INDUSTRI–PLEX SITE REMEDIAL TRUST

WOBURN, MASSACHUSET

INTERIM DESIGN REPORT

GROUNDWATER REMEDY
100% DESIGN REPORT PART II

INDUSTRI-PLEX SITE
WOBURN, MASSACHUSETTS

Prepared by:

Golder Associates Inc.
The Advent Group, Inc.
Envirex Ltd.
Environmental Science and Engineering

ISRT DESIGN-10

903-6400

MARCH 19

Golder Associates Inc.

20000 Horizon Way, Suite 500
Mt. Laurel, NJ USA 08054
Telephone (609) 273-1110
Fax (609) 273-0778

Golder Associates

TRANSMITTAL LETTER

Industri-Plex Site Remedial Trust

Dave Baumgartner
Bruce Yare D.M. Light

US EPA

Joseph DeCola

NUS Corporation

Arnie Ostrofsky

Husch & Eppenberger

Amy Wachs

Other

Ernie Propp - ICI Americas

Normandeau Associates

Lee Carbonneau

Sasaki Associates

Brad Saunders

MA DEP

Jay Naparstek

CWT

Larry Kirsch

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Golder Associates Inc.

20000 Horizon Way, Suite 500
Mt. Laurel, NJ USA 08054
Telephone (609) 273-1110
Fax (609) 273-0778

Golder Associates

INTERIM DESIGN REPORT
GROUNDWATER REMEDY
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INDUSTRI-PLEX SITE
WOBURN, MASSACHUSETTS

ISRT-DESIGN-10

Prepared for:

Industri-Plex Site Remedial Trust
36 Commerce Way
Woburn, Massachusetts

Prepared by:

Golder Associates Inc.
The ADVENT Group, Inc.
Envirex LTD.
Environmental Science and Engineering

March 1992

Project No.: 903-6400

Golder Associates Inc.

20000 Horizon Way, Suite 500
Mt. Laurel, NJ USA 08054
Telephone (609) 273-1110
Fax (609) 273-0778

Golder Associates

April 1, 1992 Project No.: 903-6400

United States Environmental Protection Agency
HRS-CAN3, JFK Federal Bldg.
90 Canal Street
Boston, MA 02203-2211

Attn: Mr. Joseph N. DeCola
Remedial Project Manager

RE: INDUSTRI-PLEX SITE, WOBURN, MASSACHUSETTS
INTERIM DESIGN REPORT - GROUNDWATER REMEDY
(100% DESIGN REPORT, PART II)

Gentlemen:

On behalf of the Industri-Plex Site Remedial Trust (ISRT) we are pleased to submit two copies of the Interim Design Report - Groundwater Remedy (100% Design Report, Part II) Industri-Plex Site, Woburn, Massachusetts" dated March 1992. We are also sending, under separate covers, one copy of this document to Jay Naparstek of Massachusetts Department of Environmental Protection and one copy to Arnie Ostrofsky of NUS Corporation.

This submission is made in fulfillment of the requirements of Appendix I, Section E.4.a (3)(d) of the Consent Decree and as further detailed in the Remedial Design Work Plan.

Very truly yours,

GOLDER ASSOCIATES INC.

P. Stephen Finn, C.Eng.
Project Manager

PSF/bjt
C:100%CL

DISTRIBUTION:

2 Copies - J. DeCola, U.S. Environmental Protection Agency

1 Copy - J. Naparstek, Massachusetts Department of Environmental Protection

1 Copy - A. Ostrofsky, NUS Corporation

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INTERIM DESIGN REPORT
GROUNDWATER REMEDY
100% DESIGN REPORT, PART II

INDUSTRI-PLEX SITE

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CHAPTER 1

EXECUTIVE SUMMARY

CHAPTER 1.0
EXECUTIVE SUMMARY

This Interim Design Report - Groundwater Remedy (100% Design Report, Part II) is submitted in partial fulfillment of the Industri-Plex Site Consent Decree. Groundwater migrating away from source areas at the Site contains ammonia, benzene, toluene, arsenic, lead, and chromium. These plumes are moving through two buried valleys, which contain permeable glacial sand and gravel deposits, toward the Hall's Brook Holding Area. Seven recovery wells will be installed to control the migration of these plumes:

1. Four hydraulic barrier wells will be installed in Boston Edison Right-of-Way No. 9 to control the downgradient movement of the plumes by creating a hydraulic barrier; and,

2. Three "hot spot" recovery wells will be installed to remove affected groundwater near the East Central and West Hide Piles.

Aquifer hydraulic characteristic information (transmissivity and storativity) from two high capacity pumping tests was used to estimate the yield of the groundwater recovery wells. These estimates were 262 and 275 gallons per minute (gpm). Based on these estimates, the groundwater treatment plant will be designed for a total flow of 300 gpm.

Performance of the groundwater recovery system will be monitored by measuring water levels in the seven recovery wells, four monitoring wells, and thirteen piezometers. The piezometers are located to evaluate the effectiveness of the hydraulic barrier in creating inward hydraulic gradients. The monitoring wells are located downgradient of the hydraulic barrier to monitor the effect of the barrier wells. Groundwater quality will also be determined in the "hot spot" recovery wells to assess changes in the nature and concentration of constituents at these locations. Groundwater samples from the "hot spot" recovery wells and the four monitoring wells will be analyzed for ammonia, benzene, toluene, arsenic, lead, and chromium.

Phase I Treatability Studies indicated that immobilized cell/fluid bed biodegradation of ammonia and organics and metals removal by precipitation with caustic and ferric chloride were suitable technologies for treating Site groundwater. Surface water discharge of treated groundwater containing nitrate/nitrite, generated by the biological degradation of ammonia, was a concern. A Phase II Treatability Study was undertaken to determine if fluid bed bioreactors could be used to convert the nitrate/nitrite to nitrogen gas. This was done by installing an anoxic fluid bed bioreactor to denitrify the nitrate/nitrite. This Phase II Study was successful with ammonia, nitrite and nitrate concentrations of one part per million or less in the treated effluent. Results of the Phase I and Phase II Treatability Studies are summarized below:

Constituent (mg/l)	Influent	Effluent	Percent Removal
Ammonia	323	1	>99
Nitrate	65	<1	98
Nitrite	241	1	>99
Benzene	0.440	ND	>99
Toluene	0.155	ND	>99
Arsenic	0.146	0.042	62

Recovered groundwater will be treated in a 300 gpm capacity treatment plant with the following unit operations:

1. Equalization: Recovered groundwater will be accumulated in a tank prior to treatment in order to reduce concentration and flow variations.

2. Biodegradation: Ammonia, benzene, and toluene will be biologically degraded using a train of three fluid bed/immobilized cell bioreactors.

3. Metals Removal: Arsenic, lead, and chromium will be removed by precipitation with caustic and ferric chloride or by using another suitable technology.

An odor control system will capture and treat any air flows from processes that may generate odors. Vents from the odor control system will be monitored to insure effective odor control.

Treated groundwater will be discharged to a recharge basin located in the Atlantic Avenue drainway which in turn will overflow into the Hall's Brook Holding Area. Effluent limits for the groundwater treatment plant are as follows:

Constituent (mg/l)	Effluent Limit (mg/l)
Ammonia	8.4
Nitrate/Nitrite	10
Phosphorous, Total	2
Benzene	1.060
Toluene	3.500
Arsenic	1.000
Lead	0.035
Chromium	0.120

The point of compliance is the upstream end of the Hall's Brook Holding Area where Hall's Brook enters the upper third of the ponded area.

An evaluation of the impact of the groundwater treatment plant discharge on surface water quality, with a focus on the potential for algal blooms, indicates there is little likelihood of an adverse impact from this discharge provided nitrate and phosphorous concentrations are controlled.

CHAPTER 2

GROUNDWATER EXTRACTION SYSTEM

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CHAPTER 2.0
GROUNDWATER EXTRACTION SYSTEM

2.1 HYDROGEOLOGIC DESIGN

2.1.1 Introduction

The hydrogeologic design of the groundwater extraction system for the Industri-Plex Site in Woburn, Massachusetts is provided in this section. The extraction system is intended to achieve the following two objectives:

1. establish a hydraulic barrier to prevent constituents of concern from migrating off-Site; and,

2. extract groundwater from upgradient "hot spots".

The design is based on data obtained from an on-Site aquifer pumping test (Golder, 1991a), slug testing of select monitoring wells (Golder, 1991b), an off-Site pumping test (Golder, 1990), and geologic data from a wide variety of sources. The design was performed using analytical methods based on the Theis equation (Theis, 1935).

2.1.2 Overview of Design Approach

The groundwater extraction system design approach involved the steps which are summarized below and described in detail in subsequent sections of this report.

1. Data gathered during the on-Site pumping test were incorporated into the existing geologic and hydrogeologic data base. Weighted averages of aquifer thickness and hydraulic conductivity were calculated to provide values of transmissivity representative of the aquifer as a whole.

2. Phreatic surface drawdown at various pumping rates were computed using Neuman equations (Neuman, 1975). These calculations were performed to evaluate the anticipated response of the on-Site aquifer and to assist in selecting the well

locations and range of pumping rates to be used in the subsequent Theis analyses.

3. The Theis analysis was first applied to calculate drawdown in extraction well E-5 under the conditions of the on-Site pumping test. An image well was used to simulate the recharge boundary associated with the Hall's Brook Holding Area. The calculated drawdowns were compared to those measured during the pumping test and showed that the Theis analysis and interpreted aquifer parameters were appropriate for use in the design of the extraction system.

4. The Theis analysis was then used to simulate different extraction system pumping scenarios. Analyses were carried out using a method developed by Prickett (1985). Conservative assumptions were used when necessary to overcome certain method limitations. In particular, image wells were used to simulate hydraulic boundaries and injection wells accounted for the on-Site recharge area. The Theis analyses calculated the phreatic surface elevations under different pumping, reinjection and image well scenarios. Several pumping scenarios were considered until a suitable extraction system design was selected.

5. Drawdowns computed from the selected extraction system design were applied to the latest phreatic surface contour map developed for the site (October 6 and 7, 1991). The resulting contour map showed the effects that the groundwater extraction system would have on site specific conditions. Flow lines were then drawn perpendicular to the phreatic surface contours (equipotentials) to demonstrate that the estimated drawdown would provide the necessary "hydraulic barrier" to groundwater flow through the buried valley.

6. Sensitivity analyses were performed on the selected pumping scenario to evaluate the effects of varying critical hydrogeologic parameters. In particular, the sensitivity analysis accounted for conceivable variations in hydraulic conductivity and possible additional aquifer thickness associated with fractured bedrock zones.

2.1.3 Aquifer Properties

The Theis analysis requires the following input parameters:

- transmissivity;
- inclination of aquifer surface (hydraulic gradient); and,
- specific yield

Transmissivity, which is the product of horizontal hydraulic conductivity and saturated aquifer thickness, is a key parameter for the Theis analysis and is assumed to be constant throughout the groundwater flow field. Because of this assumption, it was necessary to determine a representative value for the entire aquifer. Weighted averages for hydraulic conductivity and saturated thickness were computed to provide representative values of these parameters. The data and assumptions used and results of the weighted averaging procedures are presented in Appendix 2-A. The weighted averages for horizontal hydraulic conductivity and saturated aquifer thickness along with averages of horizontal hydraulic gradients and specific yield are discussed below.

2.1.3.1 Horizontal Hydraulic Conductivity

Horizontal hydraulic conductivity (Kr) values were determined from the slug testing of select monitoring wells and from the on-Site pumping test. Hydraulic conductivity contours interpreted from this data are presented on Figure 2-1. The weighted average of Kr was calculated using the area of each Kr zone as the weighting factor. The weighted average for horizontal hydraulic conductivity (Kr) was computed to be 61 ft/day. Portions of the aquifer expected to have lower Kr values (north end of Site) were not used in the weighted average computation and therefore this value of Kr is expected to be conservatively high.

2.1.3.2 Aquifer Thickness

The weighted average for aquifer thickness (b) was computed to be 21 feet. Aquifer thickness data was obtained from the phreatic surface contour map for October 6 and 7, 1991 presented as Figure 2-2 and from the interpreted bottom of aquifer contour map presented as Figure 2-3. Weighted average values were computed by using area as the weighting factor.

2.1.3.3 Horizontal Hydraulic Gradients and Specific Yield

Horizontal hydraulic gradients were calculated using hydraulic head values of select monitoring wells shown on Figure 2-2. The hydraulic head values are listed in Table 2-1. As can be seen from Table 2-1, the horizontal hydraulic gradients range from 0.002 ft/ft to 0.009 ft/ft with the geometric mean being 0.005 ft/ft. The geometric mean of horizontal hydraulic gradients was considered appropriate for use in the Theis analysis because of the small range of values measured.

Based on the measured values from the on-Site pumping test, the arithmetic average specific yield (Sy) value was estimated to be 0.12. This is a typical value encountered for most unconfined outwash sand aquifers.

2.1.3.4 Groundwater Levels

Synoptic groundwater level measurement data has been reviewed for the following monitoring periods: May 1990, April 1990, June 1990, July 1990, September 1990, August 1990, December 1990, April 1991, May 1991, and October 1991. The April, May, and October 1991 monitoring events provide a more comprehensive data base than earlier measurements due to the presence of additional monitoring wells at these times. In most cases, the May 1991 data was found to exhibit water levels up to 0.5 feet higher than the April and October 1991 data. While water levels were found to be approximately one foot higher in 1990 than they were in 1991; it is not expected that this difference will materially effect the groundwater extraction system design. This range of water levels is not inconsistent with the analysis of high groundwater levels for similar geologic settings in Massachusetts presented by Frimpter (1981). The May 1990 measurements exhibited the highest water levels, however, only a limited number of wells were monitored. The October 1991 phreatic surface measurements were used in the design since the data provides comprehensive information for construction of interpreted phreatic surface contours. In addition, water levels measured in October 1991 generally exceeded those measured in April 1991.

2.1.4 Preliminary Assessment of Drawdown

As a means to assess the effects of pumping and to establish preliminary pumping rates to be used in the subsequent Theis analysis, drawdowns were estimated using Neuman equations (Neuman 1975) to simulate the pumping of extraction well E-5 at rates of 50 gpm and 120 gpm. A pumping period of 90 days was used to characterize aquifer response. The effects of varying transmissivity were also assessed. A description of the analytical procedure used and numerical results of the analysis are presented in Appendix 2-B.

The results of the drawdown simulation are graphically presented on Figure 2-4. The higher value of transmissivity (7,423 ft^2/day) represents an average of the values measured along the main extraction corridor where aquifer thickness and hydraulic conductivity are greatest. The lower transmissivity value (1,281 ft^2/day) is based on the weighted average values of Kr and b previously discussed in Section 2.1.3.

Drawdowns resulting from a pumping rate of 50 gpm and T=1,281 ft^2/day at extraction well E-5 were calculated to be approximately 10.1 feet and extended in a north-northwest direction approximately 4,000 feet. These results show that pumping rates in the order of 50 gpm can affect large areas of the aquifer and produce significant drawdowns. Increasing the pumping rate at E-5 (with a given transmissivity) deepened the drawdown but did not significantly broaden the cone of depression. Conversely, increasing the transmissivity yielded shallower but broader cones of depression. It is important to note that the drawdown values discussed above may be underestimated because they correspond to the laterally infinite aquifer assumption of Neuman's equations. Actual drawdowns may be greater and may influence a wider area due to the close proximity of bedrock outcrops which act as lateral impermeable boundaries.

2.1.5 Theis Analysis

The following section presents a description and the results of the Theis analysis used to design the groundwater extraction system at the Industri-Plex Site. Theis analyses were carried out using the approach developed by Prickett (1985). This method calculates relative phreatic surface elevations throughout a laterally infinite/homogeneous aquifer with uniform transmissivity and storage and with uniform flow.

2.1.5.1 Evaluation of the Theis Analysis

To verify the choice of Theis as an applicable analytical method, an initial analysis was made to simulate the pumping test condition. Weighted average hydrogeologic parameters were used with one extraction well at the location of E-5, and a pumping rate of 120 gpm for a duration of 700 minutes. The influence of Hall's Brook Holding Area was accounted for with an image well having an injection rate of 120 gpm. This image well was located approximately 500 feet perpendicularly south of the line representing the northern edge of Hall's Brook Holding Area. The phreatic surface drawdown was calculated for this configuration and compared to the results of the pumping test at E-5. Figure 2-5 shows the results of the Theis analysis under these conditions superimposed on measured drawdown contours from the on-Site pumping test.

As can be seen from Figure 2-5, the simulated drawdown is relatively symmetrical. This is due to the infinite aquifer assumption of the Theis analysis. The drawdown at E-5 was predicted by the Theis analysis to be 1.75 feet which compares favorably to the actual measured drawdown of 1.82 feet. Further, the Theis analysis shows the zero drawdown line to have a radius of between 350 and 500 feet. The measured water levels during the pumping test exhibited an elliptically shaped zero drawdown line which extended approximately 1,100 feet in the upgradient direction, approximately 700 feet in the downgradient direction, and approximately 400 to 700 feet perpendicular to the groundwater flow direction. The elliptical shape and greater extent of the drawdown cone in certain directions is believed to be a result of the hydraulic constraints of the underlying bedrock.

Based on the above comparison it can be seen that the Theis analysis using the weighted average values of aquifer thickness and hydraulic conductivity, provides results comparable to those measured in the field. In fact, the Theis analysis and weighted average input parameters tend to underestimate the extent of drawdown. This underestimation of drawdown appears to be due to the Theis analysis not fully considering lateral bedrock boundary effects. It can be concluded from the above discussion that the Theis analysis is a reasonable and conservative method for designing the groundwater extraction system at the Industri-Plex Site.

2.1.5.2 Extraction System Design

Seven groundwater extraction wells were placed at locations to meet the two primary objectives of the groundwater extraction system stated previously in Section 2.1.1. Extraction wells E-2, E-3, E-4, and E-5 were placed along Boston Edison Right-of-Way No. 9 to provide a hydraulic barrier to groundwater flow. Extraction wells E-1, E-6, and E-7 were placed in upgradient hot spot areas. Site features such as roadways, buildings, topography, and utilities, were also considered in selecting the extraction well locations. The groundwater extraction well layout evaluated using the Theis analysis is presented on Figure 2-6.

Eight injection wells were used in the Theis analysis to simulate the effect of the proposed groundwater recharge basin as shown on Figure 2-6. These wells were equally spaced within the recharge basin area and each well was assigned an injection rate equal to one eighth of the projected total recharge rate of the basin (50 gpm).

Hall's Brook Holding Area, situated approximately 300 feet south of the main extraction corridor is considered to act as a recharge boundary. Boundary effects of the Holding Area were confirmed during the on-Site pumping test. The image well theory (Ferris et al., 1962) was applied to account for the effects of this recharge boundary on the assumptions that (1) the recharge boundary fully penetrates the aquifer and is equivalent to a constant head boundary and (2) the length of the recharge boundary is infinite. Considering that Hall's Brook Holding Area does not fully penetrate the aquifer saturated thickness and the length of the constant head boundary is finite (around 400 feet), the image well theory applied to the Holding Area will produce conservative results.

On this basis the image well theory was applied for wells E-3 and E-4. Two image wells (injection wells E-3' and E-4') were used to account for the effects of the Hall's Brook Holding Area recharge boundary. These wells were located equidistant from extraction wells E-3 and E-4 respectively and perpendicular to a line representing the northern limit of Hall's Brook Holding Area. The injection rates of E-3' and E-4' were varied until the zero drawdown line corresponded to the northern boundary of the Holding Area. The final values for the injection rates of image wells E-3' and E-4' were 70 gpm and 85 gpm, respectively. These values are higher than the extraction rates of wells E-3 and E-4 since the drawdown is also affected by the adjacent extraction wells E-2 and E-5.

Several runs of the Theis analysis were made by varying the pumping rates of the extraction wells. A pumping period of 90 days was used to characterize the aquifer response. Each run of the Theis analysis produced a drawdown contour map and a phreatic surface contour map. These maps were examined for each iteration until a pumping scenario that achieved the most favorable drawdown and flow conditions was selected.

Figure 2-6 presents the simulated drawdown contour map for the final pumping scenario. It should be noted that the drawdown and contour map is based on the laterally infinite aquifer assumption of the Theis analysis. Actual drawdowns are expected to be greater in depth and broader in lateral extent because of the lateral bedrock boundaries on-Site.

The pumping rates and drawdowns computed in each well by the Theis analysis are presented below:

Extraction Well	Pumping Rate (gpm)	Drawdown (feet)
E-1	35	2.89
E-2	45	5.45
E-3	40	4.91
E-4	45	4.04
E-5	70	5.49
E-6	20	3.30
E-7	20	2.36
TOTAL	275 gpm	

In order to derive an anticipated phreatic surface contour map for the Site under pumping conditions, the Theis drawdown were superposed on the phreatic surface contour map produced from field measurements collected on October 6 and 7, 1991. Figure 2-7, shows the interpreted phreatic surface contour map under pumping conditions. Flow lines were constructed perpendicular to the resulting phreatic surface contours which suggest flow occurs exclusively to the wells, showing that the required hydraulic barrier has been achieved.

2.1.5.3 Sensitivity Analyses

Sensitivity analyses were conducted to assess the effects of varying horizontal hydraulic conductivity (Kr) and aquifer thickness (b) on drawdown as computed by the Theis analysis of the final pumping scenario selected. The first sensitivity analysis was run using a Kr value of 9.0 x 10-2 cm/s (255 ft/day) which corresponds to the high end of the range of values determined during the on-Site pumping test, as shown on Figure 34 of the pumping test report (Golder, 1991a). The resulting drawdowns from this sensitivity analysis, which used a transmissivity of 5,355 sqft/day, are presented on Figure 2-8. The second sensitivity analysis used the weighted average aquifer thickness (21 feet) increased by 15 feet to conservatively account for any potential fractured bedrock effects. The resulting drawdowns of the second sensitivity analysis, which used a transmissivity of 2,196 sqft/day, are shown on Figure 2-9.

As can be seen from the results of the sensitivity analyses, increasing the transmissivity (by increasing Kr and b) tends to decrease the depth of drawdown but not the overall areal extent of influence. The drawdown distribution maintains similar characteristics to that of the final pumping scenario case which used the weighted averages of b and Kr. The worst case sensitivity run (T = 5,355 sqft/day) exhibited drawdowns of approximately 0.5 feet at both the eastern and western bedrock outcrops of the main buried valley.

2.2 EXTRACTION WELL DESIGN

A schematic diagram of the generalized extraction well design is presented on Sheet 2-1. The extraction wells will be constructed by drilling a 14-inch borehole through the entire thickness of the aquifer and installing 8-inch Type 304 stainless steel screen. Appropriately sized silica sand will be placed around the screen to form the well filter. Filler tubes will also be installed to maintain the filter integrity should settlement occur during well development. The well will be sealed using bentonite pellets and grout and developed using surge block and pumping techniques. A submersible pump will be placed near the bottom of the well, and a drawdown monitoring system assembly will be installed in the well. The well will then be mechanically and electrically connected to the remainder of the groundwater extraction and treatment system.

Extraction wells located to recover groundwater from upgradient hot spots (E1, E6, and E7), will be installed through the Outwash Sand in the same manner as the existing well E5. As required by USEPA, extraction wells E2, E3, and E4, located to establish a hydraulic barrier, will be installed through the full thickness of the Outwash Sand, any Till encountered, and 10 feet into bedrock. This design may permit constituent migration from the Outwash Sand into bedrock fractures, for example, during periodic shutdown of the extraction wells for maintenance. Vertical gradients between the bedrock and Outwash Sand, which are expected to be upward during pumping (Golder, 1991a) may reverse during such shutdowns.

The final design will be submitted in the Final Design Report (100% Design Report, Part II) for the groundwater remedy. Preliminary details of the design are provided in the following sections.

2.2.1 Well Screen Slot Size and Filter Pack

Screen slot and filter pack sizing will be determined using a pilot borehole and grain size distribution analyses at each extraction well location. Continuous split spoon sampling will be performed in the screen zone at each pilot borehole and the stratigraphy will be carefully logged. Samples from similar stratigraphic zones at each location will be composited for grain size distribution analyses. The well filter and screen will be sized based on the grain size distribution results, existing experience with production well design in similar materials and the operation of prototype extraction well E-5.

The final extraction well design may include multiple screen slot sizes in each well to match the proper slot size with the formation. The filter pack design will consist of either a well-graded silica sand suitable for all slot sizes or a vertically graded filter pack.

At locations E2, E3 and E4, the pilot holes will include split spoon sampling of the till and coring of bedrock. Screen and filter pack designs in the Outwash Sand and bedrock will be based on information from the pilot holes. Solid casing with a bentonite seal will be used through till zones.

2.2.2 Well Materials

The best choice of well screen material is stainless steel. Stainless steel has the advantage of being flush-threaded, chemically resistant to site compounds, and provides mechanical resistance to vigorous pumping. The stainless steel continuous slot well screen provides very good slot control over a wide range of sizes and provides a large open area. The open area lowers entrance velocities and allows for efficient well development.

The well casing will be constructed of carbon steel, stainless steel, or other steel material. The final determination of well casing material will be made in the final engineering design.

The gravel pack will be sealed against downward movement of water from the surface with a 5-foot bentonite pellet seal. If necessary, cement/bentonite grout having no more than 5 percent bentonite by dry weight will be placed above the seal to the level of the underground extraction well vault.

2.2.3 Well Diameter

Pump size will affect the diameter of the extraction wells. For several wells, a pump with a performance of less than 1 horsepower will likely be sufficient. A 4-inch pump and 6-inch shroud can be used in the wells necessitating an extraction well diameter of 8 inches. It should be noted that the well casing must be two standard pipe sizes (about 4 inches) larger than the pump diameter in order to accommodate the shroud and still provide room for cooling water to flow freely around the pump motor.

2.2.4 Drawdown Monitoring Assembly

A drawdown monitoring assembly will be installed in the well casing (Sheet 2-1). The device will perform a minimum of three functions:

- Monitor water levels in the extraction wells at predetermined frequencies;
- Provide input to the system's logic controls to regulate pumps; and
- Provide for emergency shut-off of pump in the case of excessive drawdown and notify treatment plant of this action.

The design of the drawdown monitoring system will be presented in the Final Design Report (100% Design Report, Part II) for the groundwater remedy.

2.2.5 Piping System Tie-In

Sheet 2-1 shows the preliminary well head assembly which will tie into the piping system. The well casing will extend about 3 inches into the bottom of the sealed concrete vault. The well will be sealed by using a compression collar. The collar is a three-layered device consisting of a steel well cap, a neoprene or equivalent membrane, and a steel upper plate. The well cap and plate will have openings for the discharge pipe, the pump wiring and the drawdown monitoring assembly. The pump will be suspended in the well by use of a clamping device attached to the discharge pipe.

The compression collar is sealed by tightening the upper plate down into the well cap with a series of hex bolts. As the plate tightens, the neoprene membrane is pressed tightly around the openings in the compression collar. This procedure will provide for a sealed system within the concrete vault.

2.3 EXTRACTION WELL PUMPS

Present estimates of horsepower requirements have indicated that pumps having a maximum of 3 hp will be adequate to provide for movement of groundwater to the treatment plant. In several cases, smaller size pumps may work as well. It is necessary to size the pump such that it is operating at an optimum pressure. The final specifications for the pumps will be made on the basis of flow rates at each well and will be included in the final engineering design.

The pumps will be of the stainless steel, submersible type and will be set above the bottom of the well screen to facilitate cooling. Bottom set pumps do not cool as efficiently because of the lack of water flowing past the pump motor. Because of concerns regarding pump cooling, a shroud will be placed around the pump in order to force water past the pump motor.

2.4 GROUNDWATER EXTRACTION PIPING AND FLOW CONTROL SYSTEM

Sheet 2-2 presents a layout of the groundwater extraction wells, well vaults, pipe junction vaults and piping runs to the proposed location of the groundwater treatment plant. The groundwater pumped from each extraction well will be carried to the treatment plant by 3 to 4 inch diameter fiberglass piping. Fiberglass with vinyl ester resin has been tentatively selected as the piping material based on its resistance to chemicals, particularly benzene and toluene at low concentrations. For thermal protection, the piping will be buried to a depth of 5 feet below the ground surface.

Instrumentation and controls will be housed in vaults constructed of polymerized concrete at each extraction well and header junction. Piping details within these vaults are shown on Sheets 2-3 and 2-4.

At each extraction well vault location, the flow rate will be monitored on a continuous basis by means of an inline flow meter. A ball valve equipped with an electric actuator, will be used to control the flow rate. A flow limiting valve, to maintain back pressure on the well pump, a check valve, ball valves to by-pass the flow meter assembly, sampling ports, and header cleanouts will also be contained within the vault. All valves and fittings will be constructed of stainless steel, or other corrosion resistant materials.

The header junction vaults will house the connection between two piping headers. Valves and sample ports will be installed at each header junction vault to control flow during maintenance, to act as clean outs, and to collect groundwater samples.

System flow control will be accomplished by transmitting electronic signals in the 4 to 20 milliamp range between the flow monitor at each extraction well vault and a computer to be housed at the treatment plant control panel. Continuous digital readouts of the flow and flow totalizer at each well will be displayed on the control panel. Similar electronic signals will be sent back to the extraction well vaults to control the flow using the ball valve.

The final engineering design of the extraction system piping, system logic, instrumentation, and control will be presented in the Final Design Report (100% Design Report, Part II) for the groundwater remedy.

2.5 GROUNDWATER EXTRACTION MONITORING SYSTEM

2.5.1 Introduction

The objectives for the groundwater extraction monitoring system are as follows:

1. monitoring the performance of the hydraulic barrier; and

2. monitoring temporal changes in hot spot composition.

The rationale used to address these specific objectives is described in the following sections.

2.5.2 Groundwater Extraction System Layout

The basis of design for the groundwater extraction system is described in Section 2.1 of this report. Figure 2-10 shows the extraction well layout along with the predicted steady-state piezometric surface and flow directions during pumping, and proposed groundwater extraction system monitoring points.

The groundwater extraction system consists of seven (7) groundwater pumping wells designated E1 through E7. Four of the groundwater extraction wells (E2, E3, E4, and E5) are situated in a line along the southwestern boundary of the Site, perpendicular to the overall direction of groundwater flow, and establish a hydraulic barrier to groundwater flow through the main buried valley. These four "barrier" wells are designed to redirect natural groundwater flow toward the barrier wells, creating inward hydraulic gradients and overlapping cones of depression to control off-Site migration of Hazardous Substances. The three remaining extraction wells (E1, E6, and E7) are positioned in upgradient locations to directly extract Hazardous Substances from hot spots.

2.5.3 Data Needs

In order to evaluate the effectiveness of the groundwater extraction system, monitoring data will include hydrogeologic data (piezometric head measurements) and chemical data (water quality).

Piezometric head data are necessary at various points in the aquifer in the vicinity of the extraction system hydraulic barrier. Piezometric head data in the vicinity of the barrier wells are used to assess whether hydraulic gradients are sufficient to prevent off-Site migration of Hazardous Substances.

Chemical data downgradient of the extraction system supplement piezometric head data in evaluating potential off-Site migration of Hazardous Substances. On-Site chemical data are needed to assess temporal trends in the concentration of Hazardous Substances in the hot spots.

2.5.4 Monitoring System Design

Important aspects of the groundwater monitoring system design include the location and construction details of the monitoring points and the parameters to be measured. Each of these aspects is addressed separately below.

2.5.4.1 Monitoring Point Locations

Monitoring point locations are given on Figure 2-10. Monitoring points include the seven groundwater extraction wells (E1 through E7), four monitoring wells (MW1 through MW4), and 13 piezometers (P1 through P13). The rationale for monitoring well and piezometer locations is described below.

Piezometric Head Data

In addition to monitoring water levels within the groundwater extraction wells, water level data are collected from monitoring wells and piezometers installed around the hydraulic barrier. Piezometers are situated to measure the response of the aquifer at mid points between the extraction wells. Additional piezometers and monitoring wells are located at the edges of the buried valley, immediately downgradient of the main extraction corridor and in upgradient positions to evaluate the effectiveness of the hydraulic barrier in creating inward hydraulic gradients.

