	< 1	< 1

All results provided in µg/L (part per billion)

<# indicates not detected at laboratory detection limit

#/# indicates replicate analysis

Volatile organic analysis conducted by U.S. EPA SW-846 Method 8260

Polychlorinated Biphenyls analyzed by U. S. EPA SW-846 Method 8080

Only compounds detected are shown. Additional compounds sampled for not detected are provided on laboratory data sheets in Appendix D.

TABLE 6 (continued)
GROUNDWATER ANALYTICAL RESULTS
ORGANIC COMPOUNDS

Volatile Organic Compounds	MW-7DD	MW-8	MW-10	MW-11S	MW-11D	MW-12	MW13	MW-14S	MW-14D
VINYL CHLORIDE	< 10	4	< 10	8	< 10	230	4	170	13
CARBON DISULFIDE	< 10	< 10	< 10	< 10	< 10	< 20	2	< 10	< 10
1,1-DICHLOROETHENE	< 10	< 10	< 10	< 10	< 10	< 20	< 10	45	< 10
1,2-DICHLOROETHENE (total)	< 10	19	< 10	17	4	280	< 10	850	< 10
2-BUTANONE	< 10	< 10	< 10	< 10	< 10	4	< 10	< 10	< 10
TRICHLOROETHENE	5	25	2	8	< 10	45	< 10	920	1
TETRACHLOROETHENE	< 10	< 10	< 10	< 10	< 10	< 20	< 10	< 10	< 10
TOLUENE	< 10	< 10	< 10	< 10	< 10	< 20	< 10	< 10	< 10
ETHYLBENZENE	< 10	< 10	< 10	< 10	< 10	< 20	< 10	< 10	< 10
XYLENES (total)	< 10	< 10	< 10	< 10	< 10	< 20	< 10	< 10	< 10
Total VOCs	**5**	**48**	**2**	**33**	**4**	**559**	**6**	**1,985**	**14**

Polychlorinated Biphenyls	MW-7DD	MW-8	MW-10	MW-11S	MW-11D	MW-12	MW13	MW-14S	MW-14D
AROCLOR-1254	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

All results provided in µg/L (part per billion)

<# indicates not detected at laboratory detection limit

#/# indicates replicate analysis

Volatile organic analysis conducted by U.S. EPA SW-846 Method 8260

Polychlorinated Biphenyls analyzed by U. S. EPA SW-846 Method 8080

Only compounds detected are shown. Additional compounds sampled for not detected are provided on laboratory data sheets in Appendix D.

TABLE 6 (continued)
GROUNDWATER ANALYTICAL RESULTS
ORGANIC COMPOUNDS

Volatile Organic Compounds	MW-15S	MW-15D	MW-16S	MW-16D	MW17	MW18	MW-19S	MW-19D	MW-20
VINYL CHLORIDE	< 10	2	< 10 / < 10	< 10	< 10	< 10	< 10	410	< 200
CARBON DISULFIDE	< 10	< 10	< 10 / < 10	< 10	< 10	< 10	< 10	< 20	< 200
1,1-DICHLOROETHENE	< 10	< 10	< 10 / < 10	< 10	< 10	< 10	< 10	< 20	< 200
1,2-DICHLOROETHENE (total)	76	33	< 10 / < 10	< 10	< 10	39	14	< 20	< 200
2-BUTANONE	< 10	< 10	< 10 / < 10	< 10	< 10	< 10	< 10	< 20	< 200
TRICHLOROETHENE	140	26	< 10 / < 10	< 10	< 10	210	15	2	< 200
TETRACHLOROETHENE	< 10	< 10	< 10 / < 10	< 10	< 10	< 10	< 10	< 20	< 200
TOLUENE	< 10	< 10	< 10 / < 10	< 10	< 10	< 10	< 10	< 20	< 200
ETHYLBENZENE	< 10	< 10	< 10 / < 10	< 10	< 10	< 10	< 10	< 20	2,100
XYLENES (total)	< 10	< 10	< 10 / < 10	< 10	< 10	< 10	< 10	< 20	20,000
Total VOCs	**216**	**61**	**0**	**0**	**0**	**249**	**29**	**412**	**22,100**

Polychlorinated Biphenyls	MW-15S	MW-15D	MW-16S	MW-16D	MW17	MW18	MW-19S	MW-19D	MW-20
AROCLOR-1254	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

All results provided in μg/L (part per billion)

<# indicates not detected at laboratory detection limit

#/# indicates replicate analysis

Volatile organic analysis conducted by U.S. EPA SW-846 Method 8260

Polychlorinated Biphenyls analyzed by U. S. EPA SW-846 Method 8080

Only compounds detected are shown. Additional compounds sampled for not detected are provided on laboratory data sheets in Appendix D.