Piezometers are to be screened in the first ten feet of the glacial outwash sand in order to measure the response of the water table to pumping. The groundwater extraction wells and monitoring wells are to be screened across the entire saturated thickness of the buried valley aquifer in order to provide piezometric data which are representative of the entire aquifer.

Chemical Data

Monitoring wells for groundwater sampling/analysis are located downgradient of the hydraulic barrier and at the edges of the buried valley. The monitoring wells are intended to monitor Hazardous Substances downgradient and around the groundwater extraction system barrier wells. Hot spot recovery wells will also provide chemical data to assess temporal changes in the nature and concentration of Hazardous Substances in the vicinity of the hot spots.

2.5.4.2 Monitoring Point Construction

The monitoring points are to be 2-inch minimum diameter and flush-threaded. The screen interval will be placed in the upper 10 feet of outwash sand. The piezometers have 10-foot screens and are to be completed with a bentonite pellet seal above the filter pack, bentonite grout seal, and a surficial cement seal extending to beneath the frost zone with a locking protective casing or gate box. Monitoring well construction will be identical to that of the piezometers, except that the entire saturated thickness of the aquifer will be screened.

All monitoring wells and piezometers will be developed until visual clarity has been obtained, or until field measurements of temperature, pH and conductivity remain relatively stable. A slug test will be performed in all new monitoring wells and piezometers following installation to determine in-situ hydraulic conductivity values.

In order to ensure the integrity of the monitoring point, all drilling, sampling and testing equipment will be decontaminated upon arrival at the Site. All well materials, unless they are delivered to the Site pre-washed and wrapped in plastic, will be steam-cleaned and protected until installation.

2.5.4.3 Monitoring Parameters

Piezometric head measurements are determined in all extraction wells, monitoring wells, and piezometers in the groundwater monitoring system.

Routine chemical testing includes analysis of groundwater samples from hot spot recovery wells (E1, E6, and E7) and monitoring wells (MW1, MW2, MW3, and MW4) for benzene, toluene, arsenic, chromium, lead, and ammonia. The specific conductance, pH, and temperature of groundwater samples will also be determined in the field.

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TABLE 2-1

AVERAGE HORIZONTAL HYDRAULIC GRADIENTS

	H1 (FT)	H2 (FT)	H1-H2 (FT)	L (FT)	I (FT/FT)
OW28-OW16	66.47	63.92	2.55	740.00	0.003
OW31-OW43	69.90	68.68	1.22	730.00	0.002
OW36-OW38	69.87	64.33	5.54	590.00	0.009
OW11-OW14	66.84	57.94	8.90	1405.00	0.006
OW40-OW48A	59.34	56.69	2.65	460.00	0.006
OW40-OW18A	59.34	53.70	5.64	960.00	0.006
OW12-OW18A	56.06	53.70	2.36	500.00	0.005
AVERAGE					0.005

NOTE: H1-HYDRAULIC HEAD FOR THE UP GRADIENT WELL
H2-HYDRAULIC HEAD FOR THE DOWN GRADIENT WELL
L-HORIZONTAL DISTANCE BETWEEN THE WELLS
I-HORIZONTAL HYDRAULIC GRADIENT (H1-H2/L)

TARGET SHEET

THE MATERIAL DESCRIBED BELOW
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() NON-PAPER MEDIA

() OTHER:

DESCRIPTION: DOC#. 32790

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Figure 2-1
Interpreted Horizontal Hydraulic
Conductivity Contour Map

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Figure 2-2
Interpreted Phreatic Surface Contour Map
10/06/91 to 10/07/91

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Figure 2-3
Interpreted Contour Map of Bottom of Aquifer

THE OMITTED MATERIAL IS AVAILABLE FOR REVIEW
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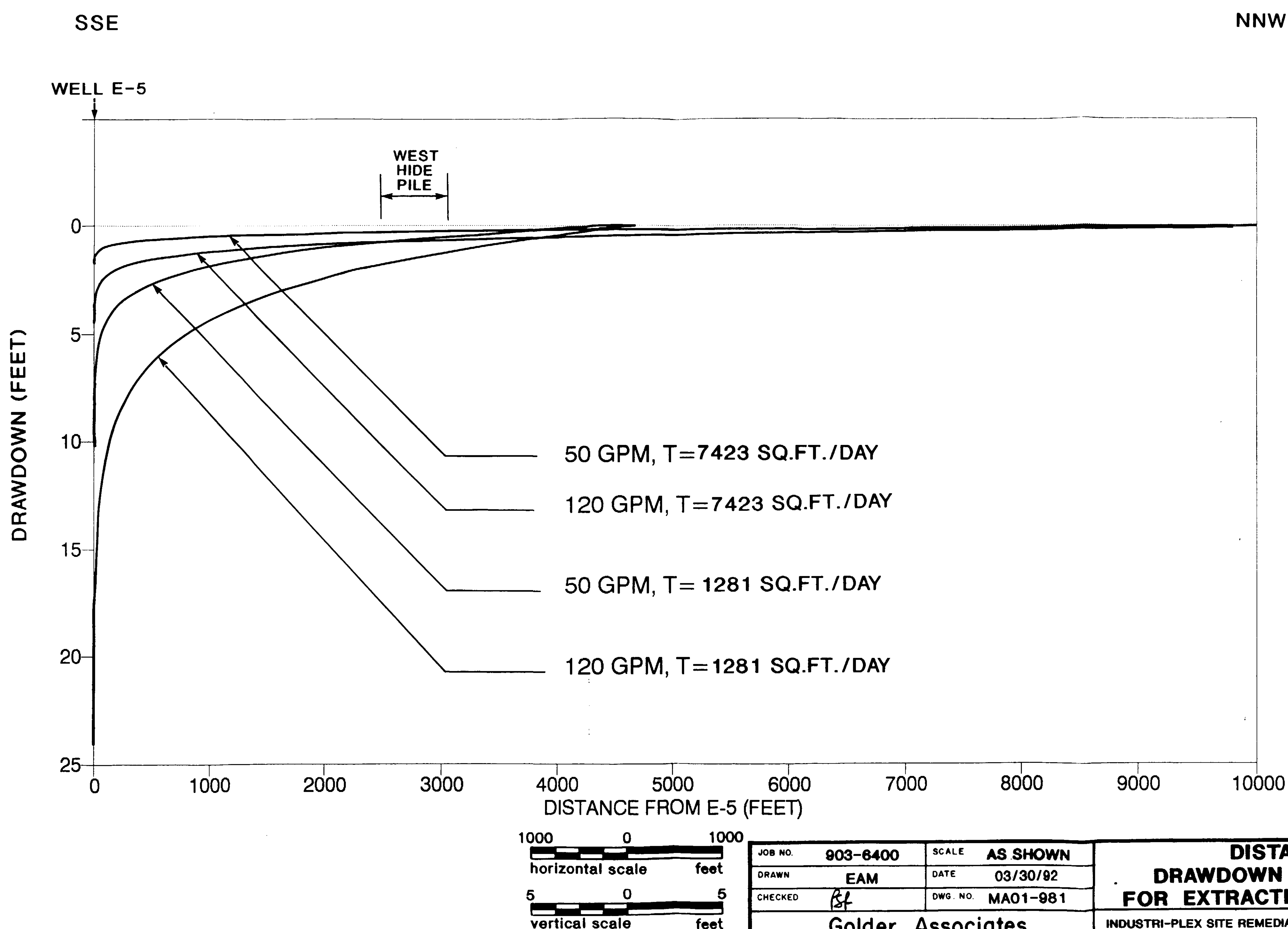
BOSTON, MA



APR 0 1 1992

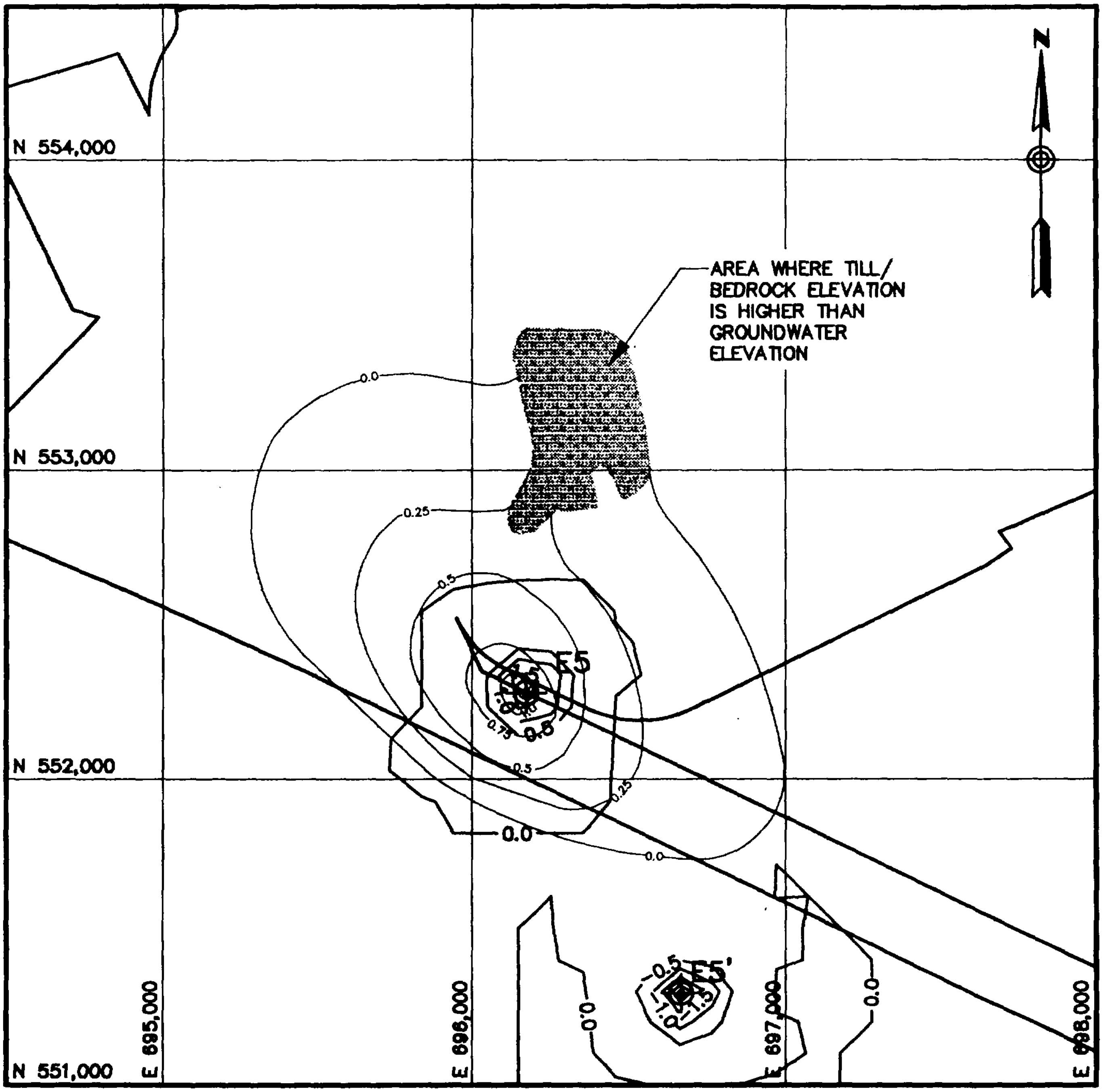
JOB NO.	903-6400	SCALE	AS SHOWN
DRAWN	EAM	DATE	03/30/92
CHECKED	[illegible]	DWG. NO.	MA01-981
Golder Associates			

DISTANCE DRAWDOWN VARIATIONS FOR EXTRACTION WELL E5

INDUSTRI-PLEX SITE REMEDIAL TRUST

FIGURE 2-4

152110



NOTES

T=1281 SQUARE FEET PER DAY

K=61 FEET PER DAY

b=21 FEET

APR 0 1 1992

500 0 500

scale feet

LEGEND

E5 EXTRACTION WELL

E5' IMAGE WELL

—1.0— SIMULATED DRAWDOWN (THEIS)

— 1.0 — DRAWDOWN (PUMPING TEST RESULTS)

——— SITE BOUNDARY

JOB No.: 903-6400	SCALE: AS SHOWN	PUMP TEST SIMULATION	
DRAWN: RDH	DATE: 03/30/92		
CHECKED: RSP	FILE No.: MA01-966		
Golder Associates		INDUSTRI-PLEX SITE REMEDIAL TRUST	FIGURE 2-5

TARGET SHEET

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Figure 2-6
Calculated Drawdown Contours Theis Analysis
(T-1281 SQ FT/D)

THE OMITTED MATERIAL IS AVAILABLE FOR REVIEW
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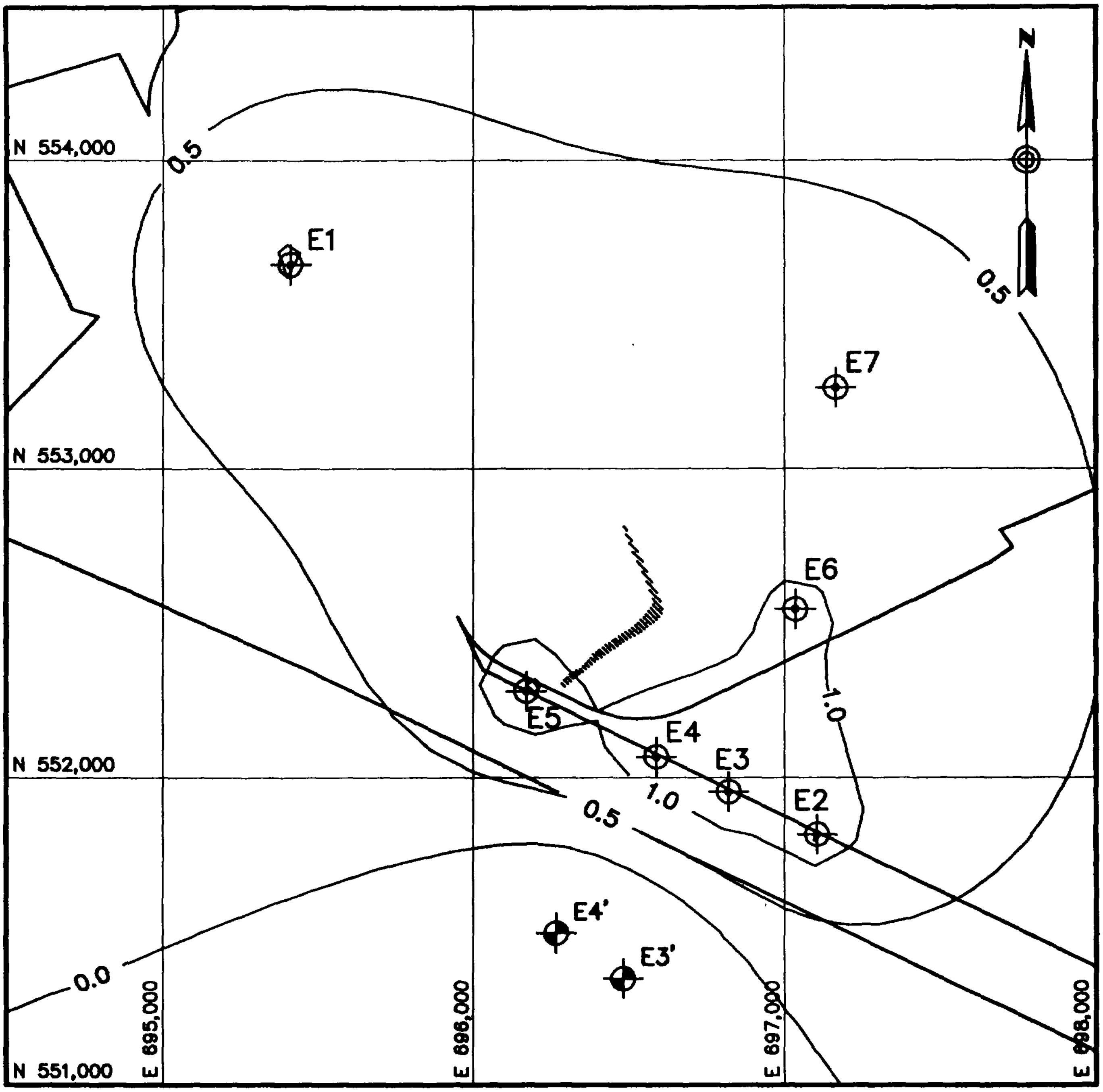
Figure 2-7
Interpreted Phreatic Surface Under Pumping Conditions

THE OMITTED MATERIAL IS AVAILABLE FOR REVIEW
BY APPOINTMENT
AT THE EPA NEW ENGLAND SUPERFUND RECORDS CENTER,
BOSTON, MA



NOTES

T=5355 SQUARE FEET PER DAY

K=255 FEET PER DAY

b=21 FEET

APR 0 1 1992

500 0 500
scale feet

LEGEND

RECHARGE BASIN

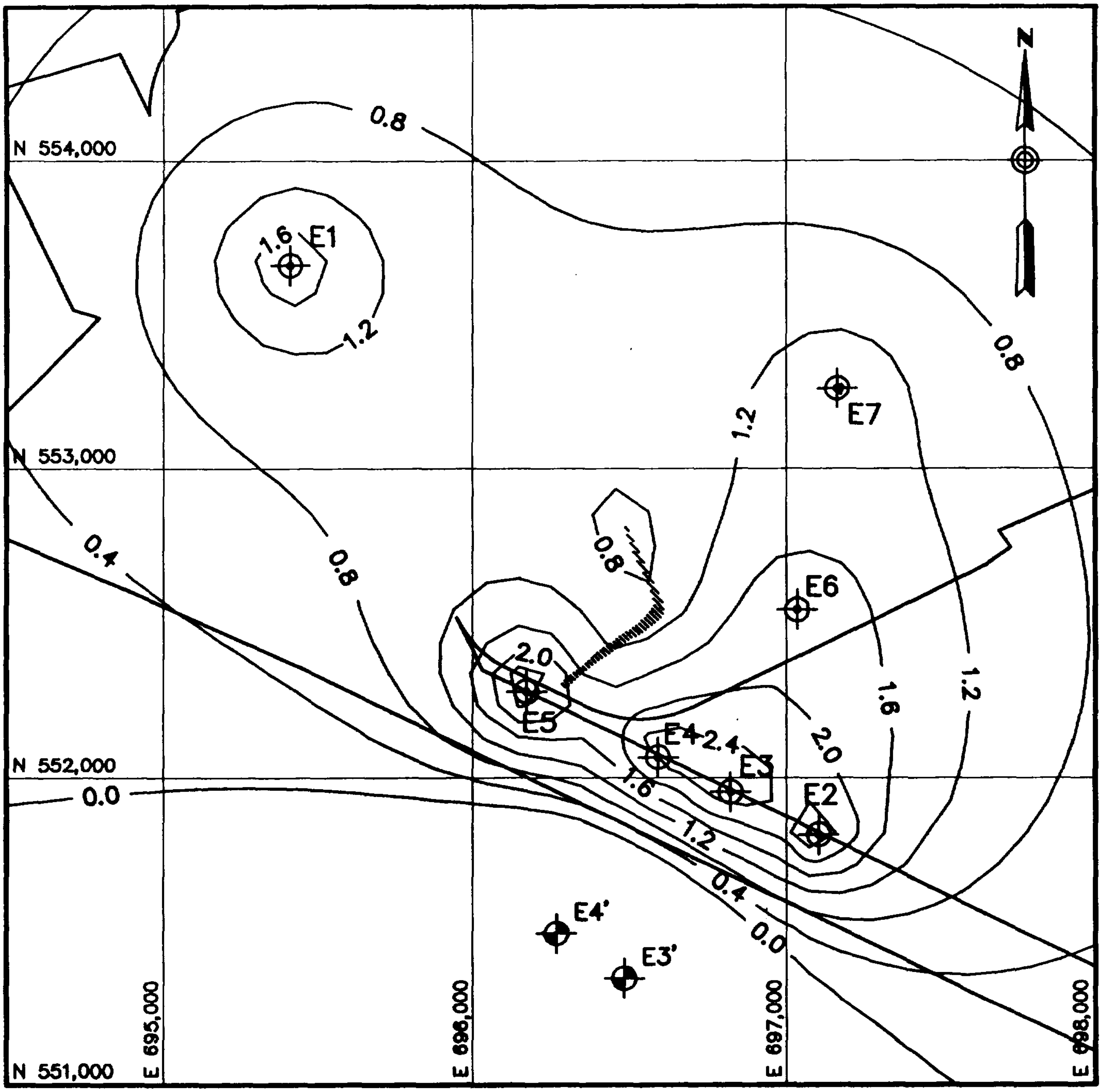
E1 EXTRACTION WELLS

E4' IMAGE WELLS

—1.0— SIMULATED DRAWDOWN

SITE BOUNDARY

JOB No.: 903-6400	SCALE: AS SHOWN	SIMULATED DRAWDOWN CONTOURS FOR SENSITIVITY RUN 1	
DRAWN: RDH	DATE: 03/31/92		
CHECKED: BP	FILE No.: MA01-951		
Golder Associates		INDUSTRI-PLEX SITE REMEDIAL TRUST	FIGURE 2-8



NOTES

T=2196 SQUARE FEET PER DAY

K=61 FEET PER DAY

b=21 FEET + 15 FEET = 36 FEET

APR 0 1 1992

500 0 500

scale feet

LEGEND

RECHARGE BASIN

E1 EXTRACTION WELLS

E4' IMAGE WELLS

—1.0— SIMULATED DRAWDOWN

SITE BOUNDARY

JOB No.: 903–6400	SCALE: AS SHOWN	**SIMULATED DRAWDOWN CONTOURS FOR SENSITIVITY RUN 2**	
DRAWN: JSG	DATE: 03/31/92		
CHECKED: RJ	FILE No.: MA01–950		
Golder Associates		INDUSTRI–PLEX SITE REMEDIAL TRUST	FIGURE 2-9

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Figure 2-10
Groundwater Extraction System Monitoring Points

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Sheet 2-1
Extraction Well Schematic

TARGET SHEET

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Sheet 2-2
Groundwater Extraction System Layout

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Interim Design Report, Groundwater Remedy
100% Design Report Part II
Sheet 2-3
Groundwater Extraction Piping Details

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Interim Design Report, Groundwater Remedy
100% Design Report Part II
Sheet 2-4
Groundwater Extraction Piping Details

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APPENDIX 2-A

Calculation of Weighted Average Values for Horizontal Hydraulic Conductivity and Saturated Aquifer Thickness

APPENDIX 2-A

Calculation of Weighted Average Values for Horizontal Hydraulic Conductivity and Saturated Aquifer Thickness

Horizontal Hydraulic Conductivity

The horizontal hydraulic conductivity (K_r) values determined from the on-Site pumping and slug tests are listed in Table A-1. The on-Site pumping test K_r values in the main extraction corridor (south end of Site) range from 44 ft/day to 566 ft/day with an arithmetic average of 163 ft/day. In the larger area of the aquifer in which slug tests were conducted (mid to north end of Site), the K_r values ranged from 2 ft/day to 363 ft/day with the average value being 55 ft/day. A comparison of geologic logs from borings advanced in these two areas shows that the outwash sand in the southern portion of the site is significantly coarser and cleaner than in the northern portion which is consistent with the exhibited trends in hydraulic conductivity.

The distribution of horizontal hydraulic conductivity is presented in Figure 2-1. In order to derive a more representative value for horizontal hydraulic conductivity, a weighted average was computed. The area enclosed by each hydraulic conductivity contour line was measured, and assigned that contour value. A weighted average based on these areas was calculated using the following formula.

$$K_{ravg} = \frac{\sum_{i=1}^{i=n} KiAi}{\sum_{i=1}^{i=n} Ai} \qquad \text{(A1)}$$

where K_{ravg} is the weighted average horizontal hydraulic conductivity, Ki is the horizontal hydraulic conductivity that corresponds with area A_i, and n is the number of zones.

The data used in the weighted average are presented in Table A-2.

The weighted average horizontal hydraulic conductivity is 61 ft/day. It is notable that certain areas expected to have lower K_r values (outside the buried valleys and at the north end of the site) were not used in the weighted average computation. Therefore, this method for calculating the average K_r is conservative (produces a higher K_r value).

<u>Aquifer Thickness</u>

Aquifer thickness values were derived from the interpreted bottom of aquifer contour map presented as Figure 5 of the Aquifer Pumping Test report (Golder, 1991a) and the October 6 and 7, 1991 phreatic surface contour map presented as Figure 2-2 in this report. The aquifer thickness refers to the distance from the phreatic surface to the top of till or bedrock (bottom of aquifer). Aquifer thicknesses are summarized in Table A-3.

The calculation of the weighted average aquifer thickness was based on the area shown on Figure 2-5 in this report. Bedrock outcrops within this area were not included in the weighted average calculations.

A weighted average of the aquifer thickness was determined using the following formula:

$$b_{avg} = \frac{\sum_{i=1}^{I=n} biAi}{\sum_{i=1}^{i=n} Ai} \qquad \text{(A2)}$$

where b_{avg} is the weighted average saturated aquifer thickness and bi is the thickness corresponding to the area Ai.

The data used to compute the weighted average are presented in Table A-4. The weighted average saturated aquifer thickness is approximately 21 feet.

TABLE A-1

MEASURED HORIZONTAL
HYDRAULIC CONDUCTIVITUES

PUMPING TEST NEUMAN ANALYSIS (1)			SLUG TEST ANALYSIS		
WELL	Kr (FT/DAY)	Kr (CM/S)	WELL	Kr (FT/DAY)	Kr (CM/S)
P-1	129.03	4.55E-02	OW-21	7.46	2.63E-03
P-2	60.50	2.13E-02	OW-32	1.55	5.48E-04
P-3	68.67	2.42E-02	OW-31	16.84	5.94E-03
P-4	148.75	5.22E-02	OW-11	75.41	2.66E-02
P-6	565.58	1.99E-01	OW-36	69.74	2.46E-02
P-7	45.34	1.60E-02	OW-37	2.16	7.61E-04
P-8	175.06	6.17E-02	OW-38	19.59	6.91E-03
OW-12	193.49	6.82E-02	OW-39	5.10	1.80E-03
OW-48	43.80	1.54E-02	OW-40	114.25	4.03E-02
OW-49	135.88	4.79E-02	OW-41	53.30	1.88E-02
OW-50	230.66	8.13E-02	OW-13	37.99	1.34E-02
AVERAGE	163.34	5.76E-02	OW-18A	362.88	1.28E-01
			OW-17	28.35	1.00E-02
			OW-42	5.22	1.84E-03
			OW-14	57.83	2.04E-02
			OW-30A	80.80	2.85E-02
			OW-23	2.89	1.02E-03
			AVERAGE	55.37	1.95E-02

NOTE: AVERAGE OF THE HYDRAULIC CONDUCTIVITY VALUES ASSUMES THE BASE OF THE AQUIFER IS AT THE TOP OF BEDROCK/TILL

(1) THE AVERAGE SATURATED AQUIFER THICKNESS WAS ASSUMED TO BE 50 FEET

TABLE A-2
WEIGHTED AVERAGE HORIZONTAL
HYDRAULIC CONDUCTIVITIES

i	Ki (CM/S)	Ki (FT/D)	Ki*Ai	Ai (SQ.FT)
1	1.5E-01	425	21080000	49600
2	7.5E-02	212	43947600	207300
3	3.5E-02	99	130323600	1316400
4	1.5E-02	43	28994556	674292
5	7.5E-03	21	19315800	919800
6	3.0E-03	9	8347500	927500
7	5.0E-04	1.4	72100	51500

K AVERAGE 61 FT/DAY

TABLE A-3

MEASURED SATURATED AQUIFER THICKNESS

WELL/ PIEZO.	ELEV.OF GRD SUR. (FT.MSL)	M.P. ELEV. (FT)	DEPTH TO WATER 10/6-10/7/91 (FT)	W.L. ELEV. 10/6-10/7/91 (FT.MSL)	DEPTH TO BOTTOM O AQUIFER (FT)	ELEV. AT BOTTOM OF AQUIFER (FT.MSL)	SATURATED AQUIFER THICKNESS (FT)
E-5	64.00	65.52 *	8.60	56.92	52.60	11.40	45.52
P-1	64.40	65.04	8.22	56.82	52.00	12.40	44.42
P-2D	65.50	66.45	9.99	56.46	52.00	13.50	42.96
P-3D	66.00	66.25	9.25	57.00	48.00	18.00	39.00
P-4D	61.80	62.70	6.04	56.66	68.50	-6.70	63.36
OW-48	63.00	64.72	8.07	56.65	52.50	10.50	46.15
P-6	67.20	67.71	11.71	56.00	68.10	-0.90	56.90
P-7	61.90	62.65	5.22	57.43	48.00	13.90	43.53
P-8	64.40	64.49	9.48	55.01	50.00	14.40	40.61
OW-49	64.20	66.06	9.89	56.17	64.00	0.20	55.97
OW-12	62.66	63.74	7.68	56.06	48.50	14.16	41.90
OW-14	64.43	65.54	7.60	57.94	35.00	29.43	28.51
OW-18	62.45	62.76	9.07	53.69	48.00	14.45	39.24
OW-50	66.80	69.20 *	13.69	55.51	56.30	10.50	45.01
AVERAGE (1)							45.22
OW-1	79.43	80.32 *	7.90	72.42	13.00	66.43	5.99
OW-2	128.00	128.02	9.82	118.20	17.00	111.00	7.20
OW-3	72.00	74.76	7.30	67.46	8.00	64.00	3.46
OW-4	70.58	71.54	6.41	65.13	8.00	62.58	2.55
OW-10	63.83	68.14 *	8.89	59.25	25.00	38.83	20.42
OW-11	70.01	71.22	4.38	66.84	26.00	44.01	22.83
OW-13	64.99	64.99	4.45	60.54	25.00	39.99	20.55
OW-16	66.14	69.72 *	5.80	63.92	26.00	40.14	23.78
OW-21	73.75	76.28	5.20	71.08	30.00	43.75	27.33
OW-23	65.54	68.54	14.43	54.11	40.00	25.54	28.57
OW-22	78.54	81.76	10.17	71.59	40.00	38.54	33.05
OW-28	74.56	77.19	10.72	66.47	9.00	65.56	0.91
OW-30	63.10	65.6	12.46	53.14	68.00	-4.90	58.04
OW-31	71.30	74.35	4.26	70.09	14.00	57.30	12.79
OW-32	71.70	75.47	4.69	70.78	6.00	65.70	5.08
OW-36	72.70	74.86	4.99	69.87	15.00	57.70	12.17
OW-37	69.30	72.6	5.30	67.30	29.50	39.80	27.50
OW-38	69.80	71.85 *	7.52	64.33	33.50	36.30	28.03
OW-39	71.80	74.14 *	9.97	64.17	28.00	43.80	20.37
OW-40	68.70	71.64	12.30	59.34	27.50	41.20	18.14
OW-41	67.50	66.95	7.62	59.33	27.00	40.50	18.83
OW-43	74.60	76.17	7.49	68.68	17.00	57.60	11.08
OW-44	69.30	70.84	2.61	68.23	17.00	52.30	15.93
OW-45	69.40	70.84	4.91	65.93	7.20	62.20	3.73
OW-47	67.80	69.23	10.17	59.06	14.00	53.80	5.26
AVERAGE (2)							27.35

NOTES:

M.P. refers to measuring point.
W.L. refers to water level
*Measuring point is top of outer casing
Water level measurements 10/6/91 through 10/7/91
Average (1) refers to wells in the vicinity of E5
Average (2) refers to all wells

TABLE A-4
WEIGHTED AVERAGE OF
SATURATED AQUIFER THICKNESS

REGION DESIGNATION	Bi (FT)	Bi*Ai	Ai (SQ.FT)
1	65.00	4472000	68800
2	55.00	13299000	241800
3	45.00	40122000	891600
4	35.00	39228000	1120800
5	25.00	42692500	1707700
6	15.00	33537000	2235800
7	5.00	12609500	2521900
SUM		185960000	8788400
WEIGHTED AVERAGE OF THICKNESS (FT)			21.16

NOTES: Bi-THICKNESS OF DESIGNATED REGION
Ai-MEASURED AREA OF DESIGNATED REGION

APPENDIX 2-B

Calculation of Drawdowns Using Neumans Method

APPENDIX 2-B

Calculation of Drawdowns Using Neumans Method

Drawdowns were simulated for pumping extraction well E-5 at rates of 120 gpm and 50 gpm with varying transmissivities. A pumping period of 90 days was used to characterize the aquifer response. The drawdown at arbitrary distances from the pumping well was calculated using the following equation (Neuman, 1975, Page 331, Eq. (13a)):

$$s = \frac{2.303Q}{4\pi T} \log \frac{2.246\ Tt}{S_y r^2} \qquad \text{(B1)}$$

where,

s: drawdown (L);

Q: pumping rate (L^3/T);

T: transmissivity (L^2/T);

t: time (T);

Sy: specific yield (dimensionless);

r: radial distance from the pumping well (L)

Equation (B1) is the solution to the straight line (drawdown versus log time) onto which, according to Jacob (1950), late drawdown data tend to fall.

The drawdown values at various radial distances from E-5 computed from Eq. (B1) are presented numerically in Table B-1 and graphically in Figure 2-4. The first transmissivity (7,423 ft^2/day) is the arithmetic average of the transmissivity values along the main extraction corridor (Golder 1991b). This area represents a small portion of the aquifer being considered. The second transmissivity (1,281 ft^2/day) is based on the weighted average hydraulic conductivity (61 ft/day) and the weighted average saturated thickness (21 feet).

TABLE B-1
CALCULATED DISTANCE VERSUS DRAWDOWN

Q (Cu.FT/DAY 50 gpm	Q (Cu.FT/DAY 120 gpm	T1 (SqFT/DAY)	T2 (SqFT/DAY)	Sy	t (90 DAYS)	r (FEET)	S1 (FT) (90 DAYS) 120 gpm	S1 (FT) (90 DAYS) 50 gpm	S2 (FT) (90 DAYS) 120 gpm	S2 (FT) (90 DAYS) 50 gpm
9625	23099	7423	1281	1.20E-02	90	1	-4.62	-1.92	-24.24	-10.10
9625	23099	7423	1281	1.20E-02	90	10	-3.48	-1.45	-17.63	-7.34
9625	23099	7423	1281	1.20E-02	90	20	-3.13	-1.31	-15.64	-6.52
9625	23099	7423	1281	1.20E-02	90	30	-2.93	-1.22	-14.47	-6.03
9625	23099	7423	1281	1.20E-02	90	40	-2.79	-1.16	-13.65	-5.69
9625	23099	7423	1281	1.20E-02	90	50	-2.68	-1.12	-13.01	-5.42
9625	23099	7423	1281	1.20E-02	90	60	-2.59	-1.08	-12.48	-5.20
9625	23099	7423	1281	1.20E-02	90	70	-2.51	-1.05	-12.04	-5.02
9625	23099	7423	1281	1.20E-02	90	80	-2.45	-1.02	-11.66	-4.86
9625	23099	7423	1281	1.20E-02	90	90	-2.39	-1.00	-11.32	-4.72
9625	23099	7423	1281	1.20E-02	90	100	-2.34	-0.97	-11.02	-4.59
9625	23099	7423	1281	1.20E-02	90	110	-2.29	-0.95	-10.74	-4.48
9625	23099	7423	1281	1.20E-02	90	120	-2.25	-0.94	-10.49	-4.37
9625	23099	7423	1281	1.20E-02	90	130	-2.21	-0.92	-10.26	-4.28
9625	23099	7423	1281	1.20E-02	90	140	-2.17	-0.90	-10.05	-4.19
9625	23099	7423	1281	1.20E-02	90	150	-2.14	-0.89	-9.85	-4.11
9625	23099	7423	1281	1.20E-02	90	160	-2.10	-0.88	-9.67	-4.03
9625	23099	7423	1281	1.20E-02	90	170	-2.07	-0.86	-9.49	-3.96
9625	23099	7423	1281	1.20E-02	90	180	-2.05	-0.85	-9.33	-3.89
9625	23099	7423	1281	1.20E-02	90	190	-2.02	-0.84	-9.18	-3.82
9625	23099	7423	1281	1.20E-02	90	200	-1.99	-0.83	-9.03	-3.76
9625	23099	7423	1281	1.20E-02	90	210	-1.97	-0.82	-8.89	-3.70
9625	23099	7423	1281	1.20E-02	90	220	-1.95	-0.81	-8.75	-3.65
9625	23099	7423	1281	1.20E-02	90	230	-1.92	-0.80	-8.63	-3.59
9625	23099	7423	1281	1.20E-02	90	240	-1.90	-0.79	-8.50	-3.54
9625	23099	7423	1281	1.20E-02	90	250	-1.88	-0.78	-8.39	-3.50
9625	23099	7423	1281	1.20E-02	90	260	-1.86	-0.78	-8.28	-3.45
9625	23099	7423	1281	1.20E-02	90	360	-1.70	-0.71	-7.34	-3.06
9625	23099	7423	1281	1.20E-02	90	460	-1.58	-0.66	-6.64	-2.77
9625	23099	7423	1281	1.20E-02	90	560	-1.48	-0.62	-6.07	-2.53
9625	23099	7423	1281	1.20E-02	90	660	-1.40	-0.58	-5.60	-2.33
9625	23099	7423	1281	1.20E-02	90	760	-1.33	-0.55	-5.20	-2.17
9625	23099	7423	1281	1.20E-02	90	860	-1.27	-0.53	-4.84	-2.02
9625	23099	7423	1281	1.20E-02	90	960	-1.22	-0.51	-4.53	-1.89
9625	23099	7423	1281	1.20E-02	90	1060	-1.17	-0.49	-4.24	-1.77
9625	23099	7423	1281	1.20E-02	90	1160	-1.12	-0.47	-3.98	-1.66
9625	23099	7423	1281	1.20E-02	90	1260	-1.08	-0.45	-3.75	-1.56
9625	23099	7423	1281	1.20E-02	90	1360	-1.04	-0.43	-3.53	-1.47
9625	23099	7423	1281	1.20E-02	90	1460	-1.01	-0.42	-3.32	-1.38
9625	23099	7423	1281	1.20E-02	90	1560	-0.98	-0.41	-3.13	-1.31
9625	23099	7423	1281	1.20E-02	90	1660	-0.94	-0.39	-2.95	-1.23
9625	23099	7423	1281	1.20E-02	90	1760	-0.92	-0.38	-2.79	-1.16
9625	23099	7423	1281	1.20E-02	90	1860	-0.89	-0.37	-2.63	-1.09
9625	23099	7423	1281	1.20E-02	90	1960	-0.86	-0.36	-2.48	-1.03
9625	23099	7423	1281	1.20E-02	90	2060	-0.84	-0.35	-2.33	-0.97
9625	23099	7423	1281	1.20E-02	90	2160	-0.81	-0.34	-2.20	-0.92
9625	23099	7423	1281	1.20E-02	90	2260	-0.79	-0.33	-2.07	-0.86

NOTES:
1. Q=PUMPING RATE (CU. FEET PER DAY)
2. T=TRANSMISSIVITY (SQ. FEET PER DAY)
3. Sy=SPECIFIC YIELD
4. r=RADIAL DISTANCE FROM PUMPING WELL (FEET)
5. t= DURATION OF PUMPING PERIOD (DAYS)
6. S=DRAWDOWN (FEET)
7. GPD/FT=GALLONS PER DAY PER FOOT

TABLE B-1 (CONT.)
CALCULATED DISTANCE VERSUS DRAWDOWN

Q (Cu.FT/DAY 50 gpm	Q (Cu.FT/DAY 120 gpm	T1 (SqFT/DAY)	T2 (SqFT/DAY)	Sy	t (90 DAYS)	r (FEET)	S1 (FT) (90 DAYS) 120 gpm	S1 (FT) (90 DAYS) 50 gpm	S2 (FT) (90 DAYS) 120 gpm	S2 (FT) (90 DAYS) 50 gpm
9625	23099	7423	1281	1.20E-02	90	2360	-0.77	-0.32	-1.94	-0.81
9625	23099	7423	1281	1.20E-02	90	2460	-0.75	-0.31	-1.82	-0.76
9625	23099	7423	1281	1.20E-02	90	2660	-0.71	-0.30	-1.60	-0.67
9625	23099	7423	1281	1.20E-02	90	2860	-0.68	-0.28	-1.39	-0.58
9625	23099	7423	1281	1.20E-02	90	3060	-0.64	-0.27	-1.20	-0.50
9625	23099	7423	1281	1.20E-02	90	3260	-0.61	-0.25	-1.02	-0.42
9625	23099	7423	1281	1.20E-02	90	3460	-0.58	-0.24	-0.85	-0.35
9625	23099	7423	1281	1.20E-02	90	3660	-0.55	-0.23	-0.68	-0.29
9625	23099	7423	1281	1.20E-02	90	3860	-0.53	-0.22	-0.53	-0.22
9625	23099	7423	1281	1.20E-02	90	4060	-0.50	-0.21	-0.39	-0.16
9625	23099	7423	1281	1.20E-02	90	4260	-0.48	-0.20	-0.25	-0.10
9625	23099	7423	1281	1.20E-02	90	4460	-0.46	-0.19	-0.12	-0.05
9625	23099	7423	1281	1.20E-02	90	4650	-0.43	-0.18	0.00	0.00
9625	23099	7423	1281	1.20E-02	90	4660	-0.43	-0.18	NA	NA
9625	23099	7423	1281	1.20E-02	90	4860	-0.41	-0.17	NA	NA
9625	23099	7423	1281	1.20E-02	90	5060	-0.39	-0.16	NA	NA
9625	23099	7423	1281	1.20E-02	90	5260	-0.37	-0.16	NA	NA
9625	23099	7423	1281	1.20E-02	90	5460	-0.36	-0.15	NA	NA
9625	23099	7423	1281	1.20E-02	90	5660	-0.34	-0.14	NA	NA
9625	23099	7423	1281	1.20E-02	90	5860	-0.32	-0.13	NA	NA
9625	23099	7423	1281	1.20E-02	90	6060	-0.30	-0.13	NA	NA
9625	23099	7423	1281	1.20E-02	90	6260	-0.29	-0.12	NA	NA
9625	23099	7423	1281	1.20E-02	90	6460	-0.27	-0.11	NA	NA
9625	23099	7423	1281	1.20E-02	90	6660	-0.26	-0.11	NA	NA
9625	23099	7423	1281	1.20E-02	90	6860	-0.24	-0.10	NA	NA
9625	23099	7423	1281	1.20E-02	90	7060	-0.23	-0.09	NA	NA
9625	23099	7423	1281	1.20E-02	90	7260	-0.21	-0.09	NA	NA
9625	23099	7423	1281	1.20E-02	90	7460	-0.20	-0.08	NA	NA
9625	23099	7423	1281	1.20E-02	90	7660	-0.19	-0.08	NA	NA
9625	23099	7423	1281	1.20E-02	90	7860	-0.17	-0.07	NA	NA
9625	23099	7423	1281	1.20E-02	90	8060	-0.16	-0.07	NA	NA
9625	23099	7423	1281	1.20E-02	90	8260	-0.15	-0.06	NA	NA
9625	23099	7423	1281	1.20E-02	90	8460	-0.14	-0.06	NA	NA
9625	23099	7423	1281	1.20E-02	90	8660	-0.13	-0.05	NA	NA
9625	23099	7423	1281	1.20E-02	90	8860	-0.12	-0.05	NA	NA
9625	23099	7423	1281	1.20E-02	90	9060	-0.10	-0.04	NA	NA
9625	23099	7423	1281	1.20E-02	90	9260	-0.09	-0.04	NA	NA
9625	23099	7423	1281	1.20E-02	90	9460	-0.08	-0.03	NA	NA
9625	23099	7423	1281	1.20E-02	90	9660	-0.07	-0.03	NA	NA
9625	23099	7423	1281	1.20E-02	90	9860	-0.06	-0.03	NA	NA
9625	23099	7423	1281	1.20E-02	90	10060	-0.05	-0.02	NA	NA
9625	23099	7423	1281	1.20E-02	90	10260	-0.04	-0.02	NA	NA
9625	23099	7423	1281	1.20E-02	90	10460	-0.03	-0.01	NA	NA
9625	23099	7423	1281	1.20E-02	90	10660	-0.02	-0.01	NA	NA
9625	23099	7423	1281	1.20E-02	90	10860	-0.01	-0.01	NA	NA
9625	23099	7423	1281	1.20E-02	90	11060	-0.01	0.00	NA	NA
9625	23099	7423	1281	1.20E-02	90	11260	0.00	NA	NA	NA

NOTES:
1. Q=PUMPING RATE (CU. FEET PER DAY)
2. T=TRANSMISSIVITY (SQ. FEET PER DAY)
3. Sy=SPECIFIC YIELD
4. r=RADIAL DISTANCE FROM PUMPING WELL (FEET)
5. t= DURATION OF PUMPING PERIOD (DAYS)
6. S=DRAWDOWN (FEET)
7. GPD/FT=GALLONS PER DAY PER FOOT

CHAPTER 3

GROUNDWATER TREATABILITY - PHASE II

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CHAPTER 3

GROUNDWATER TREATABILITY - PHASE II

3.1 INTRODUCTION

3.1.1 Background Information

The original scope of the pilot-scale groundwater treatability study was completed by October 22, 1991. An evaluation of an anoxic Fluidized Bed Reactor (FBR) was conducted in order to optimize the treatment process which included an aerobic FBR followed by metals precipitation. The anoxic FBR test commenced on October 23.

3.1.2 Technical Approach

The primary constituents of concern in the groundwater included odors, toluene, benzene, arsenic, chromium, and ammonia. The aerobic FBR pilot-scale treatment system, followed by metals precipitation, was capable of treating all of these parameters. However, alkalinity addition was necessary to maintain pH control upon nitrification of the ammonia to nitrate. Anoxic biological conversion of the nitrate allows recovery of one-half of the alkalinity used for nitrification, thus minimizing chemical additions.

Groundwater feed samples and biological effluent samples were collected and analyzed for all appropriate parameters including conventional parameters such as nitrate and nitrite, and Target Compound List (TCL) constituents. Details of the sampling procedures and protocols were provided in the November 26, 1991, Groundwater Treatability Study report prepared by **ADVENT** (1991).

3.1.3 Treatment Objectives

The overall objective of the anoxic FBR evaluation was to optimize the treatment process with regard to chemical additions. Specifically, the objective included:

1. Obtain representative blend of groundwater for use in the testing.
2. Develop a treatment performance profile of the biological systems.
3. Develop operational and design parameters for the anoxic FBR system.

3.2 GROUNDWATER COLLECTION TECHNIQUES

Groundwater collection was discussed in detail by **ADVENT** (1991). In summary, a composite groundwater sample consisting of a flow-proportioned mixture of water collected from previously installed observation wells, both at the periphery of and more central to the plumes, was used to formulate the feed to the treatment system. The flows from each well were in proportion to those expected in the full-scale system. The feed was stored in a vented recirculating tank and sufficient phosphorus nutrient and sodium bicarbonate alkalinity were added to promote nitrification.

Composite groundwater characteristics were discussed in detail by **ADVENT** (1991). Groundwater characteristics during the anoxic FBR study were similar to those previously reported. Detailed results are provided in Appendix 3-A, and result discussion will be incorporated into the discussion of treatability results.

3.3 TREATABILITY TESTING AND ANALYTICAL METHODOLOGIES

3.3.1 Test Equipment and Material

A detailed description of the aerobic FBR treatment system was provided by **ADVENT** (1991). The anoxic FBR (2.5 gpm fluidization flow) consisted of a 6-inch diameter PVC column with pumps and supporting equipment. The reactor contained the biomass and growth media (approximately 8-foot bed depth). Sand was used as the growth media. Bed fluidization was accomplished by recycling the required water flow. The forward flow was determined by the nitrate loading.

3.3.2 Treatability Testing Methods

The anoxic FBR treatability system configuration is presented in Figure 3-1. The anoxic FBR was operated as the lead column in the treatment system train, except that the column was sized to treat one-third of the nitrate present in the FBR effluent.

Nitrate conversion is accomplished by anoxic microorganisms which use the nitrate in the water as an oxygen source, in the presence of low (<0.2 mg/L) dissolved oxygen, to degrade organics (food source). In this case, the nitrate generated in the aerobic FBR was recycled back to the anoxic FBR and organics in the groundwater were used as a food source for the anoxic microorganisms. The organics present in the groundwater did not provide a sufficient Biochemical Oxygen Demand (BOD) for the desired nitrate removal, so methanol was added to provide an additional food source. In the full-scale system, the anoxic FBR column will receive all of the forward flow. No oxygen was added to the system. Peristaltic pumps were used to supply the groundwater and aerobic FBR recirculation flows to the anoxic system. Aerobic FBR operations were continued, as described by **ADVENT** (1991).

The anoxic FBR was seeded with microorganisms obtained from the Reno Sparks Wastewater Treatment Plant near Reno, Nevada, and supplemented with acclimated activated sludge from the treatability study. The unit was operated with recycle only on October 23, and forward flow was initiated on October 24. The unit was monitored daily for flow rates, temperature, dissolved oxygen, pH and conductivity.

pH control was not necessary. Methanol (20 percent solution) was added at a rate of 4.8 liters per day.

The analytical schedule for the anoxic FBR evaluation is presented in Table 3-1. Conventional parameter analyses were performed on a routine basis to assess system operations, and TCL analyses were performed at the conclusion of the study.

3.3.3 Analytical Methods

The analytical methods used, sampling containers, QA/QC samples, etc., were provided by **ADVENT** (1991). The analyses during the anoxic FBR evaluation were carried out in the same manner as described by **ADVENT** (1991). Routine analyses were performed both on-site and at **ADVENT**'s laboratory in Brentwood, Tennessee. TCL analyses were performed at Gulf South Environmental Labs of New Orleans, Louisiana.

3.4 TREATABILITY TESTING RESULTS

3.4.1 Overview

The anoxic FBR evaluation was performed on-site in Woburn from October 23 to November 6, 1991. Acclimated microorganisms from the treatability study, and sand media with anoxic microorganisms from the Reno Sparks Wastewater Treatment Plant were used to seed the column. Anoxic nitrate conversion began within one to two days of startup, as indicated by nitrogen gas evolution from the column. Cold weather conditions were tested.

Average treatment system results are provided in Table 3-2. TCL samples were collected at the conclusion of the study. A summary of TCL results is presented in Tables 3-3 and 3-4. Detailed chronological and TCL results are presented in Appendices 3-A and 3-B, respectively. By November 6, all operational objectives had been attained.

3.4.2 Treatment Results

The anoxic FBR evaluation consisted of two different periods as discussed below:

1. Startup October 23 to 28
2. Stabilized Performance October 29 to November 6

During the startup, the aerobic FBR was shutdown so that power connections could be made, water flows rerouted, etc., resulting in a temporary reduction in nitrification efficiency. By October 29, nitrification was reestablished and effluent ammonia levels remained below 5 mg/L for the remainder of the study.

3.4.2.1 Operating Parameters (pH/Titration Curves, Oxygen Uptake, and Temperature)

The groundwater pH averaged 7.6. The aerobic FBR pH was controlled at 7.0 by adding an average of 3.3 liters per day of 26 percent caustic. The anoxic FBR pH averaged 8.1, and the pH/alkalinity increase resulted in the reduced caustic usage given above. During the treatability study, the 26 percent caustic usage averaged 7.7 liters per day from October 5 to 22. Titration curves for composite groundwater before and after nutrient addition, anoxic and aerobic FBR effluents are presented in Figure 3-2.

Chronological temperature results are presented in Figure 3-3. The feed temperature averaged 14 ^{o}C from October 29 to November 6. Due to colder ambient conditions (average temperature of 13 ^{o}C), it was not necessary to cool the feed to 9 ^{o}C in order to obtain an average aerobic FBR column temperature of 20 ^{o}C and anoxic FBR column temperature of 19 ^{o}C. These conditions paralleled expected indoor winter operations.

The aerobic FBR Oxygen Uptake Rate (OUR) averaged 20 mg/L at a 0.3 gpm overall forward rate. This was identical to the average OUR at this flow rate observed during the treatability study.

3.4.2.2 Conventional Parameter Organics

The influent BOD averaged 31 mg/L. Anoxic FBR effluent BOD averaged 270 mg/L, while the average aerobic FBR effluent BOD was 12 mg/L. The increased anoxic FBR effluent BOD resulted from incomplete oxidation of the methanol added to the anoxic system. In the full-scale system, it will be possible to control the methanol feed rate to the amount necessary to attain the desired anoxic nitrate conversion, and the aerobic FBR, which will follow the anoxic FBR, will be capable of removing any excess methanol to maintain required effluent BOD levels.

The influent Chemical Oxygen Demand (COD) concentration averaged 315 mg/L. The mean anoxic FBR effluent COD was 605 mg/L, again with the increase due to the methanol additions. As discussed by **ADVENT** (1991), aerobic FBR effluent COD analyses were subject to a positive interference, and no average was computed. The average influent Total Organic Carbon (TOC) concentration was 50 mg/L. The anoxic and aerobic FBR effluent TOC concentrations averaged 103 mg/L and 21 mg/L, respectively.

3.4.2.3 Nutrient Parameters

The average influent Total Kjeldahl Nitrogen (TKN) concentration was 514 mg/L. The mean anoxic FBR effluent TKN concentration was 196 mg/L. FBR effluent TKN averaged 16 mg/L.

Chronological ammonia results are presented in Figure 3-4. The influent ammonia concentration was stable throughout the operating period, and averaged 404 mg/L according to the field Hach method and 323 mg/L according to the distillation test method. Following the aerobic FBR nitrification reestablishment by October 29, the anoxic FBR effluent ammonia averaged 165 mg/L according to the field method and 112 mg/L according to the distillation method. The mean aerobic FBR effluent ammonia levels were 2 mg/L according to the Hach method and 1 mg/L according to the distillation method.

Chronological nitrate and nitrite results are presented in Figure 3-5. The anoxic FBR was capable of complete nitrate/nitrite conversion. Effluent nitrate and nitrite levels averaged <1 mg/L and 1 mg/L, respectively. The aerobic FBR nitrate and nitrite concentrations averaged 64 and 241 mg/L, respectively.

The influent phosphate averaged 5.9 mg/L. The anoxic column had no residual phosphate due to the methanol (BOD) additions and removal. The aerobic FBR effluent phosphate averaged 5.8 mg/L.

3.4.2.4 Solids

The average influent Total Suspended Solids (TSS) and Volatile Suspended Solids (VSS) were 75 mg/L and 14 mg/L, respectively. Anoxic FBR effluent TSS and VSS concentrations were 59 mg/L and 31 mg/L, respectively. The mean aerobic FBR effluent values were 66 mg/L TSS and 34 mg/L VSS.

The influent Total Dissolved Solids (TDS) and Total Dissolved Inorganic Solids (TDIS) concentrations averaged 3,415 mg/L and 3,030 mg/L, respectively. The aerobic FBR effluent TDS and TDIS concentrations averaged 5,600 mg/L and 4,628 mg/L, respectively. These concentrations represented a significant reduction, as compared to those levels observed during the treatability study of 7,074 mg/L and 5,648 mg/L, respectively. Thus, removing one-third of the nitrate/nitrite anoxically allowed a 21 percent reduction in aerobic FBR effluent TDS, due to the alkalinity recovery.

3.4.2.5 Alkalinity

Average alkalinity concentrations were 2,150 mg/L for the influent, 2,200 mg/L for the anoxic FBR effluent, and 1,770 mg/L for the aerobic FBR effluent. These are all reported in mg/L as calcium carbonate.

3.4.2.6 Benzene and Toluene

The composite groundwater analyzed by headspace Gas Chromatography (GC headspace) benzene and toluene concentrations averaged 0.311 mg/L and 0.118 mg/L, respectively. Average anoxic FBR effluent benzene and toluene concentrations were 0.067 and <0.010 mg/L, respectively. Benzene and toluene were not detected above the 0.010 mg/L GC headspace detection limit in the aerobic FBR effluent.

3.4.2.7 TCL Results

Upon completion of the anoxic FBR evaluation, influent and effluent samples were collected for TCL analyses. Volatile TCL results are summarized in Table 3-3. Benzene and toluene were detected at 0.700 mg/L and 0.230 mg/L, respectively, in the influent. The benzene concentration was higher than previously detected, previous maximum of 0.499 mg/L by GC headspace. The previous high for toluene was 0.245 mg/L. GC headspace analyses was not performed on these samples. Given the variability of results during the treatability study, the concentrations were considered within range of expected values. These compounds were not detected in the anoxic nor aerobic FBR effluents. Acetone and xylene (total) were also detected in the influent at 0.090 mg/L and 0.013 mg/L, respectively. Acetone was detected at 0.012 mg/L in the aerobic FBR effluent, and was not detected in the anoxic FBR effluent. Xylene was not detected in the anoxic nor aerobic FBR effluents. Acetone is a common laboratory solvent, and acetone as high as 0.027 mg/L was detected in previous trip and method blanks. Acetone was not detected in any of the blanks associated with these samples.

Semi-volatile TCL results are summarized in Table 3-4. Phenol and 4-Methylphenol were the only compounds detected in the influent at 0.011 and 0.013 mg/L, respectively. No semi-volatile compounds were detected in the anoxic nor FBR effluents.

3.4.2.8 Metals Results

Arsenic and iron analyses were performed twice per week. The average results in Table 3-2 show arsenic of 0.188 mg/L in the influent, 0.171 mg/L in the aerobic FBR effluent, and 0.147 mg/L in the anoxic FBR effluent. Iron analyses averaged 27.3 mg/L in the influent, 17.9 mg/L in the aerobic FBR effluent, and 7.1 mg/L in the anoxic FBR effluent. Thus, it appeared that the anoxic microorganisms were capable of absorbing iron.

Jar tests were subsequently performed to evaluate the potential impact of this absorption on metals precipitation. Jar test results are presented in Table 3-5. Total and soluble samples were analyzed for metals on influent and aerobic and anoxic FBR effluents. Jar tests were performed at pH 9.0 using caustic for pH adjustment and ferric doses of 0, 150, 250, 500, and 800 mg/L. There was virtually no difference observed in the metals removal at the various ferric doses. There were slightly higher arsenic concentrations in the anoxic FBR jar tests, but a higher concentration was measured on the anoxic FBR sample used for the testing. Metals precipitation results for the FBR effluent were similar to those obtained during the treatability study. It was concluded that the anoxic FBR had no significant impact on metals removal.

3.4.3 Summary and Conclusions

Anoxic biological conversion of nitrate allows recovery of one-half of the alkalinity used for nitrification, thus minimizing chemical additions.

The pilot-scale anoxic FBR proved to be operable and capable of organics, nitrate, and nitrite removal. A summary of influent and effluent concentrations and system percent removals for the constituents of concern is provided in Table 3-6. Anoxic biological conversion of the nitrate and nitrite was rapidly established and was maintained throughout the operating period. The system was operated under winter conditions. Metals precipitation was not significantly impacted by the inclusion of the anoxic process.

Sufficient information was obtained to allow detailed engineering design of the full-scale system to proceed. A summary of design inputs is presented in Table 3-7.

REFERENCES

The **ADVENT** Group, Inc., 1991. Groundwater Treatability Study, Industri-Plex Site, Woburn, MA, November.

TABLE 3–1. ANALYTICAL SCHEDULE FOR ANOXIC FBR TEST

PARAMETER	COMPOSITE GROUNDWATER FREQUENCY /WEEK	ANOXIC FBR EFFLUENT FREQUENCY /WEEK	AEROBIC FBR EFFLUENT FREQUENCY /WEEK	TOTAL SAMPLES FREQUENCY /WEEK
Total TOC	2	1	1	4
Soluble TOC	1	3	3	7
Total COD	2	1	1	4
Soluble COD	0	3	3	6
Total BOD	1	1	1	3
Soluble BOD	1	1	1	3
TSS	3	3	3	9
VSS	3	3	3	9
TDS	1	1	1	3
TDIS	1	1	1	3
Total TKN	1	0	0	1
Soluble TKN	0	1	1	2
Soluble NH3–N	(a) 7/1	(a) 7/3	(a) 7/3	(a) 21/7
Soluble NO2–N	0	3	3	6
Soluble NO3–N	0	3	3	6
PO4–P	1	1	1	3
Alkalinity	1	1	1	3
Total Arsenic	2	2	2	6
Filtered Arsenic	2	2	2	6
Total Iron	2	2	2	6
Filtered Iron	2	2	2	6
Benzene	2	2	2	6
Toluene	2	2	2	6

(a) Schedule given for on/off–site analysis.

TABLE 3-2. AVERAGE TREATMENT SYSTEM EFFLUENT RESULTS (a)

PARAMETER	COMPOSITE GOUNDWATER CONC. (mg/L)	ANOXIC FBR EFFLUENT CONC. (mg/L)	AEROBIC FBR EFFLUENT CONC. (mg/L)
pH, s.u.	7.6	8.1	7.0
BOD, mg/L (b)	31	270	12
TOC, mg/L	50	103	21
TKN, mg/L	514	196	16
Hach NH3-N, mg/L	404	165	2
Distilled NH3-N, mg/L	323	112	1
NO3-N, mg/L	NA	<1	64
NO2-N, mg/L	NA	1	241
PO4-P, mg/L	5.9	0.0	5.8
Alkalinity, mg/L CaCO3	2,150	2,200	1,770
TSS, mg/L	75	59	66
VSS, mg/L	14	31	34
TDS, mg/L	3,415	4,583	5,600
TDIS, mg/L	3,030	4,210	4,628
Conductivity, umhos/cm	5,400	5,655	6,133
Arsenic, mg/L (c)	0.188	0.147	0.171
Iron, mg/L (c)	27.3	7.1	17.9
GC Benzene, mg/L	0.311	0.067	<0.010
GC Toluene, mg/L	0.118	<0.010	<0.010

(a) Averages computed from October 29 to November 6 (stabilized performance).
(b) Total BOD reported for influent, soluble BOD reported for effluent.
(c) These concentrations are upstream of metals removal system.

TABLE 3-3. SUMMARY OF VOLATILE ORGANIC COMPOUND TCL RESULTS

COMPOUND	COMPOSITE GROUNDWATER CONC. (mg/L) (a)	ANOXIC FBR EFFLUENT CONC. (mg/L)	AEROBIC FBR EFFLUENT CONC. (mg/L)
Chloromethane	ND	ND	ND
Bromomethane	ND	ND	ND
Vinyl Chloride	ND	ND	ND
Chloroethane	ND	ND	ND
Methylene Chloride	ND	ND	ND
Acetone	0.090	ND	0.012
Carbon Disulfide	ND	ND	ND
1,1-Dichloroethene	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND
1,2-Dichloroethene (total)	ND	ND	ND
Chloroform	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND
2-Butanone	ND	ND	ND
1,l,1 -Trichloroethane	ND	ND	ND
Carbon Tetrachloride	ND	ND	ND
Vinyl Acetate	ND	ND	ND
Bromodichloromethane	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND
trans-1,3-Dichloropropene	ND	ND	ND
Trichloroethene	ND	ND	ND
Dibromochloromethane	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND
Benzene	0.700	ND	ND
cis-1,3-Dichloropropene	ND	ND	ND
Bromoform	ND	ND	ND
4-Methyl-2-Pentanone	ND	ND	ND
2-Hexanone	ND	ND	ND
Tetrachloroethene	ND	ND	ND
Toluene	0.230	ND	ND
Chlorobenzene	ND	ND	ND
Ethylbenzene	ND	ND	ND
Styrene	ND	ND	ND
Xylene (total)	0.013	ND	ND

(a) Only results above the detection limit and concentrations above trip or method blank values are reported as other than "ND" - Not Detected in this Table.