TABLE 7
ORGANIC ANALYSES
GROUNDWATER EXTRACTION WELLS

VOLATILES	RW-1S:PRE-CARB at 5.5 hours	RW-1S:POST-CARB at 5.5 hours	RW-1S PRECARB at 29 hours	RW-2D at 5 hours	RW-2D at 21 hours	RW-2D Carbon Effluent	RW-2S
VINYL CHLORIDE	240	< 10	200	32	31	< 10	100 / 81
METHYLENE CHLORIDE	< 17	< 13	< 13	< 10	< 10	< 10	< 10 /< 10
ACETONE	10	8	< 12	< 10	< 10	< 10	< 10 /< 10
CARBON DISULFIDE	< 10	< 10	< 10	3	2	< 10	< 10 /< 10
1,1-DICHLOROETHENE	11	< 10	13	7	4	< 10	13 / 11
1,2-DICHLOROETHENE (total)	1,200	9	1,700	180	200	< 10	< 2,200 / 2,600
TRICHLOROETHENE	1,900	10	3,500	3,600	5,600	< 10	< 7,700 / 10,000
TETRACHLOROETHENE	2	< 10	4	< 10	1	< 10	< 15 / 14
XYLENES (total)	3	< 10	4	< 10	< 10	< 10	< 10 /< 10
PCBS							
AROCLOR-1016	< 1	< 1	< 1	< 1	< 1	< 1	< 1 / <1
AROCLOR-1221	< 2	< 2	< 2	< 2	< 2	< 2	< 2 / <2
AROCLOR-1232	< 1	< 1	< 1	< 1	< 1	< 1	< 1 / <1
AROCLOR-1242	< 1	< 1	< 1	< 1	< 1	< 1	< 1 / <1
AROCLOR-1248	< 1	< 1	< 1	< 1	< 1	< 1	< 1 / <1
AROCLOR-1254	< 1	< 1	< 1	< 1	< 1	< 1	< 1 / <1
AROCLOR-1260	< 1	< 1	< 1	< 1	< 1	< 1	< 1 / <1

<# indicates not detected at laboratory detection limit
#/# indicates replicate analysis

Volatile organic analysis conducted by U.S. EPA SW-846 Method 8260

Only compounds detected are shown. Additional compounds sampled for not detected are provided on laboratory data sheets in Appendix D.

TABLE 8
GROUNDWATER EXTRACTION WELLS METALS AND INORGANIC ANALYSES

Parameter	TOTAL METALS			
	RW-1S:PRE-CARB at 5.5 Hours	RW-1S PRECARB at 29 Hours	RW-1S:POST-CARB at 5.5 Hours	RW-2D at 5 HRS
CALCIUM	47,900	52,200	53,800	39,200
IRON	< 196	< 183	< 47.2	1,140
MAGNESIUM	6,520	7,080	7,470	7,940
MANGANESE	2,270	2,390	1,810	148
POTASSIUM	2,360	2,370	2,440	1,230
SODIUM	24,800	24,100	27,400	103,000

Parameter	DISSOLVED METALS	
	RW-1S:PRE-CARB at 5.5 Hours	RW-1S PRECARB at 29 Hours
CALCIUM	50,500	53,900
IRON	< 67.2	< 80.4
MAGNESIUM	6,760	7,250
MANGANESE	2,400	2,470
POTASSIUM	2,360	2,560
SODIUM	25,100	25,000

Parameter	INORGANIC ANALYSIS			
	RW-1S:PRE-CARB at 5.5 Hours	RW-1S PRECARB at 29 Hours	RW-1S:POST-CARB at 5.5 Hours	RW-2D at 5 HRS
Alkalinity (as CaCO3) - mg/L	122	120	157	250
Chloride - mg/L	51.7	54.2	37.3	33.0
Nitrate-Nitrite (as N) - mg/L	0.93	0.63	< 0.05	< 0.05
pH - S.U.	6.83	6.70	8.11	7.58
Specific Conductance - µmhos/cm	542	542	520	915
Sulfate - mg/L	53.4	50.0	44.6	111
Total Dissolved Solids - mg/L	291	261	269	455

All results provided in µg/L (part per billion)
<# indicates not detected at laboratory detection limit
Metals analysis conducted by U.S. EPA Method ILM03.0
Only compounds detected are shown. Additional compounds sampled for not detected are provided on laboratory data sheets in Appendix D

TABLE 9

WELL MW-7DD
HISTORICAL LAB ANALYSES
VOLATILE ORGANIC COMPOUNDS

Parameter	Sample Date			
	2/92	**7/92**	**1/93**	**8/95**
Acetone	ND	8J	8	<10
Methylene Chloride	ND	8J	<5	<10
TCE	340	100	20	5
Chlorobenzene	ND	4J	<5	<10
1,2-DCE	30J	7	4	<10
Xylene	ND	23	3	<10

Notes:

Only volatile organic compounds that have been detected at MW-7DD are shown.