TABLE 3-4. SUMMARY OF SEMI-VOLATILE COMPOUND TCL RESULTS

COMPOUND	COMPOSITE GROUNDWATER CONC. (mg/L) (a)	ANOXIC FBR EFFLUENT CONC. (mg/L)	AEROBIC FBR EFFLUENT CONC. (mg/L)
Phenol	0.011	ND	ND
bis(2-Chloroethyl)ether	ND	ND	ND
2-Chlorophenol	ND	ND	ND
1,3-Dichlorobenzene	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND
Benzyl alcohol	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND
2-Methylphenol	ND	ND	ND
bis(2-chloroisopropyl)ether	ND	ND	ND
4-Methylphenol	0.013	ND	ND
N-Nitroso-di-n-propylamine	ND	ND	ND
Hexachloroethane	ND	ND	ND
Nitrobenzene	ND	ND	ND
Isophorone	ND	ND	ND
2-Nitrophenol	ND	ND	ND
2,4-Dimethylphenol	ND	ND	ND
Benzoic acid	ND	ND	ND
bis(2-Chloroethoxy)methane	ND	ND	ND
2,4-Dichlorophenol	ND	ND	ND
1,2,4-Trichlorobenzene	ND	ND	ND
Naphthalene	ND	ND	ND
4-Chloroaniline	ND	ND	ND
Hexachlorobutadiene	ND	ND	ND
4-Chloro-3-methylphenol	ND	ND	ND
2-Methylnaphthalene	ND	ND	ND
Hexachlorocyclopentadiene	ND	ND	ND
2,4,6-Trichlorophenol	ND	ND	ND
2,4,5-Trichlorophenol	ND	ND	ND
2-Chloronaphthalene	ND	ND	ND
2-Nitroaniline	ND	ND	ND
Dimethylphthalate	ND	ND	ND
Acenaphthylene	ND	ND	ND
2,6-Dinitrotoluene	ND	ND	ND
3-Nitroaniline	ND	ND	ND
Acenaphthene	ND	ND	ND
2,4-Dinitrophenol	ND	ND	ND
4-Nitrophenol	ND	ND	ND

TABLE 3-4. SUMMARY OF SEMI-VOLATILE COMPOUND TCL RESULTS (Continued)

COMPOUND	COMPOSITE GROUNDWATER CONC. (mg/L) (a)	ANOXIC FBR EFFLUENT CONC. (mg/L)	AEROBIC FBR EFFLUENT CONC. (mg/L)
Dibenzofuran	ND	ND	ND
2,4-Dinitrotoluene	ND	ND	ND
Diethylphthalate	ND	ND	ND
4-Chlorophenyl-phenylether	ND	ND	ND
Fluorene	ND	ND	ND
4-Nitroaniline	ND	ND	ND
4,6-Dinitro-2-methylphenol	ND	ND	ND
N-Nitrosodiphenylamine	ND	ND	ND
4-Bromophenyl-phenylether	ND	ND	ND
Hexachlorobenzene	ND	ND	ND
Pentachlorophenol	ND	ND	ND
Phenanthrene	ND	ND	ND
Anthracene	ND	ND	ND
Di-n-butylphthalate	ND	ND	ND
Fluoranthene	ND	ND	ND
Pyrene	ND	ND	ND
Butylbenzylphthalate	ND	ND	ND
3,3-Dichlorobenzidine	ND	ND	ND
Benzo(a)anthracene	ND	ND	ND
Chrysene	ND	ND	ND
bis(2-Ethylhexyl)phthalate	ND	ND	ND
Di-n-Octylphthalate	ND	ND	ND
Benzo(b)fluoranthene	ND	ND	ND
Benzo(k)fluoranthene	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND
Indeno(1,2,3-cd)pyrene	ND	ND	ND
Dibenz(a,h)anthracene	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	ND

(a) Only results above the detection limit and concentrations above trip or method blank values are reported as other than "ND" - Not Detected in this Table.

TABLE 3-5. METALS REMOVAL JAR TEST RESULTS

SAMPLE (a)	As (mg/L)	Cd (mg/L)	Cr (mg/L)	Cr+6 (mg/L)	Fe (mg/L)	Pb (mg/L)	Zn (mg/L)	Be (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Ag (mg/L)
AEROBIC FBR INF TOTAL	0.135	0.008	0.053	0.02	7.00	0.006	4.25	<0.005	0.076	0.007	0.089	0.360	<0.010
AEROBIC FBR INF SOLUBLE	0.072	0.006	0.045	<0.02	0.26	0.004	2.10	<0.005	0.048	0.002	0.099	0.419	<0.010
AEROBIC FBR EFF TOTAL	0.087	<0.005	0.063	<0.02	14.60	0.006	3.00	<0.005	0.216	0.028	0.115	0.475	0.039
AEROBIC FBR EFF SOLUBLE	0.089	<0.005	0.032	0.02	0.28	0.003	0.49	<0.005	0.051	<0.002	0.087	0.486	0.036
ANOXIC FBR EFF TOTAL	0.141	<0.005	0.036	<0.02	6.50	0.005	1.19	<0.005	0.095	0.013	0.088	0.413	<0.010
ANOXIC FBR EFF SOLUBLE	0.123	<0.005	0.029	<0.02	0.37	0.003	0.12	<0.005	0.042	0.003	0.086	0.431	0.022
AEROBIC FBR EFF FE DOSE 0	0.077	0.011	0.022	<0.02	0.08	0.003	<0.005	<0.005	0.033	<0.002	0.078	0.556	<0.010
AEROBIC FBR EFF FE DOSE 150	0.064	0.010	0.026	<0.02	0.20	0.007	<0.005	<0.005	0.037	<0.002	0.092	0.592	0.016
AEROBIC FBR EFF FE DOSE 250	0.018	<0.005	0.020	0.02	0.20	0.004	<0.005	<0.005	0.047	<0.002	0.087	0.575	0.047
AEROBIC FBR EFF FE DOSE 500	0.006	<0.005	0.031	<0.02	0.20	0.005	<0.005	<0.005	0.044	<0.002	0.087	0.599	0.045
AEROBIC FBR EFF FE DOSE 800	0.009	<0.005	0.029	0.03	0.16	0.002	<0.005	<0.005	0.040	<0.002	0.090	0.537	0.069
ANOXIC EFF FE DOSE 0	0.091	0.007	0.021	<0.02	0.23	0.002	0.058	<0.005	0.045	0.003	0.081	0.465	0.010
ANOXIC EFF FE DOSE 150	0.048	0.006	0.026	<0.02	0.22	0.006	<0.005	<0.005	0.090	0.002	0.093	0.553	0.051
ANOXIC EFF FE DOSE 250	0.018	0.007	0.019	<0.02	0.20	0.002	<0.005	<0.005	0.028	0.003	0.079	0.562	0.029
ANOXIC EFF FE DOSE 500	0.018	0.008	0.018	<0.02	0.18	0.002	<0.005	<0.005	0.043	<0.002	0.086	0.485	0.035
ANOXIC EFF FE DOSE 800	0.017	0.009	0.023	<0.02	0.21	0.003	0.006	<0.005	0.064	<0.002	0.087	0.509	0.036

(a) pH adjusted to 9.0 with caustic on all Fe dose jars 0, 150, 250, 500, 800.

TABLE 3-6. SUMMARY OF TREATABILITY TESTING RESULTS

CONSITUENT OF CONCERN	COMPOSITE GROUNDWATER CONCENTRATION (mg/L)			TREATABILITY EFFLUENT CONCENTRATION (mg/L)			PERCENT REMOVAL (%)		
	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX
Ammonia	245	323	408	1	1	1	>99	>99	>99
Benzene	0.297	0.440	0.700		ND		>98	>99	>99
Chlorobenzene		ND			ND			NA	
Chloroform		ND			ND			NA	
1,1-Dichloroethane		ND			ND			NA	
1,1-Dichloroethene		ND			ND			NA	
1,2-Dichloroethene (total)		ND			ND			NA	
trans-1,2-Dichloroethene		ND			ND			NA	
Toluene	0.116	0.155	0.230		ND		>96	>97	>98
1,1,1-Trichloroethane		ND			ND			NA	
Trichloroethene		ND			ND			NA	
bis(2-Ethylhexyl)Phthalate		ND			ND			NA	
N-Nitrosodiphenylamine		ND			ND			NA	
Phenol		ND			ND			NA	
Arsenic	0.037	0.146	0.197	0.026	0.042	0.081	5	62	87

NOTES:

1. Average, minimum, maximum and percent removals computed during stabilized performance October 29 to November 6 for all parameters except arsenic, which was computed from October 6 to 22.
2. Percent removal calculated for influent parameters and <0.005 mg/L for benzene and toluene results.
3. NA – not applicable.
4. Distilled ammonia results were used.
5. Benzene, toluene, and arsenic results include both ADVENT and GSEL analyses.
6. Arsenic results taken from ADVENT (1991).

TABLE 3-7. SUMMARY OF ANOXIC FBR EVALUATION DESIGN INPUTS

TREATMENT COMPONENT	PARAMETER	RESULT
Anoxic FBR	Groundwater Feed Flow, gpm/sq feet	0.38 to 0.55
	FBR Recycle Feed Flow, gpm/sq feet	0.50 to 0.75
	Fluidization Flow, gpm/sq feet	12.8 to 14.3
	Influent DO, mg/L	0.4 to 1.4
	Effluent DO, mg/L	0.0 to 0.3
	Operating pH, s.u.	8.1
	Bed Height, feet	9.5

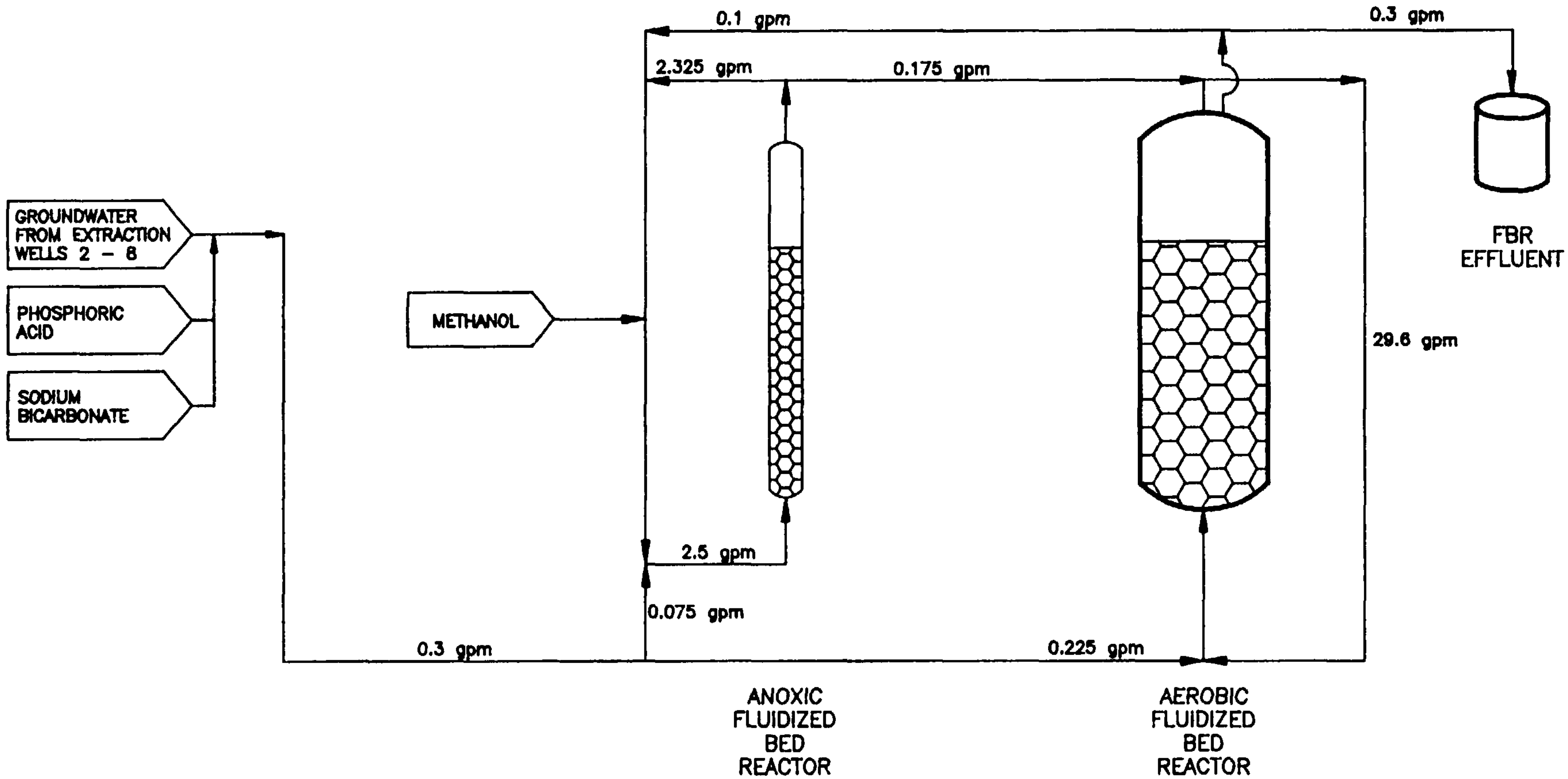
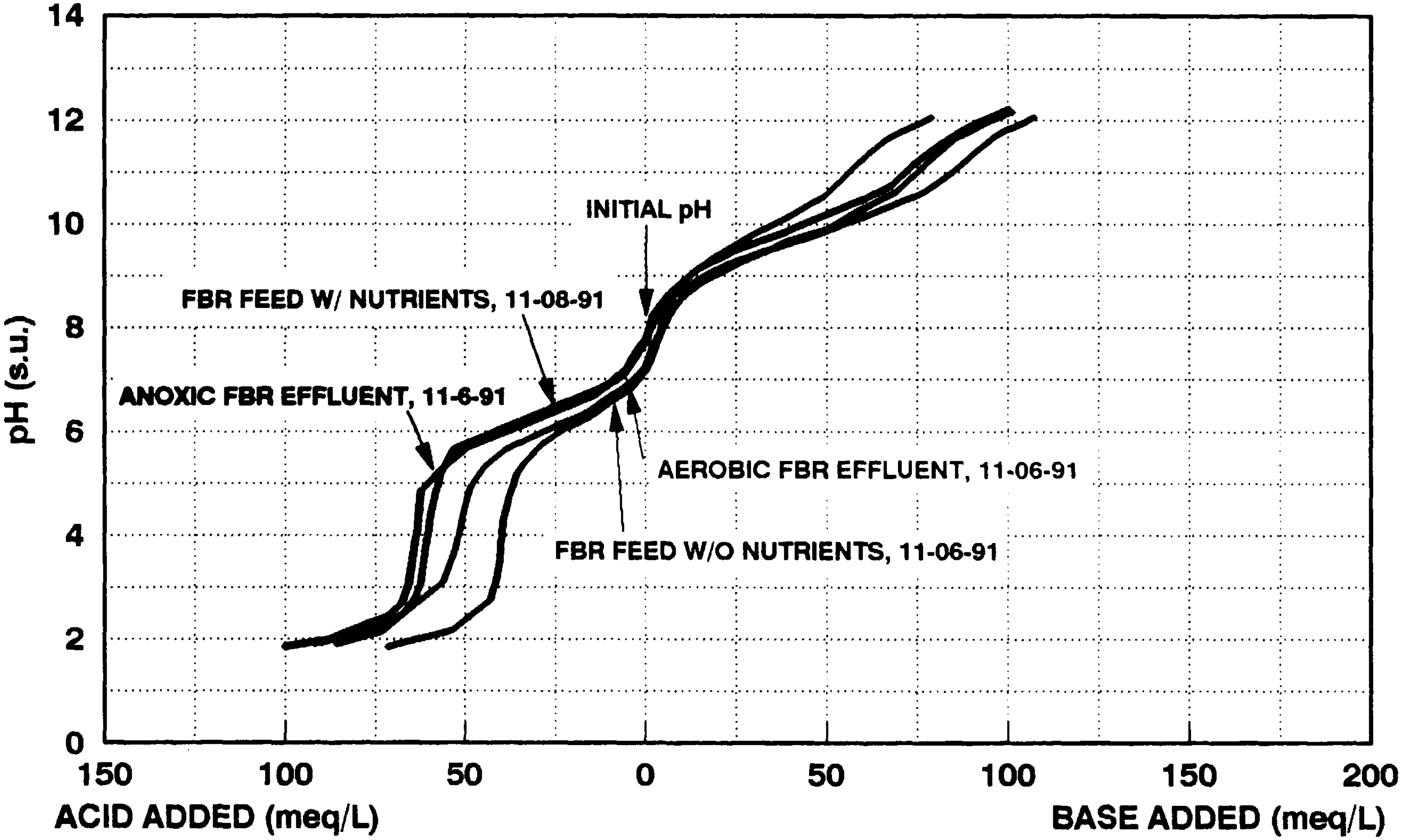


FIGURE 3–1. TREATABILITY TESTING SYSTEM CONFIGURATION

FIGURE 3-2. TITRATION CURVES
FBR FEED, AEROBIC AND ANOXIC EFFLUENTS



The ADVENT Group, Inc.

Original includes color coding.

FIGURE 3-3. CHRONOLOGICAL OPERATING TEMPERATURES

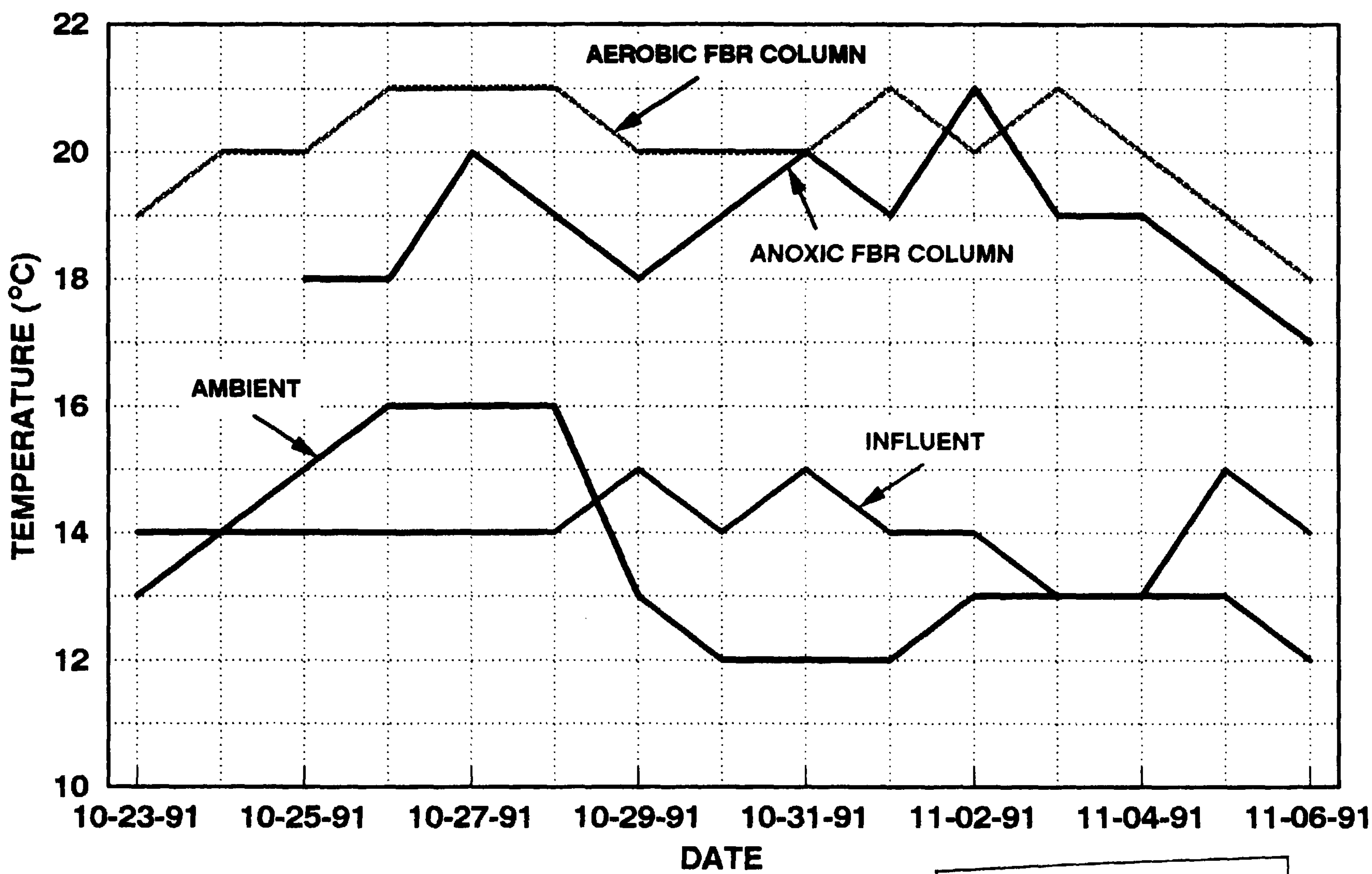


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FIGURE 3-4. CHRONOLOGICAL AMMONIA RESULTS

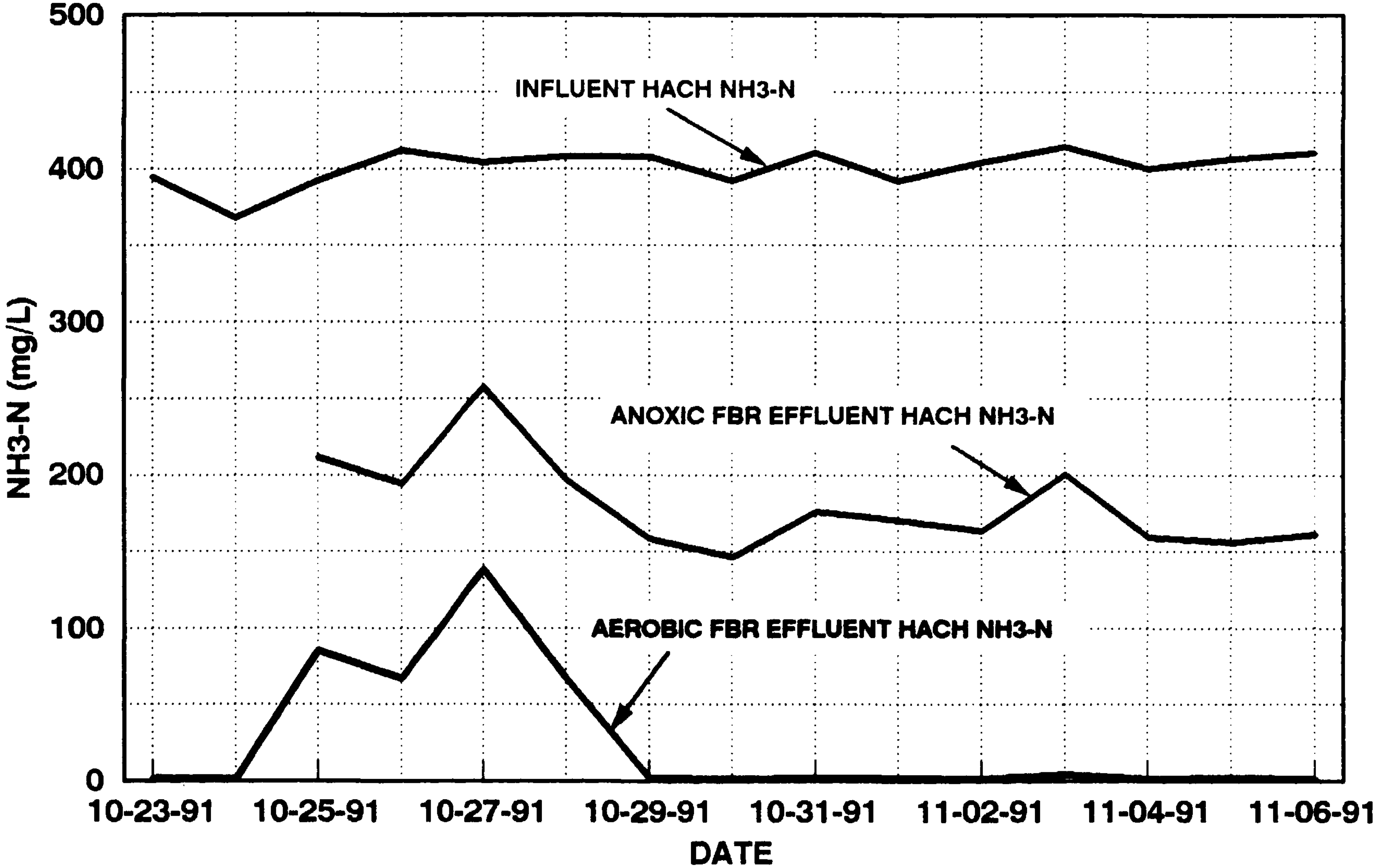

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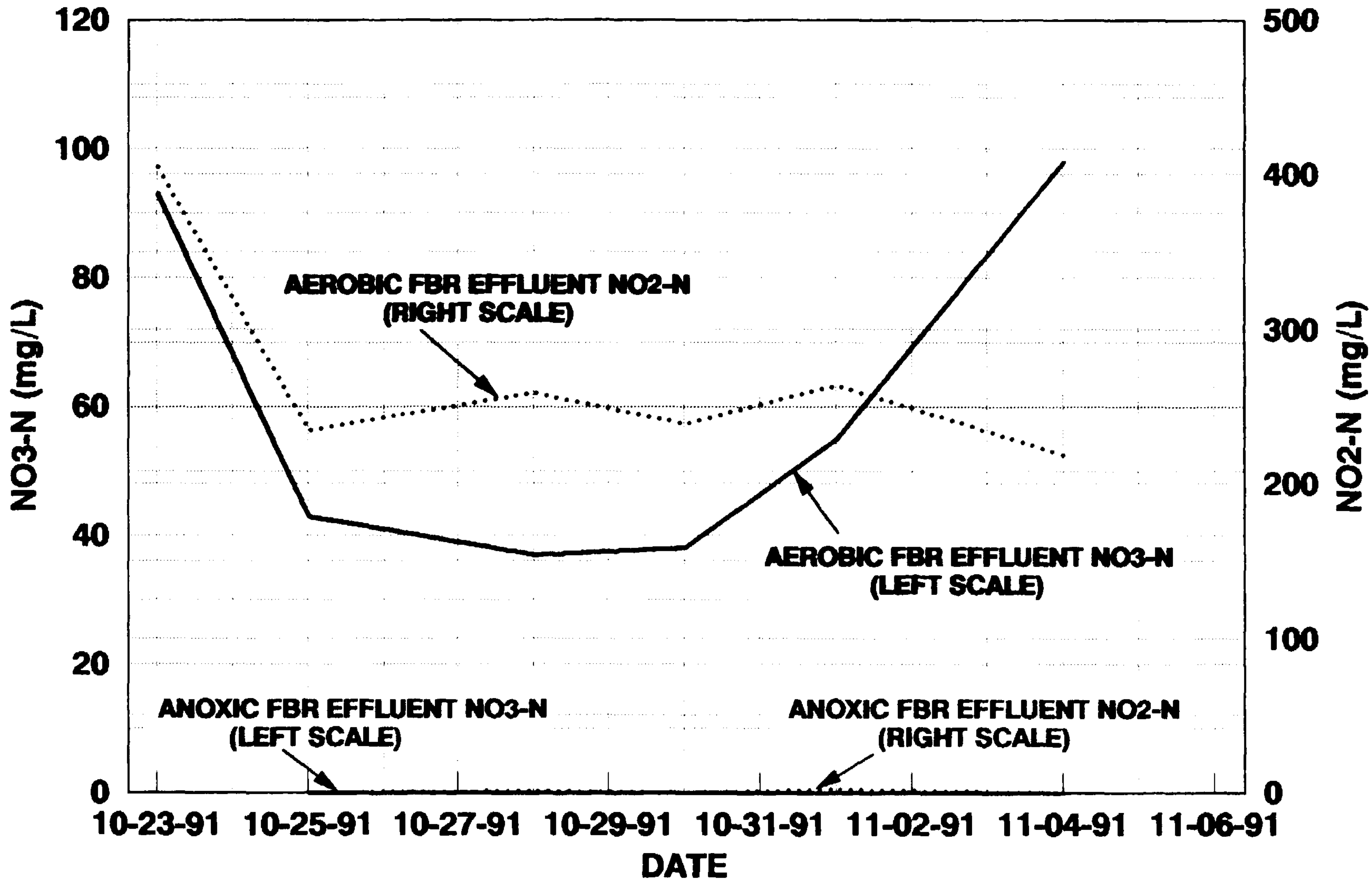
FIGURE 3-5. CHRONOLOGICAL NITRATE/NITRITE RESULTS



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APPENDIX 3-A

Detailed Chronological Results

TABLE 1. FBR FEED ANALYTICAL RESULTS
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS – WOBURN, MASSACHUSETTS

DATE	BOD TOTAL (mg/L)	BOD SOLUBLE (mg/L)	COD TOTAL (mg/L)	COD SOLUBLE (mg/L)	TOC TOTAL (mg/L)	TOC SOLUBLE (mg/L)	TKN TOTAL (mg/L)	TKN SOLUBLE (mg/L)	NH3-N TOTAL HACH (mg/L)	NH3-N TOTAL DISTILL (mg/L)	NO3-N TOTAL (mg/L)
01-Oct-91											
02-Oct-91											
03-Oct-91											
04-Oct-91											
05-Oct-91											
06-Oct-91											
07-Oct-91											
08-Oct-91											
09-Oct-91											
10-Oct-91											
11-Oct-91											
12-Oct-91											
13-Oct-91											
14-Oct-91											
15-Oct-91											
16-Oct-91											
17-Oct-91											
18-Oct-91											
19-Oct-91											
20-Oct-91											
21-Oct-91											
22-Oct-91											
23-Oct-91									394		
24-Oct-91									368		
25-Oct-91									392	350	
26-Oct-91									412		
27-Oct-91									404		
28-Oct-91	10	10	186		62	61	448		408	372	
29-Oct-91									408		
30-Oct-91									392	348	
31-Oct-91			390			31			410		

TABLE 1. FBR FEED ANALYTICAL RESULTS (Continued)
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS – WOBURN, MASSACHUSETTS

DATE	BOD TOTAL (mg/L)	BOD SOLUBLE (mg/L)	COD TOTAL (mg/L)	COD SOLUBLE (mg/L)	TOC TOTAL (mg/L)	TOC SOLUBLE (mg/L)	TKN TOTAL (mg/L)	TKN SOLUBLE (mg/L)	NH3-N TOTAL HACH (mg/L)	NH3-N TOTAL DISTILL (mg/L)	NO3-N TOTAL (mg/L)
01-Nov-91									392	245	
02-Nov-91									404		
03-Nov-91									414		
04-Nov-91	31	29	240	227	70	68	514		400	290	
05-Nov-91									406		
06-Nov-91									410	408	
07-Nov-91											
08-Nov-91											
09-Nov-91											
10-Nov-91											
11-Nov-91											
12-Nov-91											
13-Nov-91											
14-Nov-91											
15-Nov-91											
16-Nov-91											
17-Nov-91											
18-Nov-91											
19-Nov-91											
20-Nov-91											
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22-Nov-91											
23-Nov-91											
24-Nov-91											
25-Nov-91											
26-Nov-91											
27-Nov-91											
28-Nov-91											
29-Nov-91											
30-Nov-91											

TABLE 1. FBR FEED ANALYTICAL RESULTS (Continued)
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS – WOBURN, MASSACHUSETTS