< = Indicates not detected at given quantitatin limit.
ND = Not Detected. Quantitation limit not provided.
J = Indicates estimated value.

TABLE 10

SOIL AND GROUNDWATER REMEDIAL ACTION OBJECTIVES (RAOs)

Media	Parameter	RAO
Soil	Total Volatile Organics Compounds (VOCs)	10 ppm
	Each individual VOC	1 ppm
	Total Semi-Voltile Organic Compounds (SVOCs)	500 ppm
	Each Individual SVOC	50 ppm
	Polychlorinated Biphenyls (PCBs)	10 ppm
Groundwater(1)	Trans-1,2-Dichloroethylene	5 ppb
	Trichloroethene (trichloroethylene)	5 ppb
	Vinyl Chloride	5 ppb
	Ethylbenzene	5 ppb
	Toluene	5 ppb
	Xylene	5 ppb
	PCBs	0.1 ppb

(1) = Other compounds, not listed, would have RAOs in compliance with NYSDEC Ambient Groundwater Quality Standards.

ppm = part per million

ppb = part per billion

TABLE 11

GROUNDWATER EXTRACTION SYSTEM DETAILS

Well No.	Elevation (ft.-MSL)	Area of Concern	Existing or Proposed	Depth (ft.)	Screened Interval (Depth - ft.)	Well Materials	Well Diameter (in.)	Anticipated Flow Rate (gpm)
RW-1S	1277.17	NPLS	Existing	16.0	10.5 - 15.5	Stainless Steel	4	0.5 - 1.0
RW-1D	~1277	NPLS	Existing	58.0	32.0 - 57.0	Stainless Steel	8	2.0 - 4.0
RW-2S	1278.19	NPLS	Existing	16.0	10.5 - 15.5	Stainless Steel	4	0.5 - 1.0
RW-2D	1278.14	NPLS	Existing	42.0	25.0 - 40.0	Stainless Steel	4	2.0 - 4.0
RW-3S	~ 1280	Former UST/ AST Area	Proposed	15.0	5.0 - 15.0	Stainless Steel	4	0.5 - 1.0
RW-4S	~ 1280	Former UST Area	Proposed	16.0	5.5 - 15.5	Stainless Steel	4	0.5 - 1.0
RW-5S	~ 1280	Former UST Area	Proposed	16.0	5.5 - 15.5	Stainless Steel	4	0.5 - 1.0
Anticipated Total Flow								**6.5 - 13**

NOTE: Site conditions may cause modificiations to well depths and screened interval shown above for the proposed wells.

TABLE 12

City of Jamestown
Wastewater Discharge Limitations
Page 1 of 2 Pages

Parameters	Limitations*
Arsenic	1.00
Barium	4.00
Cadmium	2.00
Chromium (Hexavalent)	2.00
Chromium (Total)	4.00
Copper	1.70
Lead	1.00
Manganese	5.00
Mercury	4.00 ug/l
Nickel	2.00
Selenium	0.20
Silver	0.20
Zinc	3.00
Cyanide (Total) **	4.00
Fluoride	6.00
Phenol **	10.00

TABLE 12

City of Jamestown
Wastewater Discharge Limitations
Page 2 of 2 Pages

Parameters	Limitations*
Biochemical Oxygen Demand (5 day)	300 mg/l
Chemical Oxygen Demand	TBD
Flow (MGD)	TBD
Oil and Grease **	TBD
pH-maximum (ph units)***	TBD
ph-minimum (ph units)***	TBD
Temperature (degrees C) ***	TBD
Total Kjeldahl Nitrogen	TBD
Total Suspended Solids	350 mg/l

* Maximum concentrations (mg/l) - 24 hour flow proportional composite samples, if possible or as otherwise indicated. If flow measurement not possible, then form composite of discrete grabs collected at regular time intervals.

** Should be single grab simple.

*** Measured in field