DATE	NO2-N TOTAL (mg/L)	PO4-P TOTAL (mg/L)	H3PO4 ADDED (mL 85%/kgal)	TSS (mg/L)	VSS (mg/L)	TDS (mg/L)	TDIS (mg/L)	CONDUC-TIVITY (umhos/cm)	SO4 TOTAL (mg/L)	SULFIDE TOTAL (mg/L)	TEMP (deg C)
01-Oct-91											
02-Oct-91											
03-Oct-91											
04-Oct-91											
05-Oct-91											
06-Oct-91											
07-Oct-91											
08-Oct-91											
09-Oct-91											
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14-Oct-91											
15-Oct-91											
16-Oct-91											
17-Oct-91											
18-Oct-91											
19-Oct-91											
20-Oct-91											
21-Oct-91											
22-Oct-91											
23-Oct-91			80								14
24-Oct-91			80								14
25-Oct-91			80	133	92			5,100			14
26-Oct-91			80					5,200			14
27-Oct-91			80					5,200			14
28-Oct-91		11.6	80	57	18	2,875	2,670	5,900			14
29-Oct-91			80					6,100			15
30-Oct-91			80	83	21			6,200			14
31-Oct-91			80					5,200			15

TABLE 1. FBR FEED ANALYTICAL RESULTS (Continued)
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS - WOBURN, MASSACHUSETTS

DATE	NO2-N TOTAL (mg/L)	PO4-P TOTAL (mg/L)	H3PO4 ADDED (mL 85%/ kgal)	TSS (mg/L)	VSS (mg/L)	TDS (mg/L)	TDIS (mg/L)	CONDUC-TIVITY (umhos/cm)	SO4 TOTAL (mg/L)	SULFIDE TOTAL (mg/L)	TEMP (deg C)
01-Nov-91			80	105	16			5,300			14
02-Nov-91			80					5,100			14
03-Nov-91			80					5,300			13
04-Nov-91		0.1	80	70	15	3,415	3,030	5,100			13
05-Nov-91			80					5,200			15
06-Nov-91			80	40	4			5,100			14
07-Nov-91			80								
08-Nov-91											
09-Nov-91											
10-Nov-91											
11-Nov-91											
12-Nov-91											
13-Nov-91											
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27-Nov-91											
28-Nov-91											
29-Nov-91											
30-Nov-91											

TABLE 1. FBR FEED ANALYTICAL RESULTS (Continued)
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS - WOBURN, MASSACHUSETTS

DATE	p.H. (s.u.)	ALK-ALINITY (mg/L as CaCO3)	NaHCO3 ADDED (#/kgal)	BENZENE TOTAL (mg/L)	TOLUENE TOTAL (mg/L)	ARSENIC TOTAL (mg/L)	ARSENIC SOLUBLE (mg/L)	CHROMIUM TOTAL (mg/L)	CHROMIUM SOLUBLE (mg/L)	IRON TOTAL (mg/L)	IRON SOLUBLE (mg/L)
01-Oct-91											
02-Oct-91											
03-Oct-91											
04-Oct-91											
05-Oct-91											
06-Oct-91											
07-Oct-91											
08-Oct-91											
09-Oct-91											
10-Oct-91											
11-Oct-91											
12-Oct-91											
13-Oct-91											
14-Oct-91											
15-Oct-91											
16-Oct-91											
17-Oct-91											
18-Oct-91											
19-Oct-91											
20-Oct-91											
21-Oct-91											
22-Oct-91											
23-Oct-91	7.7		16								
24-Oct-91	7.7		16								
25-Oct-91	7.6		16								
26-Oct-91	7.6		16								
27-Oct-91	7.7		16								
28-Oct-91	8.0	2,200	16	<0.010	<0.010	0.113	0.034			18.9	0.28
29-Oct-91	7.8		16								
30-Oct-91			16								
31-Oct-91	7.6		16	0.324	0.120	0.179	0.166			35.6	0.80

TABLE 1. FBR FEED ANALYTICAL RESULTS (Continued)
INDUSTRI–PLEX SITE GROUNDWATER TREATABILITY RESULTS – WOBURN, MASSACHUSETTS

DATE	p.H. (s.u.)	ALK–ALINITY (mg/L as CaCO3)	NaHCO3 ADDED (#/kgal)	BENZENE TOTAL (mg/L)	TOLUENE TOTAL (mg/L)	ARSENIC TOTAL (mg/L)	ARSENIC SOLUBLE (mg/L)	CHROMIUM TOTAL (mg/L)	CHROMIUM SOLUBLE (mg/L)	IRON TOTAL (mg/L)	IRON SOLUBLE (mg/L)
01-Nov-91	7.5		16								
02-Nov-91	7.6		16								
03-Nov-91	7.7		16								
04-Nov-91	7.6	2,150	16	0.297	0.116	0.196	0.197			18.9	0.59
05-Nov-91	7.6		16								
06-Nov-91	7.6		16								
07-Nov-91											
08-Nov-91											
09-Nov-91											
10-Nov-91											
11-Nov-91											
12-Nov-91											
13-Nov-91											
14-Nov-91											
15-Nov-91											
16-Nov-91											
17-Nov-91											
18-Nov-91											
19-Nov-91											
20-Nov-91											
21-Nov-91											
22-Nov-91											
23-Nov-91											
24-Nov-91											
25-Nov-91											
26-Nov-91											
27-Nov-91											
28-Nov-91											
29-Nov-91											
30-Nov-91											

TABLE 2. FBR EFFLUENT ANALYTICAL RESULTS
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS – WOBURN, MASSACHUSETTS

DATE	BOD TOTAL (mg/L)	BOD SOLUBLE (mg/L)	COD TOTAL (mg/L)	COD SOLUBLE (mg/L)	TOC TOTAL (mg/L)	TOC SOLUBLE (mg/L)	TKN TOTAL (mg/L)	TKN SOLUBLE (mg/L)	NH3-N TOTAL HACH (mg/L)	NH3-N TOTAL DISTILL (mg/L)	NO3-N TOTAL (mg/L)
01-Oct-91											
02-Oct-91											
03-Oct-91											
04-Oct-91											
05-Oct-91											
06-Oct-91											
07-Oct-91											
08-Oct-91											
09-Oct-91											
10-Oct-91											
11-Oct-91											
12-Oct-91											
13-Oct-91											
14-Oct-91											
15-Oct-91											
16-Oct-91											
17-Oct-91											
18-Oct-91											
19-Oct-91											
20-Oct-91											
21-Oct-91											
22-Oct-91											
23-Oct-91									1	< 1	93
24-Oct-91									1		
25-Oct-91				620		65			85	89	43
26-Oct-91									67		
27-Oct-91									138		
28-Oct-91	88	87	425	346	40	29		100	67	56	37
29-Oct-91									2		
30-Oct-91				276		16			1	1	38
31-Oct-91									2		

TABLE 2. FBR EFFLUENT ANALYTICAL RESULTS (Continued)
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS - WOBURN, MASSACHUSETTS

DATE	BOD TOTAL (mg/L)	BOD SOLUBLE (mg/L)	COD TOTAL (mg/L)	COD SOLUBLE (mg/L)	TOC TOTAL (mg/L)	TOC SOLUBLE (mg/L)	TKN TOTAL (mg/L)	TKN SOLUBLE (mg/L)	NH3-N TOTAL HACH (mg/L)	NH3-N TOTAL DISTILL (mg/L)	NO3-N TOTAL (mg/L)
01-Nov-91				321		22		15	2	1	55
02-Nov-91									1		
03-Nov-91									4		
04-Nov-91	47	12	349	273	31	24		17	1	1	98
05-Nov-91									2		
06-Nov-91									1		
07-Nov-91											
08-Nov-91											
09-Nov-91											
10-Nov-91											
11-Nov-91											
12-Nov-91											
13-Nov-91											
14-Nov-91											
15-Nov-91											
16-Nov-91											
17-Nov-91											
18-Nov-91											
19-Nov-91											
20-Nov-91											
21-Nov-91											
22-Nov-91											
23-Nov-91											
24-Nov-91											
25-Nov-91											
26-Nov-91											
27-Nov-91											
28-Nov-91											
29-Nov-91											
30-Nov-91											

TABLE 2. FBR EFFLUENT ANALYTICAL RESULTS (Continued)
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS - WOBURN, MASSACHUSETTS

DATE	NO2-N TOTAL (mg/L)	PO4-P TOTAL (mg/L)	TSS (mg/L)	VSS (mg/L)	TDS (mg/L)	TDIS (mg/L)	CONDUC-TIVITY (umhos/cm)	SO4 TOTAL (mg/L)	SULFIDE TOTAL (mg/L)	COLUMN TEMP (deg C)	COLUMN p.H. (s.u.)
01-Oct-91											
02-Oct-91											
03-Oct-91											
04-Oct-91											
05-Oct-91											
06-Oct-91											
07-Oct-91											
08-Oct-91											
09-Oct-91											
10-Oct-91											
11-Oct-91											
12-Oct-91											
13-Oct-91											
14-Oct-91											
15-Oct-91											
16-Oct-91											
17-Oct-91											
18-Oct-91											
19-Oct-91											
20-Oct-91											
21-Oct-91											
22-Oct-91											
23-Oct-91	405						6,800			19	7.2
24-Oct-91							6,000			20	7.0
25-Oct-91	235		179	94			6,200			20	7.0
26-Oct-91							6,200			21	6.9
27-Oct-91							6,100			21	7.1
28-Oct-91	259	11.4	98	39	4,603	3,688	6,100			21	6.8
29-Oct-91							6,200			20	6.9
30-Oct-91	239		71	31			6,200			20	6.9
31-Oct-91							6,100			20	7.1

TABLE 2. FBR EFFLUENT ANALYTICAL RESULTS (Continued)
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS – WOBURN, MASSACHUSETTS

DATE	NO2-N TOTAL (mg/L)	PO4-P TOTAL (mg/L)	TSS (mg/L)	VSS (mg/L)	TDS (mg/L)	TDIS (mg/L)	CONDUC-TIVITY (umhos/cm)	SO4 TOTAL (mg/L)	SULFIDE TOTAL (mg/L)	COLUMN TEMP (deg C)	COLUMN p.H. (s.u.)
01-Nov-91	264		75	37			6,100			21	7.0
02-Nov-91							6,100			20	7.1
03-Nov-91							6,000			21	7.0
04-Nov-91	219	0.1	59	35	5,600	4,628	6,300			20	7.0
05-Nov-91							6,100			19	6.9
06-Nov-91			58	32			6,100			18	6.9
07-Nov-91											
08-Nov-91											
09-Nov-91											
10-Nov-91											
11-Nov-91											
12-Nov-91											
13-Nov-91											
14-Nov-91											
15-Nov-91											
16-Nov-91											
17-Nov-91											
18-Nov-91											
19-Nov-91											
20-Nov-91											
21-Nov-91											
22-Nov-91											
23-Nov-91											
24-Nov-91											
25-Nov-91											
26-Nov-91											
27-Nov-91											
28-Nov-91											
29-Nov-91											
30-Nov-91											

TABLE 2. FBR EFFLUENT ANALYTICAL RESULTS (Continued)
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS – WOBURN, MASSACHUSETTS

DATE	ALK-ALINITY (mg/L as CaCO3)	BENZENE TOTAL (mg/L)	TOLUENE TOTAL (mg/L)	ARSENIC TOTAL (mg/L)	ARSENIC SOLUBLE (mg/L)	CHROMIUM TOTAL (mg/L)	CHROMIUM SOLUBLE (mg/L)	IRON TOTAL (mg/L)	IRON SOLUBLE (mg/L)
01-Oct-91									
02-Oct-91									
03-Oct-91									
04-Oct-91									
05-Oct-91									
06-Oct-91									
07-Oct-91									
08-Oct-91									
09-Oct-91									
10-Oct-91									
11-Oct-91									
12-Oct-91									
13-Oct-91									
14-Oct-91									
15-Oct-91									
16-Oct-91									
17-Oct-91									
18-Oct-91									
19-Oct-91									
20-Oct-91									
21-Oct-91									
22-Oct-91									
23-Oct-91									
24-Oct-91									
25-Oct-91									
26-Oct-91									
27-Oct-91									
28-Oct-91	1,880	<0.010	<0.010	0.101	0.099			24.9	1.85
29-Oct-91									
30-Oct-91									
31-Oct-91		<0.010	<0.010	0.162	0.088			24.0	1.99

TABLE 2. FBR EFFLUENT ANALYTICAL RESULTS (Continued)
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS – WOBURN, MASSACHUSETTS

DATE	ALK-ALINITY (mg/L as CaCO3)	BENZENE TOTAL (mg/L)	TOLUENE TOTAL (mg/L)	ARSENIC TOTAL (mg/L)	ARSENIC SOLUBLE (mg/L)	CHROMIUM TOTAL (mg/L)	CHROMIUM SOLUBLE (mg/L)	IRON TOTAL (mg/L)	IRON SOLUBLE (mg/L)
01-Nov-91									
02-Nov-91									
03-Nov-91									
04-Nov-91	1,770	<0.010	<0.010	0.179	0.162			11.7	1.30
05-Nov-91									
06-Nov-91									
07-Nov-91									
08-Nov-91									
09-Nov-91									
10-Nov-91									
11-Nov-91									
12-Nov-91									
13-Nov-91									
14-Nov-91									
15-Nov-91									
16-Nov-91									
17-Nov-91									
18-Nov-91									
19-Nov-91									
20-Nov-91									
21-Nov-91									
22-Nov-91									
23-Nov-91									
24-Nov-91									
25-Nov-91									
26-Nov-91									
27-Nov-91									
28-Nov-91									
29-Nov-91									
30-Nov-91									

TABLE 3. FBR OPERATIONAL RESULTS
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS – WOBURN, MASSACHUSETTS

DATE	FORWARD FLOW (gpm)	RECYCLE FLOW (gpm)	NaOH STRENGTH ADDED (%)	NaOH ADDED (L/day)	INFLUENT D.O. (mg/L)	EFFLUENT D.O. (mg/L)	OUR (mg/L)	BED HEIGHT (ft)	AMBIENT TEMP (Deg C)
01-Oct-91									
02-Oct-91									
03-Oct-91									
04-Oct-91									
05-Oct-91									
06-Oct-91									
07-Oct-91									
08-Oct-91									
09-Oct-91									
10-Oct-91									
11-Oct-91									
12-Oct-91									
13-Oct-91									
14-Oct-91									
15-Oct-91									
16-Oct-91									
17-Oct-91									
18-Oct-91									
19-Oct-91									
20-Oct-91									
21-Oct-91									
22-Oct-91									
23-Oct-91	0.30	29.6	26	4.9	24.0	5.0	19.0		13
24-Oct-91	0.23	29.6	26	12.3	26.0	6.6	19.4		14
25-Oct-91	0.29	29.6	26	5.4	17.7	3.0	14.7	9.5	15
26-Oct-91	0.30	30.0	26	6.3	18.3	3.1	15.2	10.5	16
27-Oct-91	0.29	29.8	26	6.0	18.5	1.1	17.4	10.5	16
28-Oct-91	0.28	29.5	26	4.1	23.3	1.5	21.7	10.0	16
29-Oct-91	0.29	29.6	26	4.2	22.5	3.2	19.3	10.0	13
30-Oct-91	0.28	30.0	26	3.2	21.0	2.1	18.9	10.0	12
31-Oct-91	0.28	30.0	26	3.1	21.5	2.4	19.5	9.5	12

TABLE 3. FBR OPERATIONAL RESULTS (Continued)
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS - WOBURN, MASSACHUSETTS

DATE	FORWARD FLOW (gpm)	RECYCLE FLOW (gpm)	NaOH STRENGTH ADDED (%)	NaOH ADDED (L/day)	INFLUENT D.O. (mg/L)	EFFLUENT D.O. (mg/L)	OUR (mg/L)	BED HEIGHT (ft)	AMBIENT TEMP (Deg C)
01-Nov-91	0.28	29.5	26	6.6	22.0	1.7	20.3	10.0	12
02-Nov-91	0.28	30.4	26	1.9	22.8	2.2	20.6	10.0	13
03-Nov-91	0.30	29.6	26	1.9	22.7	1.8	20.9	10.0	13
04-Nov-91	0.29	29.6	26	3.5	22.2	2.6	19.6	10.0	13
05-Nov-91	0.29	30.4	26	3.4	22.8	4.8	18.0	10.0	13
06-Nov-91	0.29	30.4	26	1.6	21.9	2.3	19.6	10.0	12
07-Nov-91									
08-Nov-91									
09-Nov-91									
10-Nov-91									
11-Nov-91									
12-Nov-91									
13-Nov-91									
14-Nov-91									
15-Nov-91									
16-Nov-91									
17-Nov-91									
18-Nov-91									
19-Nov-91									
20-Nov-91									
21-Nov-91									
22-Nov-91									
23-Nov-91									
24-Nov-91									
25-Nov-91									
26-Nov-91									
27-Nov-91									
28-Nov-91									
29-Nov-91									
30-Nov-91									

TABLE 4. ANOXIC COLUMN EFFLUENT ANALYTICAL RESULTS
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS - WOBURN, MASSACHUSETTS

DATE	BOD TOTAL (mg/L)	BOD SOLUBLE (mg/L)	COD TOTAL (mg/L)	COD SOLUBLE (mg/L)	TOC TOTAL (mg/L)	TOC SOLUBLE (mg/L)	TKN TOTAL (mg/L)	TKN SOLUBLE (mg/L)	NH3-N TOTAL HACH (mg/L)	NH3-N TOTAL DISTILL (mg/L)	NO3-N TOTAL (mg/L)
01-Oct-91											
02-Oct-91											
03-Oct-91											
04-Oct-91											
05-Oct-91											
06-Oct-91											
07-Oct-91											
08-Oct-91											
09-Oct-91											
10-Oct-91											
11-Oct-91											
12-Oct-91											
13-Oct-91											
14-Oct-91											
15-Oct-91											
16-Oct-91											
17-Oct-91											
18-Oct-91											
19-Oct-91											
20-Oct-91											
21-Oct-91											
22-Oct-91											
23-Oct-91											
24-Oct-91											
25-Oct-91				1,170					211	187	< 1
26-Oct-91									194		
27-Oct-91									257		
28-Oct-91	597	580	940	960	146	140		212	196	163	< 1
29-Oct-91									158		
30-Oct-91				865		137			146	129	< 1
31-Oct-91									176		

TABLE 4. ANOXIC COLUMN EFFLUENT ANALYTICAL RESULTS (Continued)
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS – WOBURN, MASSACHUSETTS

DATE	BOD TOTAL (mg/L)	BOD SOLUBLE (mg/L)	COD TOTAL (mg/L)	COD SOLUBLE (mg/L)	TOC TOTAL (mg/L)	TOC SOLUBLE (mg/L)	TKN TOTAL (mg/L)	TKN SOLUBLE (mg/L)	NH3-N TOTAL HACH (mg/L)	NH3-N TOTAL DISTILL (mg/L)	NO3-N TOTAL (mg/L)
01-Nov-91				440		78			170	92	< 1
02-Nov-91									163		
03-Nov-91									200		
04-Nov-91	255	270	570	510	92	95		196	159	116	< 1
05-Nov-91									156		
06-Nov-91									161		
07-Nov-91											
08-Nov-91											
09-Nov-91											
10-Nov-91											
11-Nov-91											
12-Nov-91											
13-Nov-91											
14-Nov-91											
15-Nov-91											
16-Nov-91											
17-Nov-91											
18-Nov-91											
19-Nov-91											
20-Nov-91											
21-Nov-91											
22-Nov-91											
23-Nov-91											
24-Nov-91											
25-Nov-91											
26-Nov-91											
27-Nov-91											
28-Nov-91											
29-Nov-91											
30-Nov-91											

TABLE 4. ANOXIC COLUMN EFFLUENT ANALYTICAL RESULTS (Continued)
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS – WOBURN, MASSACHUSETTS

DATE	NO2-N TOTAL (mg/L)	PO4-P TOTAL (mg/L)	TSS (mg/L)	VSS (mg/L)	TDS (mg/L)	TDIS (mg/L)	CONDUC-TIVITY (umhos/cm)	SO4 TOTAL (mg/L)	SULFIDE TOTAL (mg/L)	COLUMN TEMP (deg C)	COLUMN p.H. (s.u.)
01-Oct-91											
02-Oct-91											
03-Oct-91											
04-Oct-91											
05-Oct-91											
06-Oct-91											
07-Oct-91											
08-Oct-91											
09-Oct-91											
10-Oct-91											
11-Oct-91											
12-Oct-91											
13-Oct-91											
14-Oct-91											
15-Oct-91											
16-Oct-91											
17-Oct-91											
18-Oct-91											
19-Oct-91											
20-Oct-91											
21-Oct-91											
22-Oct-91											
23-Oct-91											
24-Oct-91											
25-Oct-91	< 1		408	316			5,900			18	7.7
26-Oct-91							5,100			18	8.0
27-Oct-91							5,100			20	7.8
28-Oct-91	1	0.0	86	38	3,970	3,640	5,100			19	8.0
29-Oct-91							5,400			18	8.0
30-Oct-91	< 1		66	29			5,500			19	8.0
31-Oct-91							5,500			20	8.1

TABLE 4. ANOXIC COLUMN EFFLUENT ANALYTICAL RESULTS (Continued)
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS – WOBURN, MASSACHUSETTS

DATE	NO2-N TOTAL (mg/L)	PO4-P TOTAL (mg/L)	TSS (mg/L)	VSS (mg/L)	TDS (mg/L)	TDIS (mg/L)	CONDUC-TIVITY (umhos/cm)	SO4 TOTAL (mg/L)	SULFIDE TOTAL (mg/L)	COLUMN TEMP (deg C)	COLUMN p.H. (s.u.)
01-Nov-91	2		66	38			5,700			19	8.1
02-Nov-91							6,100			21	8.1
03-Nov-91							5,900			19	8.1
04-Nov-91	< 1	0.0	62	34	4,583	4,210	6,100			19	8.1
05-Nov-91							5,400			18	8.0
06-Nov-91			40	22			5,300			17	8.1
07-Nov-91											
08-Nov-91											
09-Nov-91											
10-Nov-91											
11-Nov-91											
12-Nov-91											
13-Nov-91											
14-Nov-91											
15-Nov-91											
16-Nov-91											
17-Nov-91											
18-Nov-91											
19-Nov-91											
20-Nov-91											
21-Nov-91											
22-Nov-91											
23-Nov-91											
24-Nov-91											
25-Nov-91											
26-Nov-91											
27-Nov-91											
28-Nov-91											
29-Nov-91											
30-Nov-91											

TABLE 4. ANOXIC COLUMN EFFLUENT ANALYTICAL RESULTS (Continued)
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS – WOBURN, MASSACHUSETTS

DATE	ALK-ALINITY (mg/L as CaCO3)	BENZENE TOTAL (mg/L)	TOLUENE TOTAL (mg/L)	ARSENIC TOTAL (mg/L)	ARSENIC SOLUBLE (mg/L)	CHROMIUM TOTAL (mg/L)	CHROMIUM SOLUBLE (mg/L)	IRON TOTAL (mg/L)	IRON SOLUBLE (mg/L)
01-Oct-91									
02-Oct-91									
03-Oct-91									
04-Oct-91									
05-Oct-91									
06-Oct-91									
07-Oct-91									
08-Oct-91									
09-Oct-91									
10-Oct-91									
11-Oct-91									
12-Oct-91									
13-Oct-91									
14-Oct-91									
15-Oct-91									
16-Oct-91									
17-Oct-91									
18-Oct-91									
19-Oct-91									
20-Oct-91									
21-Oct-91									
22-Oct-91									
23-Oct-91									
24-Oct-91									
25-Oct-91									
26-Oct-91									
27-Oct-91									
28-Oct-91	2,230	<0.010	<0.010	0.083	0.059			17.3	16.6
29-Oct-91									
30-Oct-91									
31-Oct-91		0.043	<0.010	0.143	0.097			4.62	1.90

TABLE 4. ANOXIC COLUMN EFFLUENT ANALYTICAL RESULTS (Continued)
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS - WOBURN, MASSACHUSETTS

DATE	ALK-ALINITY (mg/L as CaCO3)	BENZENE TOTAL (mg/L)	TOLUENE TOTAL (mg/L)	ARSENIC TOTAL (mg/L)	ARSENIC SOLUBLE (mg/L)	CHROMIUM TOTAL (mg/L)	CHROMIUM SOLUBLE (mg/L)	IRON TOTAL (mg/L)	IRON SOLUBLE (mg/L)
01-Nov-91									
02-Nov-91									
03-Nov-91									
04-Nov-91	2,220	0.091	<0.010	0.150	0.139			9.6	0.83
05-Nov-91									
06-Nov-91									
07-Nov-91									
08-Nov-91									
09-Nov-91									
10-Nov-91									
11-Nov-91									
12-Nov-91									
13-Nov-91									
14-Nov-91									
15-Nov-91									
16-Nov-91									
17-Nov-91									
18-Nov-91									
19-Nov-91									
20-Nov-91									
21-Nov-91									
22-Nov-91									
23-Nov-91									
24-Nov-91									
25-Nov-91									
26-Nov-91									
27-Nov-91									
28-Nov-91									
29-Nov-91									
30-Nov-91									

TABLE 5. ANOXIC COLUMN OPERATIONAL RESULTS
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS – WOBURN, MASSACHUSETTS

DATE	FEED FLOW (L/day)	FBR EFF FLOW (L/day)	METHANOL STRENGTH ADDED (%)	RECYCLE FLOW (gpm)	METHANOL ADDED (L/day)	INFLUENT D.O. (mg/L)	EFFLUENT D.O. (mg/L)	BED HEIGHT (ft)
01-Oct-91								
02-Oct-91								
03-Oct-91								
04-Oct-91								
05-Oct-91								
06-Oct-91								
07-Oct-91								
08-Oct-91								
09-Oct-91								
10-Oct-91								
11-Oct-91								
12-Oct-91								
13-Oct-91								
14-Oct-91								
15-Oct-91								
16-Oct-91								
17-Oct-91								
18-Oct-91								
19-Oct-91								
20-Oct-91								
21-Oct-91								
22-Oct-91								
23-Oct-91								
24-Oct-91								
25-Oct-91	446	562	20	2.8	4.5	0.5	0.0	9.5
26-Oct-91	432	605	20	2.8	4.8	1.0	0.0	9.5
27-Oct-91	461	547	20	2.8	4.2	0.4	0.3	9.3
28-Oct-91	403	547	20	2.8	4.2	1.0	0.0	9.5
29-Oct-91	416	562	20	2.8	4.2	1.0	0.0	9.3
30-Oct-91	403	562	20	2.8	4.5	1.4	0.3	9.5
31-Oct-91	403	554	20	2.8	5.0	1.1	0.0	9.5

TABLE 5. ANOXIC COLUMN OPERATIONAL RESULTS (Continued)
INDUSTRI-PLEX SITE GROUNDWATER TREATABILITY RESULTS - WOBURN, MASSACHUSETTS

DATE	FEED FLOW (L/day)	FBR EFF FLOW (L/day)	METHANOL STRENGTH ADDED (%)	RECYCLE FLOW (gpm)	METHANOL ADDED (L/day)	INFLUENT D.O. (mg/L)	EFFLUENT D.O. (mg/L)	BED HEIGHT (ft)
01-Nov-91	403	547	20	2.8	4.9	1.0	0.1	9.5
02-Nov-91	403	547	20	2.8	5.0	1.1	0.0	9.5
03-Nov-91	410	547	20	2.8	5.0	0.9	0.0	9.5
04-Nov-91	403	569	20	2.8	4.9	1.1	0.0	9.5
05-Nov-91	406	554	20	2.8	4.9	1.1	0.0	9.5
06-Nov-91	403	554	20	2.8	4.8	1.0	0.0	9.5
07-Nov-91								
08-Nov-91								
09-Nov-91								
10-Nov-91								
11-Nov-91								
12-Nov-91								
13-Nov-91								
14-Nov-91								
15-Nov-91								
16-Nov-91								
17-Nov-91								
18-Nov-91								
19-Nov-91								
20-Nov-91								
21-Nov-91								
22-Nov-91								
23-Nov-91								
24-Nov-91								
25-Nov-91								
26-Nov-91								
27-Nov-91								
28-Nov-91								
29-Nov-91								
30-Nov-91								

APPENDIX 3-B

Detailed TCL Analytical Results

NATIONAL EXPRESS LABORATORIES, INC.
NATEX
Gulf South Environmental Laboratory, Inc.
6801 Press Drive—East Building
New Orleans, LA 70126
(504) 283-4223
FAX (504) 288-3625

Sample Data
Summary Package

The Advent Group

Episode: HUJ

Presented to:

Mr. Ron Falco
The Advent Group
201 Summit View Drive
Suite 313
Brentwood, TN 37027

Presented By:

Analytical Chemistry Department
Gulf South Environmental Laboratory, Inc.
P.O. Box 26518
New Orleans, Louisiana 70186

December 2, 1991

recycled paper

Gulf South Environmental Laboratory

Narrative

The Advent Group project consisted of six (6) water samples (including matrix spike and matrix spike duplicate) which were received by Gulf South Environmental Laboratory on November 13, 1991, and logged in as Episode HUJ. The samples were identified as follows:

FBRINF FBREFF ANOEFF FINFMS INFMSD TRPBLK

The samples were analyzed for volatile organics, and semivolatile organics only.

Volatile

Samples FBRINF, FINFMS and INFMSD were diluted 1:5 prior to analyses due to the level of benzene in the sample. No other problems were encountered with these analyses.

Semivolatile

Analysis of sample FBREFF yielded low recovery of acid surrogates and low area counts for d_{12}perylene (IS6). The extract was rerun to confirm these findings and this analysis is being submitted as additional information. The sample was re-extracted, re-analyzed and is being submitted as FBREFFRE. Again, acid surrogate recoveries were low, indicating a matrix effect. Inadvertently, sample FINFMS was not spiked with matrix spiking solution. The matrix spike sample was re-extracted outside the holding time. Low levels of phenol and methylphenol were detected in the sample and the MSD, but not in the MS. This may have been due to the expired holding time or to lack of homogeneity in the sample bottles.

"I certify that this data package is in compliance with the terms and conditions of the contract, both technically and for completeness, for other than the conditions detailed above. Release of the data contained in this hardcopy data package or computer-readable diskette has been authorized by the Laboratory Manager or his designee, as verified by the following signature."

Shelley R. Antoine

Shelley R. Antoine
GC/MS Laboratory Manager

12/2/91
Date

1A
VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FBRINF

Lab Name: G S E L I   Contract: ________

Lab Code: GULF   Case No.: ADVENT   SAS No.: ________   SDG No.: HUJ001

Matrix: (soil/water) WATER   Lab Sample ID: HUJ001

Sample wt/vol: 1.0 (g/mL) ML   Lab File ID: VOHUJ01

Level: (low/med) LOW   Date Received: 11/13/91

% Moisture: not dec. ____   Date Analyzed: 11/13/91

Column: (pack/cap) CAP   Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
74-87-3	Chloromethane	50	U
74-83-9	Bromomethane	50	U
75-01-4	Vinyl Chloride	50	U
75-00-3	Chloroethane	50	U
75-09-2	Methylene Chloride	13	BJ
67-64-1	Acetone	90	
75-15-0	Carbon Disulfide	25	U
75-35-4	1,1-Dichloroethene	25	U
75-34-3	1,1-Dichloroethane	25	U
540-59-0	1,2-Dichloroethene (total)	25	U
67-66-3	Chloroform	25	U
107-06-2	1,2-Dichloroethane	25	U
78-93-3	2-Butanone	50	U
71-55-6	1,1,1-Trichloroethane	25	U
56-23-5	Carbon Tetrachloride	25	U
108-05-4	Vinyl Acetate	50	U
75-27-4	Bromodichloromethane	25	U
78-87-5	1,2-Dichloropropane	25	U
10061-01-5	cis-1,3-Dichloropropene	25	U
79-01-6	Trichloroethene	25	U
124-48-1	Dibromochloromethane	25	U
79-00-5	1,1,2-Trichloroethane	25	U
71-43-2	Benzene	700	
10061-02-6	trans-1,3-Dichloropropene	25	U
75-25-2	Bromoform	25	U
108-10-1	4-Methyl-2-Pentanone	50	U
591-78-6	2-Hexanone	50	U
127-18-4	Tetrachloroethene	25	U
79-34-5	1,1,2,2-Tetrachloroethane	25	U
108-88-3	Toluene	230	
108-90-7	Chlorobenzene	25	U
100-41-4	Ethylbenzene	25	U
100-42-5	Styrene	25	U
1330-20-7	Xylene (total)	13	J

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FBRINF

Lab Name: G S E L I   Contract: ____

Lab Code: GULF   Case No.: ADVENT   SAS No.: ____   SDG No.: HUJ001

Matrix: (soil/water) WATER   Lab Sample ID: HUJ001

Sample wt/vol: 1000 (g/mL) ML   Lab File ID: SVHUJ01

Level: (low/med) LOW   Date Received: 11/13/91

% Moisture: not dec. ____ dec. ____   Date Extracted: 11/13/91

Extraction: (SepF/Cont/Sonc) CONT   Date Analyzed: 11/18/91

GPC Cleanup: (Y/N) N   pH: 8.0   Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
108-95-2	Phenol	11	
111-44-4	bis(2-Chloroethyl)Ether	10	U
95-57-8	2-Chlorophenol	10	U
541-73-1	1,3-Dichlorobenzene	10	U
106-46-7	1,4-Dichlorobenzene	10	U
100-51-6	Benzyl alcohol	10	U
95-50-1	1,2-Dichlorobenzene	10	U
95-48-7	2-Methylphenol	4	J
108-60-1	bis(2-Chloroisopropyl)ether	10	U
106-44-5	4-Methylphenol	13	
621-64-7	N-Nitroso-Di-n-Propylamine	10	U
67-72-1	Hexachloroethane	10	U
98-95-3	Nitrobenzene	10	U
78-59-1	Isophorone	10	U
88-75-5	2-Nitrophenol	10	U
105-67-9	2,4-Dimethylphenol	10	U
65-85-0	Benzoic Acid	50	U
111-91-1	bis(2-Chloroethoxy)methane	10	U
120-83-2	2,4-Dichlorophenol	10	U
120-82-1	1,2,4-Trichlorobenzene	10	U
91-20-3	Naphthalene	5	J
106-47-8	4-Chloroaniline	10	U
87-68-3	Hexachlorobutadiene	10	U
59-50-7	4-Chloro-3-methylphenol	10	U
91-57-6	2-Methylnaphthalene	10	U
77-47-4	Hexachlorocyclopentadiene	10	U
88-06-2	2,4,6-Trichlorophenol	10	U
95-95-4	2,4,5-Trichlorophenol	50	U
91-58-7	2-Chloronaphthalene	10	U
88-74-4	2-Nitroaniline	50	U
131-11-3	Dimethylphthalate	10	U
208-96-8	Acenaphthylene	10	U
606-20-2	2,6-Dinitrotoluene	10	U

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FBRINF

Lab Name: G S E L I   Contract: ____

Lab Code: GULF   Case No.: ADVENT   SAS No.: ____   SDG No.: HUJ001

Matrix: (soil/water) WATER   Lab Sample ID: HUJ001

Sample wt/vol: 1000 (g/mL) ML   Lab File ID: SVHUJ01

Level: (low/med) LOW   Date Received: 11/13/91

% Moisture: not dec. ____ dec. ____   Date Extracted: 11/13/91

Extraction: (SepF/Cont/Sonc) CONT   Date Analyzed: 11/18/91

GPC Cleanup: (Y/N) N   pH: 8.0   Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
99-09-2	3-Nitroaniline	50	U
83-32-9	Acenaphthene	10	U
51-28-5	2,4-Dinitrophenol	50	U
100-02-7	4-Nitrophenol	50	U
132-64-9	Dibenzofuran	10	U
121-14-2	2,4-Dinitrotoluene	10	U
84-66-2	Diethylphthalate	10	U
7005-72-3	4-Chlorophenyl-phenylether	10	U
86-73-7	Fluorene	10	U
100-01-6	4-Nitroaniline	50	U
534-52-1	4,6-Dinitro-2-methylphenol	50	U
86-30-6	N-Nitrosodiphenylamine (1)	10	U
101-55-3	4-Bromophenyl-phenylether	10	U
118-74-1	Hexachlorobenzene	10	U
87-86-5	Pentachlorophenol	50	U
85-01-8	Phenanthrene	10	U
120-12-7	Anthracene	10	U
84-74-2	Di-n-butylphthalate	10	U
206-44-0	Fluoranthene	10	U
129-00-0	Pyrene	10	U
85-68-7	Butylbenzylphthalate	10	U
91-94-1	3,3'-Dichlorobenzidine	20	U
56-55-3	Benzo(a)Anthracene	10	U
218-01-9	Chrysene	10	U
117-81-7	bis(2-Ethylhexyl)Phthalate	5	BJ
117-84-0	Di-n-Octylphthalate	10	U
205-99-2	Benzo(b)fluoranthene	10	U
207-08-9	Benzo(k)fluoranthene	10	U
50-32-8	Benzo(a)Pyrene	10	U
193-39-5	Indeno(1,2,3-cd)Pyrene	10	U
53-70-3	Dibenz(a,h)Anthracene	10	U
191-24-2	Benzo(g,h,i)Perylene	10	U

(1) - Cannot be separated from Diphenylamine

1A

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FBREFF

Lab Name: G S E L I Contract: ____

Lab Code: GULF Case No.: ADVENT SAS No.: ____ SDG No.: HUJ001

Matrix: (soil/water) WATER Lab Sample ID: HUJ002

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VOHUJ02

Level: (low/med) LOW Date Received: 11/13/91

% Moisture: not dec. ____ Date Analyzed: 11/13/91

Column: (pack/cap) CAP Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
74-87-3	Chloromethane	10	U
74-83-9	Bromomethane	10	U
75-01-4	Vinyl Chloride	10	U
75-00-3	Chloroethane	10	U
75-09-2	Methylene Chloride	2	BJ
67-64-1	Acetone	12	
75-15-0	Carbon Disulfide	5	U
75-35-4	1,1-Dichloroethene	5	U
75-34-3	1,1-Dichloroethane	5	U
540-59-0	1,2-Dichloroethene (total)	5	U
67-66-3	Chloroform	5	U
107-06-2	1,2-Dichloroethane	5	U
78-93-3	2-Butanone	10	U
71-55-6	1,1,1-Trichloroethane	5	U
56-23-5	Carbon Tetrachloride	5	U
108-05-4	Vinyl Acetate	10	U
75-27-4	Bromodichloromethane	5	U
78-87-5	1,2-Dichloropropane	5	U
10061-01-5	cis-1,3-Dichloropropene	5	U
79-01-6	Trichloroethene	5	U
124-48-1	Dibromochloromethane	5	U
79-00-5	1,1,2-Trichloroethane	5	U
71-43-2	Benzene	5	U
10061-02-6	trans-1,3-Dichloropropene	5	U
75-25-2	Bromoform	5	U
108-10-1	4-Methyl-2-Pentanone	10	U
591-78-6	2-Hexanone	10	U
127-18-4	Tetrachloroethene	5	U
79-34-5	1,1,2,2-Tetrachloroethane	5	U
108-88-3	Toluene	5	U
108-90-7	Chlorobenzene	5	U
100-41-4	Ethylbenzene	5	U
100-42-5	Styrene	5	U
1330-20-7	Xylene (total)	5	U

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FBREFF

Lab Name: G S E L I Contract: ______

Lab Code: GULF Case No.: ADVENT SAS No.: ______ SDG No.: HUJ001

Matrix: (soil/water) WATER Lab Sample ID: HUJ002

Sample wt/vol: 1000 (g/mL) ML Lab File ID: SVHUJ02

Level: (low/med) LOW Date Received: 11/13/91

% Moisture: not dec. ____ dec. ____ Date Extracted: 11/13/91

Extraction: (SepF/Cont/Sonc) CONT Date Analyzed: 11/18/91

GPC Cleanup: (Y/N) N pH: 7.7 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
108-95-2	Phenol	10	U
111-44-4	bis(2-Chloroethyl)Ether	10	U
95-57-8	2-Chlorophenol	10	U
541-73-1	1,3-Dichlorobenzene	10	U
106-46-7	1,4-Dichlorobenzene	10	U
100-51-6	Benzyl alcohol	10	U
95-50-1	1,2-Dichlorobenzene	10	U
95-48-7	2-Methylphenol	10	U
108-60-1	bis(2-Chloroisopropyl)ether	10	U
106-44-5	4-Methylphenol	10	U
621-64-7	N-Nitroso-Di-n-Propylamine	10	U
67-72-1	Hexachloroethane	10	U
98-95-3	Nitrobenzene	10	U
78-59-1	Isophorone	10	U
88-75-5	2-Nitrophenol	10	U
105-67-9	2,4-Dimethylphenol	10	U
65-85-0	Benzoic Acid	50	U
111-91-1	bis(2-Chloroethoxy)methane	10	U
120-83-2	2,4-Dichlorophenol	10	U
120-82-1	1,2,4-Trichlorobenzene	10	U
91-20-3	Naphthalene	10	U
106-47-8	4-Chloroaniline	10	U
87-68-3	Hexachlorobutadiene	10	U
59-50-7	4-Chloro-3-methylphenol	10	U
91-57-6	2-Methylnaphthalene	10	U
77-47-4	Hexachlorocyclopentadiene	10	U
88-06-2	2,4,6-Trichlorophenol	10	U
95-95-4	2,4,5-Trichlorophenol	50	U
91-58-7	2-Chloronaphthalene	10	U
88-74-4	2-Nitroaniline	50	U
131-11-3	Dimethylphthalate	10	U
208-96-8	Acenaphthylene	10	U
606-20-2	2,6-Dinitrotoluene	10	U

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FBREFF

Lab Name: G S E L I   Contract: ____

Lab Code: GULF   Case No.: ADVENT   SAS No.: ____   SDG No.: HUJ001

Matrix: (soil/water) WATER   Lab Sample ID: HUJ002

Sample wt/vol: 1000 (g/mL) ML   Lab File ID: SVHUJ02

Level: (low/med) LOW   Date Received: 11/13/91

% Moisture: not dec. ____ dec. ____   Date Extracted: 11/13/91

Extraction: (SepF/Cont/Sonc) CONT   Date Analyzed: 11/18/91

GPC Cleanup: (Y/N) N   pH: 7.7   Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
99-09-2	3-Nitroaniline	50	U
83-32-9	Acenaphthene	10	U
51-28-5	2,4-Dinitrophenol	50	U
100-02-7	4-Nitrophenol	50	U
132-64-9	Dibenzofuran	10	U
121-14-2	2,4-Dinitrotoluene	10	U
84-66-2	Diethylphthalate	10	U
7005-72-3	4-Chlorophenyl-phenylether	10	U
86-73-7	Fluorene	10	U
100-01-6	4-Nitroaniline	50	U
534-52-1	4,6-Dinitro-2-methylphenol	50	U
86-30-6	N-Nitrosodiphenylamine (1)	10	U
101-55-3	4-Bromophenyl-phenylether	10	U
118-74-1	Hexachlorobenzene	10	U
87-86-5	Pentachlorophenol	50	U
85-01-8	Phenanthrene	10	U
120-12-7	Anthracene	10	U
84-74-2	Di-n-butylphthalate	10	U
206-44-0	Fluoranthene	10	U
129-00-0	Pyrene	10	U
85-68-7	Butylbenzylphthalate	10	U
91-94-1	3,3'-Dichlorobenzidine	20	U
56-55-3	Benzo(a)Anthracene	10	U
218-01-9	Chrysene	10	U
117-81-7	bis(2-Ethylhexyl)Phthalate	4	BJ
117-84-0	Di-n-Octylphthalate	10	U
205-99-2	Benzo(b)fluoranthene	10	U
207-08-9	Benzo(k)fluoranthene	10	U
50-32-8	Benzo(a)Pyrene	10	U
193-39-5	Indeno(1,2,3-cd)Pyrene	10	U
53-70-3	Dibenz(a,h)Anthracene	10	U
191-24-2	Benzo(g,h,i)Perylene	10	U

(1) - Cannot be separated from Diphenylamine

1B
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FBREFFRE

Lab Name: G S E L I   Contract: ______

Lab Code: GULF   Case No.: ADVENT   SAS No.: ______   SDG No.: HUJ001

Matrix: (soil/water) WATER   Lab Sample ID: HUJ002RE

Sample wt/vol: 950 (g/mL) ML   Lab File ID: SVHUJ02RE

Level: (low/med) LOW   Date Received: 11/13/91

% Moisture: not dec. ____ dec. ____   Date Extracted: 11/18/91

Extraction: (SepF/Cont/Sonc) CONT   Date Analyzed: 11/21/91

GPC Cleanup: (Y/N) N   pH: 7.7   Dilution Factor: 1.00

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
108-95-2	Phenol	10	U
111-44-4	bis(2-Chloroethyl)Ether	10	U
95-57-8	2-Chlorophenol	10	U
541-73-1	1,3-Dichlorobenzene	10	U
106-46-7	1,4-Dichlorobenzene	10	U
100-51-6	Benzyl alcohol	10	U
95-50-1	1,2-Dichlorobenzene	10	U
95-48-7	2-Methylphenol	10	U
108-60-1	bis(2-Chloroisopropyl)ether	10	U
106-44-5	4-Methylphenol	10	U
621-64-7	N-Nitroso-Di-n-Propylamine	10	U
67-72-1	Hexachloroethane	10	U
98-95-3	Nitrobenzene	10	U
78-59-1	Isophorone	10	U
88-75-5	2-Nitrophenol	10	U
105-67-9	2,4-Dimethylphenol	10	U
65-85-0	Benzoic Acid	52	U
111-91-1	bis(2-Chloroethoxy)methane	10	U
120-83-2	2,4-Dichlorophenol	10	U
120-82-1	1,2,4-Trichlorobenzene	10	U
91-20-3	Naphthalene	10	U
106-47-8	4-Chloroaniline	10	U
87-68-3	Hexachlorobutadiene	10	U
59-50-7	4-Chloro-3-methylphenol	10	U
91-57-6	2-Methylnaphthalene	10	U
77-47-4	Hexachlorocyclopentadiene	10	U
88-06-2	2,4,6-Trichlorophenol	10	U
95-95-4	2,4,5-Trichlorophenol	52	U
91-58-7	2-Chloronaphthalene	10	U
88-74-4	2-Nitroaniline	52	U
131-11-3	Dimethylphthalate	10	U
208-96-8	Acenaphthylene	10	U
606-20-2	2,6-Dinitrotoluene	10	U

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

FBREFFRE

Lab Name: G S E L I   Contract: ________

Lab Code: GULF   Case No.: ADVENT   SAS No.: ______   SDG No.: HUJ001

Matrix: (soil/water) WATER   Lab Sample ID: HUJ002RE

Sample wt/vol: 950 (g/mL) ML   Lab File ID: SVHUJ02RE

Level: (low/med) LOW   Date Received: 11/13/91

% Moisture: not dec. ____ dec. ____   Date Extracted: 11/18/91

Extraction: (SepF/Cont/Sonc) CONT   Date Analyzed: 11/21/91

GPC Cleanup: (Y/N) N   pH: 7.7   Dilution Factor: 1.00

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
99-09-2	3-Nitroaniline	52	U
83-32-9	Acenaphthene	10	U
51-28-5	2,4-Dinitrophenol	52	U
100-02-7	4-Nitrophenol	52	U
132-64-9	Dibenzofuran	10	U
121-14-2	2,4-Dinitrotoluene	10	U
84-66-2	Diethylphthalate	10	U
7005-72-3	4-Chlorophenyl-phenylether	10	U
86-73-7	Fluorene	10	U
100-01-6	4-Nitroaniline	52	U
534-52-1	4,6-Dinitro-2-methylphenol	52	U
86-30-6	N-Nitrosodiphenylamine (1)	10	U
101-55-3	4-Bromophenyl-phenylether	10	U
118-74-1	Hexachlorobenzene	10	U
87-86-5	Pentachlorophenol	52	U
85-01-8	Phenanthrene	10	U
120-12-7	Anthracene	10	U
84-74-2	Di-n-butylphthalate	10	U
206-44-0	Fluoranthene	10	U
129-00-0	Pyrene	10	U
85-68-7	Butylbenzylphthalate	10	U
91-94-1	3,3'-Dichlorobenzidine	21	U
56-55-3	Benzo(a)Anthracene	10	U
218-01-9	Chrysene	10	U
117-81-7	bis(2-Ethylhexyl)Phthalate	3	BJ
117-84-0	Di-n-Octylphthalate	10	U
205-99-2	Benzo(b)fluoranthene	10	U
207-08-9	Benzo(k)fluoranthene	10	U
50-32-8	Benzo(a)Pyrene	10	U
193-39-5	Indeno(1,2,3-cd)Pyrene	10	U
53-70-3	Dibenz(a,h)Anthracene	10	U
191-24-2	Benzo(g,h,i)Perylene	10	U

(1) - Cannot be separated from Diphenylamine

1A
VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

ANOEFF

Lab Name: G S E L I Contract: ____

Lab Code: GULF Case No.: ADVENT SAS No.: ____ SDG No.: HUJ001

Matrix: (soil/water) WATER Lab Sample ID: HUJ003

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VOHUJ03

Level: (low/med) LOW Date Received: 11/13/91

% Moisture: not dec. ____ Date Analyzed: 11/13/91

Column: (pack/cap) CAP Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
74-87-3	Chloromethane	10	U
74-83-9	Bromomethane	10	U
75-01-4	Vinyl Chloride	10	U
75-00-3	Chloroethane	10	U
75-09-2	Methylene Chloride	2	BJ
67-64-1	Acetone	10	U
75-15-0	Carbon Disulfide	5	U
75-35-4	1,1-Dichloroethene	5	U
75-34-3	1,1-Dichloroethane	5	U
540-59-0	1,2-Dichloroethene (total)	5	U
67-66-3	Chloroform	5	U
107-06-2	1,2-Dichloroethane	5	U
78-93-3	2-Butanone	10	U
71-55-6	1,1,1-Trichloroethane	5	U
56-23-5	Carbon Tetrachloride	5	U
108-05-4	Vinyl Acetate	10	U
75-27-4	Bromodichloromethane	5	U
78-87-5	1,2-Dichloropropane	5	U
10061-01-5	cis-1,3-Dichloropropene	5	U
79-01-6	Trichloroethene	5	U
124-48-1	Dibromochloromethane	5	U
79-00-5	1,1,2-Trichloroethane	5	U
71-43-2	Benzene	5	U
10061-02-6	trans-1,3-Dichloropropene	5	U
75-25-2	Bromoform	5	U
108-10-1	4-Methyl-2-Pentanone	10	U
591-78-6	2-Hexanone	10	U
127-18-4	Tetrachloroethene	5	U
79-34-5	1,1,2,2-Tetrachloroethane	5	U
108-88-3	Toluene	5	U
108-90-7	Chlorobenzene	5	U
100-41-4	Ethylbenzene	5	U
100-42-5	Styrene	5	U
1330-20-7	Xylene (total)	5	U

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

ANOEFF

Lab Name: G S E L I   Contract: ____________

Lab Code: GULF   Case No.: ADVENT   SAS No.: ______   SDG No.: HUJ001

Matrix: (soil/water) WATER   Lab Sample ID: HUJ003

Sample wt/vol: 1000 (g/mL) ML   Lab File ID: SVHUJ03

Level: (low/med) LOW   Date Received: 11/13/91

% Moisture: not dec. ____ dec. ____   Date Extracted: 11/13/91

Extraction: (SepF/Cont/Sonc) CONT   Date Analyzed: 11/18/91

GPC Cleanup: (Y/N) N   pH: 8.3   Dilution Factor: 1.0

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L

CAS NO.	COMPOUND	UG/L	Q
108-95-2	Phenol	10	U
111-44-4	bis(2-Chloroethyl)Ether	10	U
95-57-8	2-Chlorophenol	10	U
541-73-1	1,3-Dichlorobenzene	10	U
106-46-7	1,4-Dichlorobenzene	10	U
100-51-6	Benzyl alcohol	10	U
95-50-1	1,2-Dichlorobenzene	10	U
95-48-7	2-Methylphenol	10	U
108-60-1	bis(2-Chloroisopropyl)ether	10	U
106-44-5	4-Methylphenol	10	U
621-64-7	N-Nitroso-Di-n-Propylamine	10	U
67-72-1	Hexachloroethane	10	U
98-95-3	Nitrobenzene	10	U
78-59-1	Isophorone	10	U
88-75-5	2-Nitrophenol	10	U
105-67-9	2,4-Dimethylphenol	10	U
65-85-0	Benzoic Acid	50	U
111-91-1	bis(2-Chloroethoxy)methane	10	U
120-83-2	2,4-Dichlorophenol	10	U
120-82-1	1,2,4-Trichlorobenzene	10	U
91-20-3	Naphthalene	10	U
106-47-8	4-Chloroaniline	10	U
87-68-3	Hexachlorobutadiene	10	U
59-50-7	4-Chloro-3-methylphenol	10	U
91-57-6	2-Methylnaphthalene	10	U
77-47-4	Hexachlorocyclopentadiene	10	U
88-06-2	2,4,6-Trichlorophenol	10	U
95-95-4	2,4,5-Trichlorophenol	50	U
91-58-7	2-Chloronaphthalene	10	U
88-74-4	2-Nitroaniline	50	U
131-11-3	Dimethylphthalate	10	U
208-96-8	Acenaphthylene	10	U
606-20-2	2,6-Dinitrotoluene	10	U

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

ANOEFF

Lab Name: G S E L I　　Contract: ____

Lab Code: GULF　　Case No.: ADVENT　　SAS No.: ____　　SDG No.: HUJ001

Matrix: (soil/water) WATER　　Lab Sample ID: HUJ003

Sample wt/vol: 1000 (g/mL) ML　　Lab File ID: SVHUJ03

Level: (low/med) LOW　　Date Received: 11/13/91

% Moisture: not dec. ____ dec. ____　　Date Extracted: 11/13/91

Extraction: (SepF/Cont/Sonc) CONT　　Date Analyzed: 11/18/91

GPC Cleanup: (Y/N) N　　pH: 8.3　　Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
99-09-2	3-Nitroaniline	50	U
83-32-9	Acenaphthene	10	U
51-28-5	2,4-Dinitrophenol	50	U
100-02-7	4-Nitrophenol	50	U
132-64-9	Dibenzofuran	10	U
121-14-2	2,4-Dinitrotoluene	10	U
84-66-2	Diethylphthalate	10	U
7005-72-3	4-Chlorophenyl-phenylether	10	U
86-73-7	Fluorene	10	U
100-01-6	4-Nitroaniline	50	U
534-52-1	4,6-Dinitro-2-methylphenol	50	U
86-30-6	N-Nitrosodiphenylamine (1)	10	U
101-55-3	4-Bromophenyl-phenylether	10	U
118-74-1	Hexachlorobenzene	10	U
87-86-5	Pentachlorophenol	50	U
85-01-8	Phenanthrene	10	U
120-12-7	Anthracene	10	U
84-74-2	Di-n-butylphthalate	10	U
206-44-0	Fluoranthene	10	U
129-00-0	Pyrene	10	U
85-68-7	Butylbenzylphthalate	10	U
91-94-1	3,3'-Dichlorobenzidine	20	U
56-55-3	Benzo(a)Anthracene	10	U
218-01-9	Chrysene	10	U
117-81-7	bis(2-Ethylhexyl)Phthalate	4	BJ
117-84-0	Di-n-Octylphthalate	10	U
205-99-2	Benzo(b)fluoranthene	10	U
207-08-9	Benzo(k)fluoranthene	10	U
50-32-8	Benzo(a)Pyrene	10	U
193-39-5	Indeno(1,2,3-cd)Pyrene	10	U
53-70-3	Dibenz(a,h)Anthracene	10	U
191-24-2	Benzo(g,h,i)Perylene	10	U

(1) - Cannot be separated from Diphenylamine

1A

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

TRPBLK

Lab Name: G S E L I Contract: ____________

Lab Code: GULF Case No.: ADVENT SAS No.: ________ SDG No.: HUJ001

Matrix: (soil/water) WATER Lab Sample ID: HUJ006

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: VOHUJ06

Level: (low/med) LOW Date Received: 11/13/91

% Moisture: not dec. ____ Date Analyzed: 11/13/91

Column: (pack/cap) CAP Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
74-87-3	Chloromethane	10	U
74-83-9	Bromomethane	10	U
75-01-4	Vinyl Chloride	10	U
75-00-3	Chloroethane	10	U
75-09-2	Methylene Chloride	8	B
67-64-1	Acetone	10	U
75-15-0	Carbon Disulfide	5	U
75-35-4	1,1-Dichloroethene	5	U
75-34-3	1,1-Dichloroethane	5	U
540-59-0	1,2-Dichloroethene (total)	5	U
67-66-3	Chloroform	5	U
107-06-2	1,2-Dichloroethane	5	U
78-93-3	2-Butanone	10	U
71-55-6	1,1,1-Trichloroethane	5	U
56-23-5	Carbon Tetrachloride	5	U
108-05-4	Vinyl Acetate	10	U
75-27-4	Bromodichloromethane	5	U
78-87-5	1,2-Dichloropropane	5	U
10061-01-5	cis-1,3-Dichloropropene	5	U
79-01-6	Trichloroethene	5	U
124-48-1	Dibromochloromethane	5	U
79-00-5	1,1,2-Trichloroethane	5	U
71-43-2	Benzene	5	U
10061-02-6	trans-1,3-Dichloropropene	5	U
75-25-2	Bromoform	5	U
108-10-1	4-Methyl-2-Pentanone	10	U
591-78-6	2-Hexanone	10	U
127-18-4	Tetrachloroethene	5	U
79-34-5	1,1,2,2-Tetrachloroethane	5	U
108-88-3	Toluene	5	U
108-90-7	Chlorobenzene	5	U
100-41-4	Ethylbenzene	5	U
100-42-5	Styrene	5	U
1330-20-7	Xylene (total)	5	U

2A

WATER VOLATILE SURROGATE RECOVERY

L Name: G S E L I Contract: ____________

Lab Code: GULF Case No.: ADVENT SAS No.: ________ SDG No.: HUJ001

	EPA SAMPLE NO.	S1 (TOL)#	S2 (BFB)#	S3 (DCE)#	OTHER	TOT OUT
01	ANOEFF	102	89	99		0
02	FBREFF	100	89	96		0
03	FBRINF	99	94	101		0
04	TRPBLK	103	88	95		0
05	FINFMS	100	89	95		0
06	INFMSD	99	88	100		0
07	VBLKW1	105	90	96		0

	QC LIMITS
S1 (TOL) = Toluene-d8	(88-110)
S2 (BFB) = Bromofluorobenzene	(86-115)
S3 (DCE) = 1,2-Dichloroethane-d4	(76-114)

Column to be used to flag recovery values

* Values outside of contract required QC limits

D Surrogates diluted out

2C

WATER SEMIVOLATILE SURROGATE RECOVERY

Lab Name: G S E L I Contract: ____________

Lab Code: GULF Case No.: ADVENT SAS No.: ________ SDG No.: HUJ001

	EPA SAMPLE NO.	S1 (NBZ) #	S2 (FBP) #	S3 (TPH) #	S4 (PHL) #	S5 (2FP) #	S6 (TBP) #	OTHER	TOT OUT
01	ANOEFF	75	71	70	76	72	66		0
02	FBREFF	78	68	65	*	0 *	16		2
03	FBREFFRE	74	66	68	5 *	0 *	28		2
04	FBRINF	82	68	65	78	70	84		0
05	FINFMS	85	83	74	77	87	85		0
06	INFMSD	76	72	69	74	66	79		0
07	SBLKW1	76	61	61	73	88	70		0
08	SBLKW2	78	77	73	78	80	86		0
09	SBLKW3	72	60	79	66	61	79		0

	QC LIMITS
S1 (NBZ) = Nitrobenzene-d5	(35-114)
S2 (FBP) = 2-Fluorobiphenyl	(43-116)
S3 (TPH) = Terphenyl	(33-141)
S4 (PHL) = Phenol-d5	(10-94)
S5 (2FP) = 2-Fluorophenol	(21-100)
S6 (TBP) = 2,4,6-Tribromophenol	(10-123)

Column to be used to flag recovery values
* Values outside of contract required QC limits
D Surrogates diluted out

3A

WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Lab Name: G S E L I   Contract: ____________

Lab Code: GULF   Case No.: ADVENT   SAS No.: ________   SDG No.: HUJ001

Matrix Spike - EPA Sample No.: FBRINF

COMPOUND	SPIKE ADDED (ug/L)	SAMPLE CONCENTRATION (ug/L)	MS CONCENTRATION (ug/L)	MS % REC #	QC LIMITS REC.
1,1-Dichloroethene	250	0	250	100	61-145
Trichloroethene	250	0	243	97	71-120
Benzene	250	695	910	86	76-127
Toluene	250	226	470	98	76-125
Chlorobenzene	250	0	262	105	75-130

COMPOUND	SPIKE ADDED (ug/L)	MSD CONCENTRATION (ug/L)	MSD % REC #	% RPD #	QC LIMITS RPD	QC LIMITS REC.
1,1-Dichloroethene	250	268	107	-7	14	61-145
Trichloroethene	250	245	98	-1	14	71-120
Benzene	250	970	110	-24 *	11	76-127
Toluene	250	498	109	-11	13	76-125
Chlorobenzene	250	264	106	-1	13	75-130

Column to be used to flag recovery and RPD values with an asterisk

* Values outside of QC limits

RPD: 1 out of 5 outside limits
Spike Recovery: 0 out of 10 outside limits

COMMENTS: FBRINF (WATER 1ML 1:5DIL) CLIENT:ADVENT
RTX-502.2 60M X 0.53MM 40/3-220@8 INST F

3C

WATER SEMIVOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Lab Name: G S E L I Contract: ____________

Lab Code: GULF Case No.: ADVENT SAS No.: ________ SDG No.: HUJ001

Matrix Spike - EPA Sample No.: FBRINF

COMPOUND	SPIKE ADDED (ug/L)	SAMPLE CONCENTRATION (ug/L)	MS CONCENTRATION (ug/L)	MS % REC #	QC LIMITS REC.
Phenol	104	11.3	87.4	73	12- 89
2-Chlorophenol	104	0	78.3	75	27-123
1,4-Dichlorobenzene	52.0	0	42.5	82	36 97
N-Nitroso-di-n-prop. (1)	52.0	0	46.8	90	41 116
1,2,4-Trichlorobenzene	52.0	0	45.4	87	39 98
4-Chloro-3-methylphenol	104	0	75.7	73	23 97
Acenaphthene	52.0	0	44.7	86	46-118
4-Nitrophenol	104	0	89.6	86 *	10- 80
2,4-Dinitrotoluene	52.0	0	41.6	80	24- 96
Pentachlorophenol	104	0	83.5	80	9-103
Pyrene	52.0	0	42.1	81	26-127

COMPOUND	SPIKE ADDED (ug/L)	MSD CONCENTRATION (ug/L)	MSD % REC #	% RPD #	QC LIMITS RPD	QC LIMITS REC.
Phenol	100	74.6	63	15	42	12- 89
2-Chlorophenol	100	71.2	71	5	40	27-123
1,4-Dichlorobenzene	50.0	38.7	77	6	28	36 97
N-Nitroso-di-n-prop. (1)	50.0	42.4	85	6	38	41 116
1,2,4-Trichlorobenzene	50.0	37.7	75	15	28	39 98
4-Chloro-3-methylphenol	100	70.5	70	4	42	23 97
Acenaphthene	50.0	39.0	78	10	31	46-118
4-Nitrophenol	100	76.5	76	12	50	10- 80
2,4-Dinitrotoluene	50.0	40.7	81	-1	38	24- 96
Pentachlorophenol	100	67.3	67	18	50	9-103
Pyrene	50.0	38.2	76	6	31	26-127

(1) N-Nitroso-di-n-propylamine

Column to be used to flag recovery and RPD values with an asterisk
* Values outside of QC limits

RPD: 0 out of 11 outside limits
Spike Recovery: 1 out of 22 outside limits

COMMENTS: FBRINF WATER ADVENT
0.32MM X 30M RTX-5 1.0UM 45/4-300@12 INST C

4A

VOLATILE METHOD BLANK SUMMARY

l Name: G S E L I Contract: ____________

Lab Code: GULF Case No.: ADVENT SAS No.: ________ SDG No.: HUJ001

Lab File ID: FVB111391B Lab Sample ID: VBLKW1

Date Analyzed: 11/13/91 Time Analyzed: 1150

Matrix: (soil/water) WATER Level:(low/med) LOW

Instrument ID: F

THIS METHOD BLANK APPLIES TO THE FOLLOWING SAMPLES, MS AND MSD:

	EPA SAMPLE NO.	LAB SAMPLE ID	LAB FILE ID	TIME ANALYZED
01	ANOEFF	HUJ003	VOHUJ03	1711
02	FBREFF	HUJ002	VOHUJ02	1615
03	FBRINF	HUJ001	VOHUJ01	1528
04	TRPBLK	HUJ006	VOHUJ06	1419
05	FINFMS	HUJ004	VOHUJ04MS	1807
06	INFMSD	HUJ005	VOHUJ04MSD	1846

[1ENTS: VBLKW (WATER 5MLS) BLANK CASE/SAS/CLIENT:
RTX-502.2 60M X 0.53MM 40/3-220@8 INST F

4B

SEMIVOLATILE METHOD BLANK SUMMARY

Lab Name: G S E L I Contract: ____________

Lab Code: GULF Case No.: ADVENT SAS No.: ________ SDG No.: HUJ001

Lab File ID: SVBW073B4 Lab Sample ID: SBLKW1

Date Extracted: 11/13/91 Extraction:(SepF/Cont/Sonc) CONT

Date Analyzed: 11/15/91 Time Analyzed: 1351

Matrix: (soil/water) WATER Level:(low/med) LOW

Instrument ID: C

THIS METHOD BLANK APPLIES TO THE FOLLOWING SAMPLES, MS AND MSD:

	EPA SAMPLE NO.	LAB SAMPLE ID	LAB FILE ID	DATE ANALYZED
01	ANOEFF	HUJ003	SVHUJ03	11/18/91
02	FBREFF	HUJ002	SVHUJ02	11/18/91
03	FBRINF	HUJ001	SVHUJ01	11/18/91
04	INFMSD	HUJ005MSD	SVHUJ05MSD	11/18/91

COMMENTS: SBLKW WATER BW073B4
0.32MM X 30M RTX-5 1.0UM 45/4-300@12 INST C

4B
SEMIVOLATILE METHOD BLANK SUMMARY

L Name: G S E L I Contract: ___________

Lab Code: GULF Case No.: ADVENT SAS No.: _______ SDG No.: HUJ001

Lab File ID: SVBW075B1 Lab Sample ID: SBLKW2

Date Extracted: 11/18/91 Extraction:(SepF/Cont/Sonc) CONT

Date Analyzed: 11/21/91 Time Analyzed: 1246

Matrix: (soil/water) WATER Level:(low/med) LOW

Instrument ID: C

THIS METHOD BLANK APPLIES TO THE FOLLOWING SAMPLES, MS AND MSD:

	EPA SAMPLE NO.	LAB SAMPLE ID	LAB FILE ID	DATE ANALYZED
01	FBREFFRE	HUJ002RE	SVHUJ02RE	11/21/91

COMMENTS: SBLKW WATER BW075B1 BATCH BW9175
0.32MM X 30M RTX-5 1.0UM 45/4-300@12 INST C

4B

SEMIVOLATILE METHOD BLANK SUMMARY

Lab Name: G S E L I Contract: ____________

Lab Code: GULF Case No.: ADVENT SAS No.: ________ SDG No.: HUJ001

Lab File ID: SVBW076B1 Lab Sample ID: SBLKW3

Date Extracted: 11/19/91 Extraction:(SepF/Cont/Sonc) CONT

Date Analyzed: 11/21/91 Time Analyzed: 1602

Matrix: (soil/water) WATER Level:(low/med) LOW

Instrument ID: C

THIS METHOD BLANK APPLIES TO THE FOLLOWING SAMPLES, MS AND MSD:

	EPA SAMPLE NO.	LAB SAMPLE ID	LAB FILE ID	DATE ANALYZED
01	FINFMS	HUJ004MS	SVHUJ04MSRE	11/21/91

COMMENTS: SVBLKW WATER BW076B1
0.32MM X 30M RTX-5 1.0UM 45/4-300@12 INST C

1A
VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

VBLKW1

Lab Name: G S E L I Contract: ____________

Lab Code: GULF Case No.: ADVENT SAS No.: ________ SDG No.: HUJ001

Matrix: (soil/water) WATER Lab Sample ID: VBLKW1

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: FVB111391B

Level: (low/med) LOW Date Received: ________

% Moisture: not dec. ____ Date Analyzed: 11/13/91

Column: (pack/cap) CAP Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
74-87-3	Chloromethane	10	U
74-83-9	Bromomethane	10	U
75-01-4	Vinyl Chloride	10	U
75-00-3	Chloroethane	10	U
75-09-2	Methylene Chloride	2	J
67-64-1	Acetone	10	U
75-15-0	Carbon Disulfide	5	U
75-35-4	1,1-Dichloroethene	5	U
75-34-3	1,1-Dichloroethane	5	U
540-59-0	1,2-Dichloroethene (total)	5	U
67-66-3	Chloroform	5	U
107-06-2	1,2-Dichloroethane	5	U
78-93-3	2-Butanone	10	U
71-55-6	1,1,1-Trichloroethane	5	U
56-23-5	Carbon Tetrachloride	5	U
108-05-4	Vinyl Acetate	10	U
75-27-4	Bromodichloromethane	5	U
78-87-5	1,2-Dichloropropane	5	U
10061-01-5	cis-1,3-Dichloropropene	5	U
79-01-6	Trichloroethene	5	U
124-48-1	Dibromochloromethane	5	U
79-00-5	1,1,2-Trichloroethane	5	U
71-43-2	Benzene	5	U
10061-02-6	trans-1,3-Dichloropropene	5	U
75-25-2	Bromoform	5	U
108-10-1	4-Methyl-2-Pentanone	10	U
591-78-6	2-Hexanone	10	U
127-18-4	Tetrachloroethene	5	U
79-34-5	1,1,2,2-Tetrachloroethane	5	U
108-88-3	Toluene	5	U
108-90-7	Chlorobenzene	5	U
100-41-4	Ethylbenzene	5	U
100-42-5	Styrene	5	U
1330-20-7	Xylene (total)	5	U

1B
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

SBLKW1

Lab Name: G S E L I   Contract: ____

Lab Code: GULF   Case No.: ADVENT   SAS No.: ____   SDG No.: HUJ001

Matrix: (soil/water) WATER   Lab Sample ID: SBLKW1

Sample wt/vol: 1000 (g/mL) ML   Lab File ID: SVBW073B4

Level: (low/med) LOW   Date Received: ____

% Moisture: not dec. ____ dec. ____   Date Extracted: 11/13/91

Extraction: (SepF/Cont/Sonc) CONT   Date Analyzed: 11/15/91

GPC Cleanup: (Y/N) N   pH: 7.8   Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
108-95-2	Phenol	10	U
111-44-4	bis(2-Chloroethyl)Ether	10	U
95-57-8	2-Chlorophenol	10	U
541-73-1	1,3-Dichlorobenzene	10	U
106-46-7	1,4-Dichlorobenzene	10	U
100-51-6	Benzyl alcohol	10	U
95-50-1	1,2-Dichlorobenzene	10	U
95-48-7	2-Methylphenol	10	U
108-60-1	bis(2-Chloroisopropyl)ether	10	U
106-44-5	4-Methylphenol	10	U
621-64-7	N-Nitroso-Di-n-Propylamine	10	U
67-72-1	Hexachloroethane	10	U
98-95-3	Nitrobenzene	10	U
78-59-1	Isophorone	10	U
88-75-5	2-Nitrophenol	10	U
105-67-9	2,4-Dimethylphenol	10	U
65-85-0	Benzoic Acid	50	U
111-91-1	bis(2-Chloroethoxy)methane	10	U
120-83-2	2,4-Dichlorophenol	10	U
120-82-1	1,2,4-Trichlorobenzene	10	U
91-20-3	Naphthalene	10	U
106-47-8	4-Chloroaniline	10	U
87-68-3	Hexachlorobutadiene	10	U
59-50-7	4-Chloro-3-methylphenol	10	U
91-57-6	2-Methylnaphthalene	10	U
77-47-4	Hexachlorocyclopentadiene	10	U
88-06-2	2,4,6-Trichlorophenol	10	U
95-95-4	2,4,5-Trichlorophenol	50	U
91-58-7	2-Chloronaphthalene	10	U
88-74-4	2-Nitroaniline	50	U
131-11-3	Dimethylphthalate	10	U
208-96-8	Acenaphthylene	10	U
606-20-2	2,6-Dinitrotoluene	10	U

1C
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

SBLKW1

Lab Name: G S E L I   Contract: ______

Lab Code: GULF   Case No.: ADVENT   SAS No.: ______   SDG No.: HUJ001

Matrix: (soil/water) WATER   Lab Sample ID: SBLKW1

Sample wt/vol: 1000 (g/mL) ML   Lab File ID: SVBW073B4

Level: (low/med) LOW   Date Received: ______

% Moisture: not dec. ____ dec. ____   Date Extracted: 11/13/91

Extraction: (SepF/Cont/Sonc) CONT   Date Analyzed: 11/15/91

GPC Cleanup: (Y/N) N   pH: 7.8   Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
99-09-2	3-Nitroaniline	50	U
83-32-9	Acenaphthene	10	U
51-28-5	2,4-Dinitrophenol	50	U
100-02-7	4-Nitrophenol	50	U
132-64-9	Dibenzofuran	10	U
121-14-2	2,4-Dinitrotoluene	10	U
84-66-2	Diethylphthalate	10	U
7005-72-3	4-Chlorophenyl-phenylether	10	U
86-73-7	Fluorene	10	U
100-01-6	4-Nitroaniline	50	U
534-52-1	4,6-Dinitro-2-methylphenol	50	U
86-30-6	N-Nitrosodiphenylamine (1)	10	U
101-55-3	4-Bromophenyl-phenylether	10	U
118-74-1	Hexachlorobenzene	10	U
87-86-5	Pentachlorophenol	50	U
85-01-8	Phenanthrene	10	U
120-12-7	Anthracene	10	U
84-74-2	Di-n-butylphthalate	10	U
206-44-0	Fluoranthene	10	U
129-00-0	Pyrene	10	U
85-68-7	Butylbenzylphthalate	10	U
91-94-1	3,3'-Dichlorobenzidine	20	U
56-55-3	Benzo(a)Anthracene	10	U
218-01-9	Chrysene	10	U
117-81-7	bis(2-Ethylhexyl)Phthalate	2	J
117-84-0	Di-n-Octylphthalate	10	U
205-99-2	Benzo(b)fluoranthene	10	U
207-08-9	Benzo(k)fluoranthene	10	U
50-32-8	Benzo(a)Pyrene	10	U
193-39-5	Indeno(1,2,3-cd)Pyrene	10	U
53-70-3	Dibenz(a,h)Anthracene	10	U
191-24-2	Benzo(g,h,i)Perylene	10	U

(1) - Cannot be separated from Diphenylamine

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

SBLKW2

Lab Name: G S E L I Contract: ____________

Lab Code: GULF Case No.: ADVENT SAS No.: ________ SDG No.: HUJ001

Matrix: (soil/water) WATER Lab Sample ID: SBLKW2

Sample wt/vol: 1000 (g/mL) ML Lab File ID: SVBW075B1

Level: (low/med) LOW Date Received: ________

% Moisture: not dec. ____ dec. ____ Date Extracted: 11/18/91

Extraction: (SepF/Cont/Sonc) CONT Date Analyzed: 11/21/91

GPC Cleanup: (Y/N) N pH: 8.7 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
108-95-2	Phenol	10	U
111-44-4	bis(2-Chloroethyl)Ether	10	U
95-57-8	2-Chlorophenol	10	U
541-73-1	1,3-Dichlorobenzene	10	U
106-46-7	1,4-Dichlorobenzene	10	U
100-51-6	Benzyl alcohol	10	U
95-50-1	1,2-Dichlorobenzene	10	U
95-48-7	2-Methylphenol	10	U
108-60-1	bis(2-Chloroisopropyl)ether	10	U
106-44-5	4-Methylphenol	10	U
621-64-7	N-Nitroso-Di-n-Propylamine	10	U
67-72-1	Hexachloroethane	10	U
98-95-3	Nitrobenzene	10	U
78-59-1	Isophorone	10	U
88-75-5	2-Nitrophenol	10	U
105-67-9	2,4-Dimethylphenol	10	U
65-85-0	Benzoic Acid	50	U
111-91-1	bis(2-Chloroethoxy)methane	10	U
120-83-2	2,4-Dichlorophenol	10	U
120-82-1	1,2,4-Trichlorobenzene	10	U
91-20-3	Naphthalene	10	U
106-47-8	4-Chloroaniline	10	U
87-68-3	Hexachlorobutadiene	10	U
59-50-7	4-Chloro-3-methylphenol	10	U
91-57-6	2-Methylnaphthalene	2	J
77-47-4	Hexachlorocyclopentadiene	10	U
88-06-2	2,4,6-Trichlorophenol	10	U
95-95-4	2,4,5-Trichlorophenol	50	U
91-58-7	2-Chloronaphthalene	10	U
88-74-4	2-Nitroaniline	50	U
131-11-3	Dimethylphthalate	10	U
208-96-8	Acenaphthylene	10	U
606-20-2	2,6-Dinitrotoluene	10	U

1C
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

SBLKW2

Lab Name: G S E L I   Contract: ____________

Lab Code: GULF   Case No.: ADVENT   SAS No.: ________   SDG No.: HUJ001

Matrix: (soil/water) WATER   Lab Sample ID: SBLKW2

Sample wt/vol: 1000 (g/mL) ML   Lab File ID: SVBW075B1

Level: (low/med) LOW   Date Received: ________

% Moisture: not dec. ____ dec. ____   Date Extracted: 11/18/91

Extraction: (SepF/Cont/Sonc) CONT   Date Analyzed: 11/21/91

GPC Cleanup: (Y/N) N   pH: 8.7   Dilution Factor: 1.0

CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L

CAS NO.	COMPOUND	CONCENTRATION	Q
99-09-2	3-Nitroaniline	50	U
83-32-9	Acenaphthene	2	J
51-28-5	2,4-Dinitrophenol	50	U
100-02-7	4-Nitrophenol	50	U
132-64-9	Dibenzofuran	10	U
121-14-2	2,4-Dinitrotoluene	10	U
84-66-2	Diethylphthalate	10	U
7005-72-3	4-Chlorophenyl-phenylether	10	U
86-73-7	Fluorene	10	U
100-01-6	4-Nitroaniline	50	U
534-52-1	4,6-Dinitro-2-methylphenol	50	U
86-30-6	N-Nitrosodiphenylamine (1)	10	U
101-55-3	4-Bromophenyl-phenylether	10	U
118-74-1	Hexachlorobenzene	10	U
87-86-5	Pentachlorophenol	50	U
85-01-8	Phenanthrene	10	U
120-12-7	Anthracene	10	U
84-74-2	Di-n-butylphthalate	10	U
206-44-0	Fluoranthene	10	U
129-00-0	Pyrene	3	J
85-68-7	Butylbenzylphthalate	10	U
91-94-1	3,3'-Dichlorobenzidine	20	U
56-55-3	Benzo(a)Anthracene	10	U
218-01-9	Chrysene	10	U
117-81-7	bis(2-Ethylhexyl)Phthalate	2	J
117-84-0	Di-n-Octylphthalate	10	U
205-99-2	Benzo(b)fluoranthene	10	U
207-08-9	Benzo(k)fluoranthene	10	U
50-32-8	Benzo(a)Pyrene	10	U
193-39-5	Indeno(1,2,3-cd)Pyrene	10	U
53-70-3	Dibenz(a,h)Anthracene	10	U
191-24-2	Benzo(g,h,i)Perylene	10	U

(1) - Cannot be separated from Diphenylamine

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

SBLKW3

Lab Name: G S E L I   Contract: ______

Lab Code: GULF   Case No.: ADVENT   SAS No.: ______   SDG No.: HUJ001

Matrix: (soil/water) WATER   Lab Sample ID: SBLKW3

Sample wt/vol: 1000 (g/mL) ML   Lab File ID: SVBW076B1

Level: (low/med) LOW   Date Received: ______

% Moisture: not dec. ____ dec. ____   Date Extracted: 11/19/91

Extraction: (SepF/Cont/Sonc) CONT   Date Analyzed: 11/21/91

GPC Cleanup: (Y/N) N   pH: 7.9   Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
108-95-2	Phenol	10	U
111-44-4	bis(2-Chloroethyl)Ether	10	U
95-57-8	2-Chlorophenol	10	U
541-73-1	1,3-Dichlorobenzene	10	U
106-46-7	1,4-Dichlorobenzene	10	U
100-51-6	Benzyl alcohol	10	U
95-50-1	1,2-Dichlorobenzene	10	U
95-48-7	2-Methylphenol	10	U
108-60-1	bis(2-Chloroisopropyl)ether	10	U
106-44-5	4-Methylphenol	10	U
621-64-7	N-Nitroso-Di-n-Propylamine	10	U
67-72-1	Hexachloroethane	10	U
98-95-3	Nitrobenzene	10	U
78-59-1	Isophorone	10	U
88-75-5	2-Nitrophenol	10	U
105-67-9	2,4-Dimethylphenol	10	U
65-85-0	Benzoic Acid	50	U
111-91-1	bis(2-Chloroethoxy)methane	10	U
120-83-2	2,4-Dichlorophenol	10	U
120-82-1	1,2,4-Trichlorobenzene	10	U
91-20-3	Naphthalene	10	U
106-47-8	4-Chloroaniline	10	U
87-68-3	Hexachlorobutadiene	10	U
59-50-7	4-Chloro-3-methylphenol	10	U
91-57-6	2-Methylnaphthalene	10	U
77-47-4	Hexachlorocyclopentadiene	10	U
88-06-2	2,4,6-Trichlorophenol	10	U
95-95-4	2,4,5-Trichlorophenol	50	U
91-58-7	2-Chloronaphthalene	10	U
88-74-4	2-Nitroaniline	50	U
131-11-3	Dimethylphthalate	10	U
208-96-8	Acenaphthylene	10	U
606-20-2	2,6-Dinitrotoluene	10	U

1C
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

SBLKW3

Lab Name: G S E L I Contract: ____

Lab Code: GULF Case No.: ADVENT SAS No.: ____ SDG No.: HUJ001

Matrix: (soil/water) WATER Lab Sample ID: SBLKW3

Sample wt/vol: 1000 (g/mL) ML Lab File ID: SVBW076B1

Level: (low/med) LOW Date Received: ____

% Moisture: not dec. ____ dec. ____ Date Extracted: 11/19/91

Extraction: (SepF/Cont/Sonc) CONT Date Analyzed: 11/21/91

GPC Cleanup: (Y/N) N pH: 7.9 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
99-09-2	3-Nitroaniline	50	U
83-32-9	Acenaphthene	10	U
51-28-5	2,4-Dinitrophenol	50	U
100-02-7	4-Nitrophenol	50	U
132-64-9	Dibenzofuran	10	U
121-14-2	2,4-Dinitrotoluene	10	U
84-66-2	Diethylphthalate	10	U
7005-72-3	4-Chlorophenyl-phenylether	10	U
86-73-7	Fluorene	10	U
100-01-6	4-Nitroaniline	50	U
534-52-1	4,6-Dinitro-2-methylphenol	50	U
86-30-6	N-Nitrosodiphenylamine (1)	10	U
101-55-3	4-Bromophenyl-phenylether	10	U
118-74-1	Hexachlorobenzene	10	U
87-86-5	Pentachlorophenol	50	U
85-01-8	Phenanthrene	10	U
120-12-7	Anthracene	10	U
84-74-2	Di-n-butylphthalate	10	U
206-44-0	Fluoranthene	10	U
129-00-0	Pyrene	10	U
85-68-7	Butylbenzylphthalate	10	U
91-94-1	3,3'-Dichlorobenzidine	20	U
56-55-3	Benzo(a)Anthracene	10	U
218-01-9	Chrysene	10	U
117-81-7	bis(2-Ethylhexyl)Phthalate	3	J
117-84-0	Di-n-Octylphthalate	10	U
205-99-2	Benzo(b)fluoranthene	10	U
207-08-9	Benzo(k)fluoranthene	10	U
50-32-8	Benzo(a)Pyrene	10	U
193-39-5	Indeno(1,2,3-cd)Pyrene	10	U
53-70-3	Dibenz(a,h)Anthracene	10	U
191-24-2	Benzo(g,h,i)Perylene	10	U

(1) - Cannot be separated from Diphenylamine

8A

VOLATILE INTERNAL STANDARD AREA SUMMARY

Lab Name: G S E L I Contract: ____________

Lab Code: GULF Case No.: ADVENT SAS No.: ________ SDG No.: HUJ001

Lab File ID (Standard): FVS111391A Date Analyzed: 11/13/91

Instrument ID: F Time Analyzed: 1039

Matrix:(soil/water) WATER Level:(low/med) LOW Column:(pack/cap) CAP

		IS1(BCM) AREA #	RT	IS2(DFB) AREA #	RT	IS3(CBZ) AREA #	RT
	12 HOUR STD	30499	5.52	113237	6.85	93919	11.52
	UPPER LIMIT	60998		226474		187838	
	LOWER LIMIT	15250		56618		46960	
	EPA SAMPLE NO.						
01	ANDEFF	29522	5.48	111297	6.83	92408	11.50
02	FBREFF	29752	5.47	111573	6.82	96803	11.50
03	FBRINF	29430	5.45	106243	6.82	93539	11.50
04	TRPBLK	29521	5.48	111723	6.83	91251	11.52
05	FINFMS	33213	5.47	122079	6.83	101989	11.50
06	INFMSD	29320	5.47	112222	6.82	95992	11.50
07	VBLKW1	30173	5.50	114051	6.85	90631	11.52

IS1 (BCM) = Bromochloromethane
IS2 (DFB) = 1,4-Difluorobenzene
IS3 (CBZ) = Chlorobenzene

UPPER LIMIT = + 100% of internal standard area.
LOWER LIMIT = - 50% of internal standard area.

Column used to flag internal standard area values with an asterisk

8B

SEMIVOLATILE INTERNAL STANDARD AREA SUMMARY

L_ Name: G S E L I Contract: ____________

Lab Code: GULF Case No.: ADVENT SAS No.: ________ SDG No.: HUJ001

Lab File ID (Standard): CS111591A Date Analyzed: 11/15/91

Instrument ID: C Time Analyzed: 1002

		IS1(DCB) AREA #	RT	IS2(NPT) AREA #	RT	IS3(ANT) AREA #	RT
	12 HOUR STD	11591	8.75	48631	12.17	25678	16.74
	UPPER LIMIT	23182		97262		51356	
	LOWER LIMIT	5796		24316		12839	
	EPA SAMPLE NO.						
01	SBLKW1	13886	8.74	57348	12.17	29911	16.75

IS1 (DCB) = 1,4-Dichlorobenzene-d4
S2 (NPT) = Naphthalene-d8
IS3 (ANT) = Acenaphthene-d10

UPPER LIMIT = + 100% of internal standard area.
LOWER LIMIT = - 50% of internal standard area.

Column used to flag internal standard area values with an asterisk

8C

SEMIVOLATILE INTERNAL STANDARD AREA SUMMARY

Lab Name: G S E L I Contract: ____________

Lab Code: GULF Case No.: ADVENT SAS No.: ________ SDG No.: HUJ001

Lab File ID (Standard): CS111591A Date Analyzed: 11/15/91

Instrument ID: C Time Analyzed: 1002

	IS4(PHN) AREA #	RT	IS5(CRY) AREA #	RT	IS6(PRY) AREA #	RT
12 HOUR STD	39622	20.49	28212	27.32	26803	31.11
UPPER LIMIT	79244		56424		53606	
LOWER LIMIT	19811		14106		13402	
EPA SAMPLE NO.						
01 SBLKW1	47879	20.49	41546	27.32	40772	31.16

IS4 (PHN) = Phenanthrene-d10
IS5 (CRY) = Chrysene-d12
IS6 (PRY) = Perylene-d12

UPPER LIMIT = + 100% of internal standard area.
LOWER LIMIT = - 50% of internal standard area.

Column used to flag internal standard area values with an asterisk

8B

SEMIVOLATILE INTERNAL STANDARD AREA SUMMARY

Lab Name: G S E L I Contract: ____________

Lab Code: GULF Case No.: ADVENT SAS No.: ________ SDG No.: HUJ001

Lab File ID (Standard): CS111891A Date Analyzed: 11/18/91

Instrument ID: C Time Analyzed: 1111

		IS1(DCB) AREA #	RT	IS2(NPT) AREA #	RT	IS3(ANT) AREA #	RT
	12 HOUR STD	17489	8.95	72034	12.20	35985	16.69
	UPPER LIMIT	34978		144068		71970	
	LOWER LIMIT	8744		36017		17992	
	EPA SAMPLE NO.						
01	ANOEFF	14766	9.09	61536	12.22	31084	16.67
02	FBREFF	13918	8.95	59461	12.19	29802	16.67
03	FBRINF	11623	9.00	49632	12.20	25739	16.69
04	INFMSD	10031	8.94	43904	12.19	23980	16.70

IS1 (DCB) = 1,4-Dichlorobenzene-d4
IS2 (NPT) = Naphthalene-d8
IS3 (ANT) = Acenaphthene-d10

UPPER LIMIT = + 100% of internal standard area.
LOWER LIMIT = - 50% of internal standard area.

Column used to flag internal standard area values with an asterisk

8C

SEMIVOLATILE INTERNAL STANDARD AREA SUMMARY

Lab Name: G S E L I Contract: ____________

Lab Code: GULF Case No.: ADVENT SAS No.: ________ SDG No.: HUJ001

Lab File ID (Standard): CS111891A Date Analyzed: 11/18/91

Instrument ID: C Time Analyzed: 1111

		IS4 (PHN) AREA #	RT	IS5 (CRY) AREA #	RT	IS6 (PRY) AREA #	RT
	12 HOUR STD	55171	20.40	43412	27.19	42376	30.92
	UPPER LIMIT	110342		86824		84752	
	LOWER LIMIT	27586		21706		21188	
	EPA SAMPLE NO.						
01	ANOEFF	45739	20.39	32212	27.19	30657	30.96
02	FBREFF	47038	20.39	35046	27.19	17664 *	30.92
03	FBRINF	41062	20.40	33162	27.21	34828	30.86
04	INFMSD	36867	20.42	27564	27.21	28560	30.91

IS4 (PHN) = Phenanthrene-d10
IS5 (CRY) = Chrysene-d12
IS6 (PRY) = Perylene-d12

UPPER LIMIT = + 100% of internal standard area.
LOWER LIMIT = - 50% of internal standard area.

Column used to flag internal standard area values with an asterisk

8B

SEMIVOLATILE INTERNAL STANDARD AREA SUMMARY

Lab Name: G S E L I Contract: ___________

Lab Code: GULF Case No.: ADVENT SAS No.: _______ SDG No.: HUJ001

Lab File ID (Standard): CS112191A Date Analyzed: 11/21/91

Instrument ID: C Time Analyzed: 1014

		IS1(DCB) AREA	#	RT	IS2(NPT) AREA	#	RT	IS3(ANT) AREA	#	RT
	12 HOUR STD	11839		8.57	49990		11.92	27096		16.45
	UPPER LIMIT	23678			99980			54192		
	LOWER LIMIT	5920			24995			13548		
	EPA SAMPLE NO.									
01	FBREFFRE	8596		8.77	36753		11.97	20150		16.45
02	FINFMS	7077		8.82	31164		11.99	17574		16.45
03	SBLKW2	8876		8.65	39964		11.95	22044		16.47
04	SBLKW3	10455		8.54	46997		11.90	25759		16.45

IS1 (DCB) = 1,4-Dichlorobenzene-d4
IS2 (NPT) = Naphthalene-d8
IS3 (ANT) = Acenaphthene-d10

UPPER LIMIT = + 100% of internal standard area.
LOWER LIMIT = - 50% of internal standard area.

Column used to flag internal standard area values with an asterisk

FORM VIII SV-1 1/87 Rev.

8C
SEMIVOLATILE INTERNAL STANDARD AREA SUMMARY

Lab Name: G S E L I   Contract: ______

Lab Code: GULF   Case No.: ADVENT   SAS No.: ______   SDG No.: HUJ001

Lab File ID (Standard): CS112191A   Date Analyzed: 11/21/91

Instrument ID: C   Time Analyzed: 1014

		IS4(PHN) AREA #	RT	IS5(CRY) AREA #	RT	IS6(PRY) AREA #	RT
	12 HOUR STD	43862	20.19	32592	26.99	30497	30.67
	UPPER LIMIT	87724		65184		60994	
	LOWER LIMIT	21931		16296		15248	
	EPA SAMPLE NO.						
01	FBREFFRE	31325	20.17	21833	26.96	19264	30.64
02	FINFMS	27166	20.17	21057	26.99	21020	30.74
03	SBLKW2	35996	20.19	28777	26.99	27909	30.67
04	SBLKW3	44313	20.17	33969	26.97	31360	30.62

IS4 (PHN) = Phenanthrene-d10
IS5 (CRY) = Chrysene-d12
IS6 (PRY) = Perylene-d12

UPPER LIMIT = + 100% of internal standard area.
LOWER LIMIT = - 50% of internal standard area.

Column used to flag internal standard area values with an asterisk

CHAPTER 4

GROUNDWATER TREATMENT PLANT DESIGN

CHAPTER 4.0

GROUNDWATER TREATMENT PLANT DESIGN

Based on the treatability study done by Advent (1991), design parameters were established for the groundwater treatment plant (GWTP) for the Industri-Plex Site Remedial Trust in Woburn, MA.

Influent constituent concentrations plus one (1) standard deviation, which represent the basis for design, are listed in Table 4-1.

The GWTP will be designed to handle a hydraulic peak flow of 300 gallons per minute. Two trains will be built based on a design flow of 275 gallons per minute, or 138 gallons per minute per train. Each train will be hydraulically capable of operation at 150 gallons per minute. Four barrier wells and three outlying wells will deliver the groundwater to the GWTP.

The first step in the treatment process will be equalization of the strength and flow from the various extraction wells. The equalization tank will be provided with a mixing system to maintain the suspension of any particulate matter. The tank will be vented to an odor control system for elimination of odors. An oxygenated plant recycle flow will be added to the equalization tank in order to precipitate iron for removal in the clarifiers.

Following equalization, the groundwater will be split between two biological treatment trains, with three fluidized bed reactors in each train. The biological fluidized bed system is a fixed film process in which the wastewater and recycle flow is passed upward through a bed of sand or granular activated carbon (GAC) at a rate adequate for fluidization of the media. A population of biological organisms coat each grain similar to the biological coating on a trickling filter. The compact nature of the treatment system is the result of the large surface area provided by the media particles to develop biological growth. This surface area has been measured at over 3,280 meters squared per meters cubed (1,000 feet squared per feet cubed) of reactor volume. Increased flexibility for treatment of shock loads and toxic loadings are realized since the biological mass is fixed or immobilized in the system, making potential washout of the biological organisms much less likely. At sites where there are relatively low organic concentrations, the use of immobilized cells is crucial to the long term stability of the bio-system.

The growth rate of cells in this instance is slow and loss of biomass cannot be tolerated. The biological cells in the GAC fluidized bed exist in the openings of the activated carbon grain structure and resist attrition due to sloughing, washout and settleability problems. Suspended growth systems, including those using powdered activated carbon, normally cannot maintain viable biomass populations at these low organic loading rates. Carbon replacement costs will be low, and due only to natural attrition of carbon and carbon replacement due to absorption of refractory materials. Unlike powdered activated carbon, none is wasted with the sludge. Hauling costs for spent carbon will be significantly reduced.

At the Woburn, MA Site, the first process equipment in each train will be an anoxic fluid bed reactor with a sand media for biological conversion of nitrates recycled from subsequent treatment steps. This is followed by a GAC fluid bed system which will provide treatment of BTEX compounds and ammonia. This step will utilize 90% pure oxygen dissolved in the groundwater prior to entering the reactor for uptake by the biomass, which eliminates the stripping of the BTEX normally associated with aeration in conventional activated sludge processes. Each aerobic GAC fluid bed reactor will be followed by another anoxic fluid bed reactor with sand media for final treatment of any residual nitrates.

The flow from each final anoxic reactor will join in a common tank where dissolved oxygen levels will be increased and any residual methanol will be removed. From this tank, which also serves as a splitter, the flow proceeds toward pH adjustment, and introduction of a metals precipitating agent in flash mix and flocculation tanks, followed by optional polymer addition.

The physical/chemical precipitation of metals is the next step in the treatment process. This step will be carried out in each train by a thirty-five foot diameter clarifier through conventional gravity sedimentation. Suspended solids will settle and be removed as sludge to a single sludge holding tank. From the sludge holding tank solids will be dewatered and dried prior to final disposal. Clarifier effluent will go to a final monitoring tank prior to discharge where it will be monitored for dissolved oxygen, pH and sampled for laboratory analysis.

An odor control system will capture and treat any air flows from processes which may generate odors such as flow equalization and sludge drying. Odor control systems are currently being scrutinized, with wet systems being favored due to the ability of the biological system to treat the small waste streams generated by the odor control equipment.

The treatment systems will be housed in a building which will include office space, a laboratory area, and maintenance facilities.

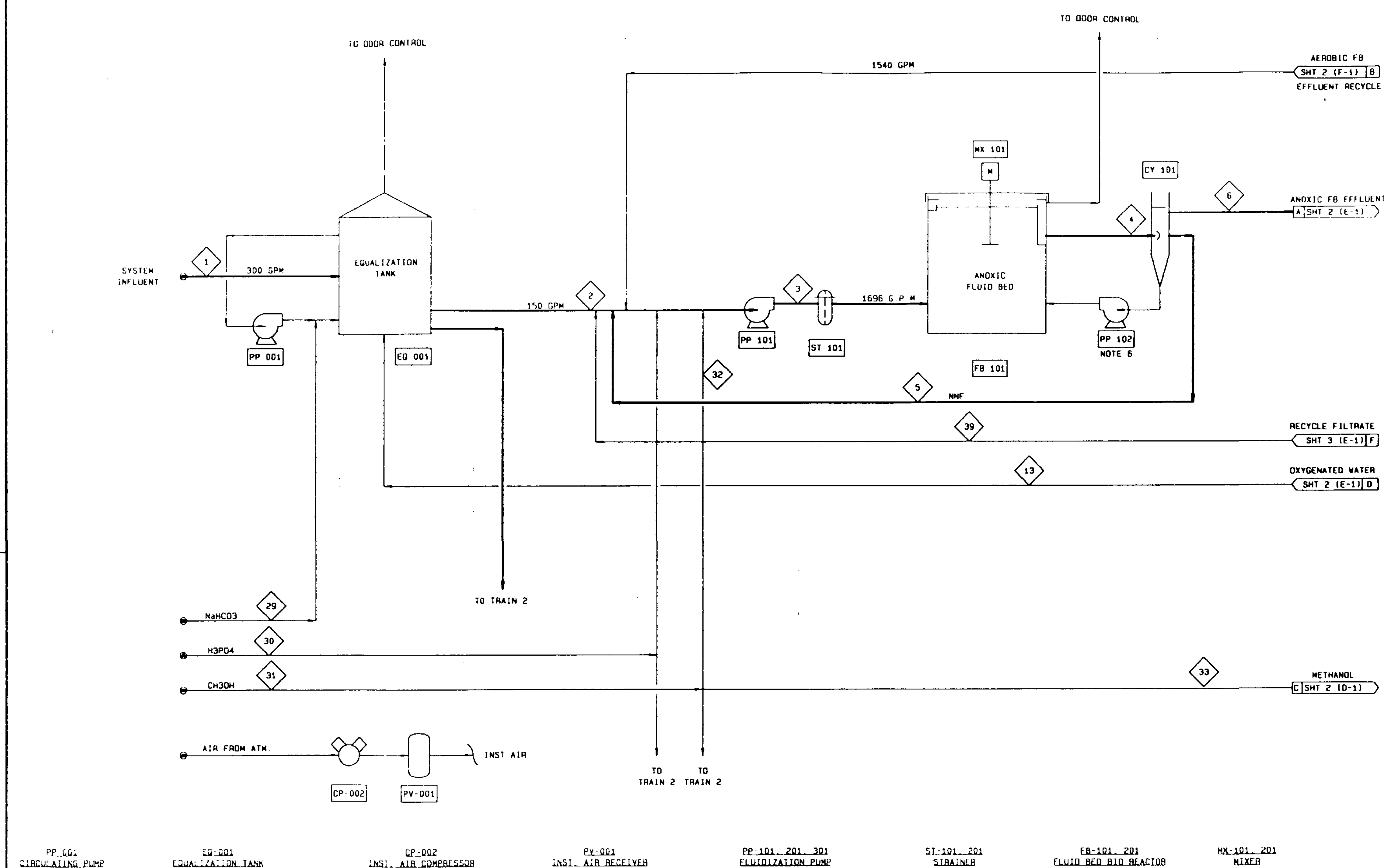
References

Advent Group, Inc., 1991. Groundwater Treatability Study, Industri-Plex Site Remedial Trust, Woburn, MA, November.

TABLE 4-1

GROUNDWATER CONSTITUENT CONCENTRATIONS

Groundwater Constituent	Concentration (mg/l)
T BOD_5	47.84
S BOD_5	39.23
T COD	287.53
S COD	269.18
TSS	186.56
TDS	3494.25
VSS	38.30
Benzene	0.42
Toluene	0.177
T As	0.311
S As	0.151
T Cr	0.13
S Cr	0.058
T Fe	19.03
S Fe	1.43
T Pb	0.11
S Pb	0.11



NOTES.

1) ONLY ONE OF TWO IDENTICAL FLUID BED TRAINS IS SHOWN.

2) EQUIPMENT NUMBERS BEGINNING WITH "1" INDICATE TRAIN 1 EQUIPMENT, AND LIKEWISE FOR TRAIN 2. EQUIPMENT NUMBERS BEGINNING WITH "0" INDICATE EQUIPMENT COMMOMN TO BOTH TRAINS. AN "X" USED AS THE FIRST NUMBER REFERS TO EITHER TRAIN 1 OR TRAIN 2 EQUIPMENT.

3) BIOMASS CONTROL MIXERS ARE USED TO GENTLY SHEAR BIOMASS FROM MEDIA PARTICLES TO CONTROL BED HEIGHT.

4) FLUIDIZATION PUMP PP-201 NORMALLY SUPPLIES INFLUENT WATER TO TRAIN 2. PUMP PP-301 FORMS BACKUP DUTY FOR BOTH PUMPS PP-101 AND PP-202 THE OTHER FLUIDIZED BED PUMP SYSTEMS ARE SET UP SIMILARLY

5) THE OXYGEN GENERATOR IS A BATCH-TYPE CYCLING SYSTEM. IN THE MODE SHOWN, THE RESIN TANK ON THE LEFT IS PRODUCING OXYGEN, WHILE THE TANK ON THE RIGHT IS BEING PURGED.

6) THE MEDIA RETURN PUMPS ARE OPERATED INTERMITTENTLY.

7) PROCESS DESIGN BASIS

INFLUENT WATER FLOW (GPM) 300
TEMPERATURE, F 45-55

	INFLUENT	EFFLUENT
BOD (MG/L)	48	
COD (MG/L)	288	
TSS	187	
TDS (MG/L)	3494	
IRON (MG/L)	19	
BENZENE	0.4	
TOLUENE	0.2	

ABBREVIATIONS:

NNF = NO NORMAL FLOW
NC = NORMALLY CLOSED
NO = NORMALLY OPEN
* = PRELIMINARY

PRELIMINARY

SHEET 4 - 1

ECN NUMBER	REV. NO.	BY	DESCRIPTION OF REVISION / REV BY / DATE
LOCATION OF REVISION			

SCALE / DATE ISSUED 3/26/92
DIMENSIONS IN INCHES UNLESS SPECIFIED
TOLERANCES UNLESS OTHERWISE SPECIFIED
DRAWN JL

CUSTOMER INDUSTRI-PLEX SITE REMEDIAL TRUST
LOCATION WOBURN, MA
ENGINEER ENVIREX LTD.

Envirex Ltd.

TITLE PROCESS FLOW SCHEMATIC FLUID BED SYSTEM

DRAWING NUMBER F-8009-101A

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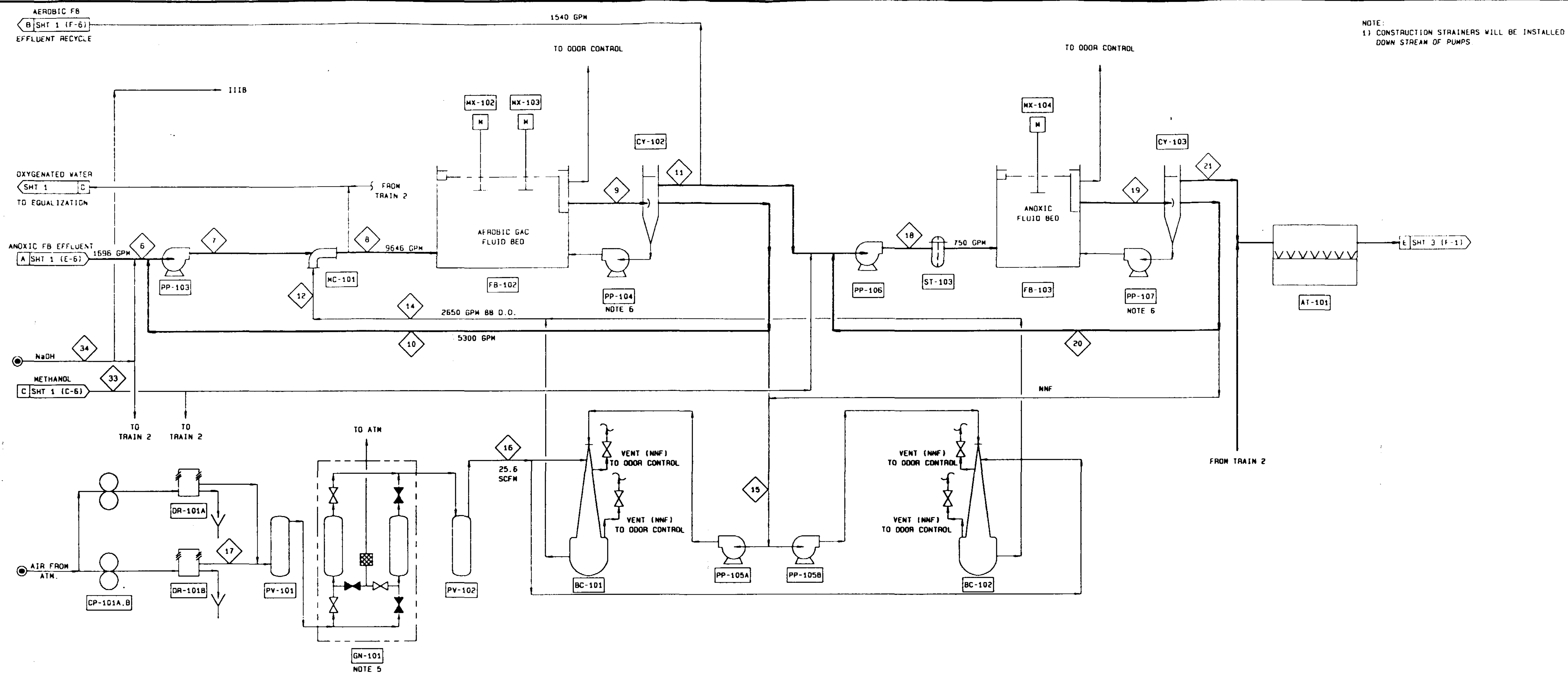

PP-103, 203, 303 FLUIDIZATION PUMP

FB-102, 202 FLUID BED BIOREACTOR

MX-102, 103, 202,203 BIOMASS CONTROL MIXER

PP-104, 204 MEDIA RETURN PUMP

CY-102, 202 SEPARATOR TANK

PP-106, 206, 306 FLUIDIZATION PUMP

ST-103, 203 STRAINER

FB-103, 203 FLUID BED BIOREACTOR

PP-107, 207 MEDIA RETURN PUMP

CY-103, 203 SEPARATOR TANK

CP-101A,B PROCESS AIR COMPRESSOR

DR-101A, B AIR DRYER

PV-101 AIR RECEIVER

MC-102, 202 MIXING CHAMBER

GN-101, 102 OXYGEN GENERATOR

PV-102 OXYGEN RECEIVER

BC-101, 102, 201, 202 PRESSURIZED BUBBLE CONTACTOR

PP-105A, 105B, 205A, 205B PBC PUMP

AT-101, 102 AERATION TANK

PRELIMINARY

SHEET 4 - 2

ECN NUMBER	REV. NO.	BY	DESCRIPTION OF REVISION	REV. BY	DATE
LOCATION OF REVISION					

SCALE | DATE ISSUED 3/26/92 | DIMENSIONS IN INCHES UNLESS SPECIFIED | TOLERANCES UNLESS OTHERWISE SPECIFIED | DRAWN JL | CHECKED | APPROVED

CUSTOMER INDUSTRI-PLEX SITE REMEDIAL TRUST
LOCATION WOBURN, MA
ENGINEER ENVIREX LTD.

Envirex Ltd.
WAUKESHA, WI 53187

TITLE PROCESS FLOW SCHEMATIC FLUID BED SYSTEM

DRAWING NUMBER F8009-102A

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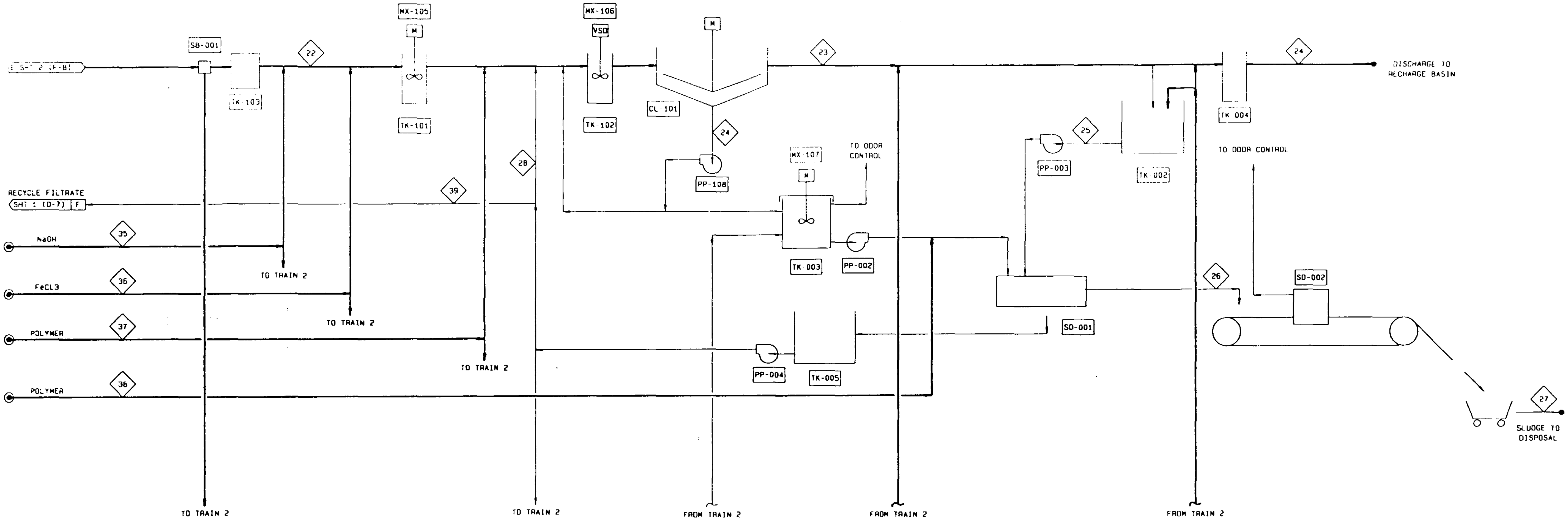


SB-101 SPLITTER BOX

MX-105, 205 MIXER

MX-106, 206 MIXER

MX-107 MIXER

CL-101, 201 METALS PRECIPITATION CLARIFIER

TK-003 SLUDGE HOLDING TANK

SD-001 SOLIDS DEWATERING

TK-004 EFFLUENT MONITORING TANK

TK-103, 203 PRIMARY METALS REMOVAL

TK-101, 201 FLASH MIX TANK

TK-102, 202 FLOCCULATION TANK

PP-002 SLUDGE FEED PUMP

TK-002 EFFLUENT STORAGE TANK

PP-003 WASHWATER PUMP

SD-002 SLUDGE DRYER

PP-108, 208 SLUDGE RECIRCULATION PUMP

TK-005 FILTRATE TANK

PP-004 FILTRATE PUMP

PRELIMINARY

SHEET 4 - 3

ECN NUMBER	REV NO	BY	DESCRIPTION OF REVISION	REV BY	DATE

LOCATION OF REVISION

DATE ISSUED 3/26/92

DRAWN JL

CUSTOMER INDUSTRI-PLEX SITE REMEDIAL TRUST
LOCATION WOBURN, MA
ENGINEER ENVIREX LTD.

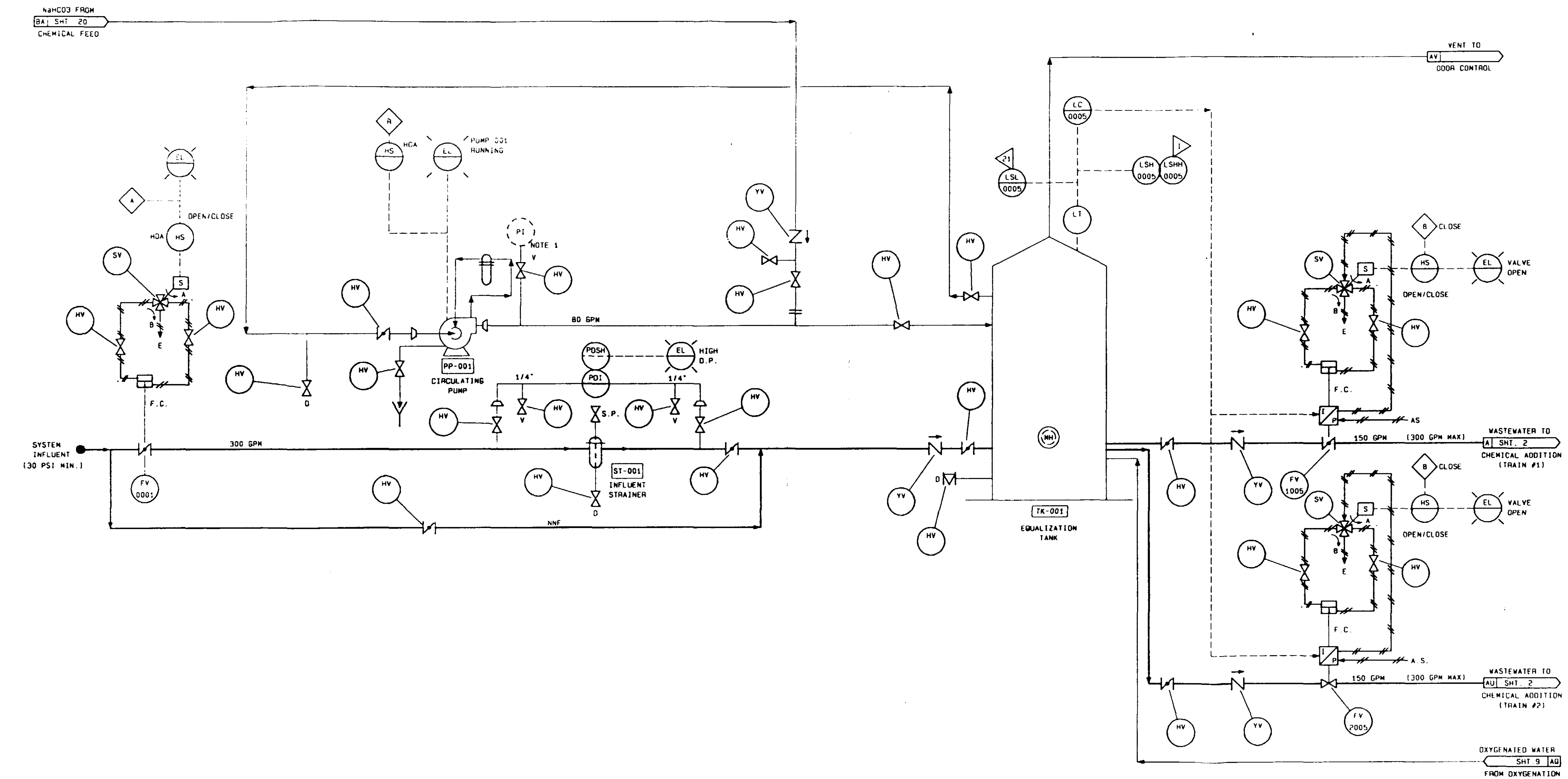
Envirex Ltd.

TITLE PROCESS FLOW SCHEMATIC PHYSICAL/CHEMICAL TREATMENT

DRAWING NUMBER F8009-103A

March 26, 1992 10:58:43 AM

NOTE:
1) TEMPORARY PRESSURE INDICATORS WILL BE USED ON AN AS-NEEDED BASIS



PRELIMINARY

SHEET 4 - 4

ABBREVIATIONS:

NNF = NO NORMAL FLOW

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LOCATION OF REVISION

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DIMENSIONS IN INCHES UNLESS SPECIFIED	
TOLERANCES UNLESS OTHERWISE SPECIFIED	
DRAWN KMS	PROJECT ENG
CHECKED	APPROVED

CUSTOMER: INDUSTRI-PLEX SITE REMEDIAL TRUST
LOCATION: WOBURN, MA.
ENGINEER: ENVIREX LTD.

Envirex Ltd.
WAUKESHA, WI 53187

TITLE: P&I DIAGRAM EQUALIZATION

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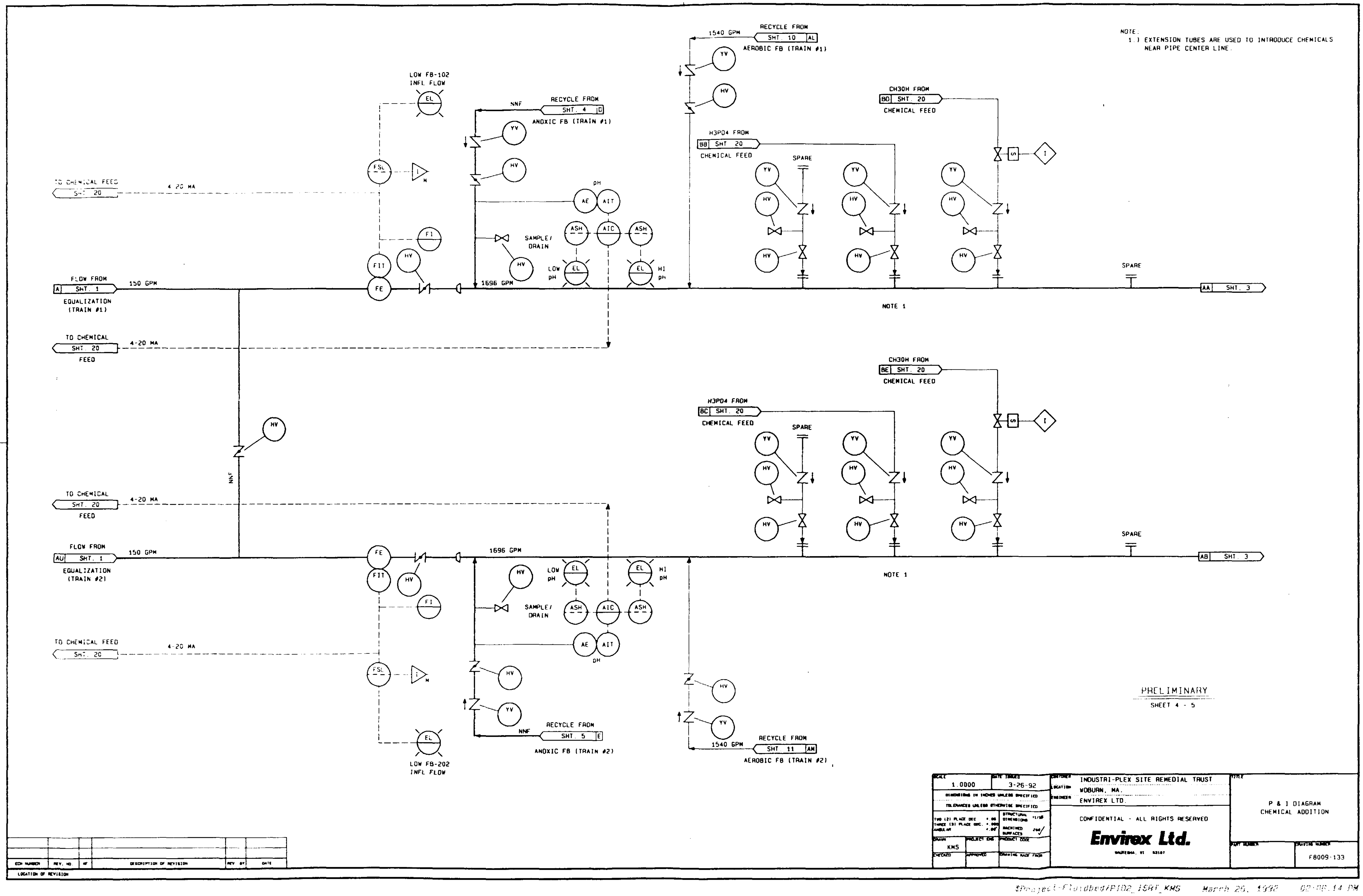

NOTE:
1.) EXTENSION TUBES ARE USED TO INTRODUCE CHEMICALS NEAR PIPE CENTER LINE.
FLOW FROM
A SHT. 1
EQUALIZATION (TRAIN #1)
150 GPM
TO CHEMICAL FEED
SHT. 20
4-20 MA
TO CHEMICAL
SHT. 20
FEED
LOW FB-102
INFL FLOW
FSL
FI
FIT
FE
HV
YV
EL
AE
AIT
AIC
ASH
pH
LOW pH
HI pH
SAMPLE/
DRAIN
NNF
RECYCLE FROM
SHT. 4 G
ANOXIC FB (TRAIN #1)
1696 GPM
1540 GPM
RECYCLE FROM
SHT. 10 AL
AEROBIC FB (TRAIN #1)
CH3OH FROM
BD SHT. 20
CHEMICAL FEED
H3PO4 FROM
BB SHT. 20
CHEMICAL FEED
SPARE
NOTE 1
AA SHT. 3
CH3OH FROM
BE SHT. 20
CHEMICAL FEED
H3PO4 FROM
BC SHT. 20
CHEMICAL FEED
AB SHT. 3
FLOW FROM
AU SHT. 1
EQUALIZATION (TRAIN #2)
LOW FB-202
INFL FLOW
RECYCLE FROM
SHT. 5 E
ANOXIC FB (TRAIN #2)
RECYCLE FROM
SHT. 11 AM
AEROBIC FB (TRAIN #2)
PRELIMINARY
SHEET 4 - 5
SCALE 1.0000
DATE ISSUED 3-26-92
DRAWN KMS
INDUSTRI-PLEX SITE REMEDIAL TRUST
WOBURN, MA.
ENVIREX LTD.
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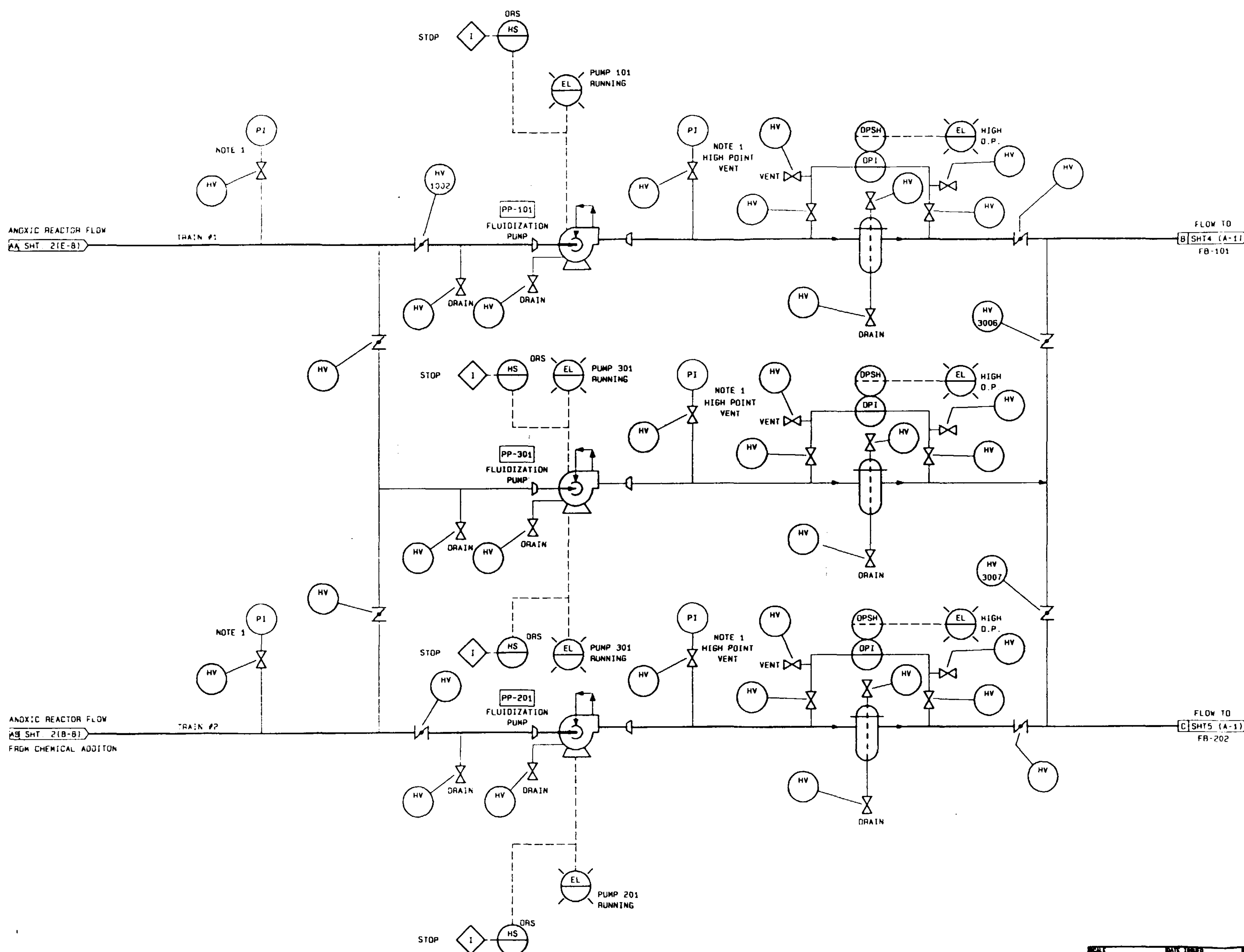
Envirex Ltd.
P & I DIAGRAM
CHEMICAL ADDITION
F8009-133
ECN NUMBER
REV. NO
DESCRIPTION OF REVISION
REV. BY
DATE
LOCATION OF REVISION
March 26, 1992



PRELIMINARY

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TOLERANCES UNLESS OTHERWISE SPECIFIED	
DRAWN KMS	PROJECT ENG.
CHECKED	APPROVED

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LOCATION: WOBURN, MA
ENGINEER: ENVIREX, LTD

Envirex Ltd.

TITLE: P & I DIAGRAM PUMP SKID #1

PART NUMBER: F8009

DRAWING NUMBER: F8009-134

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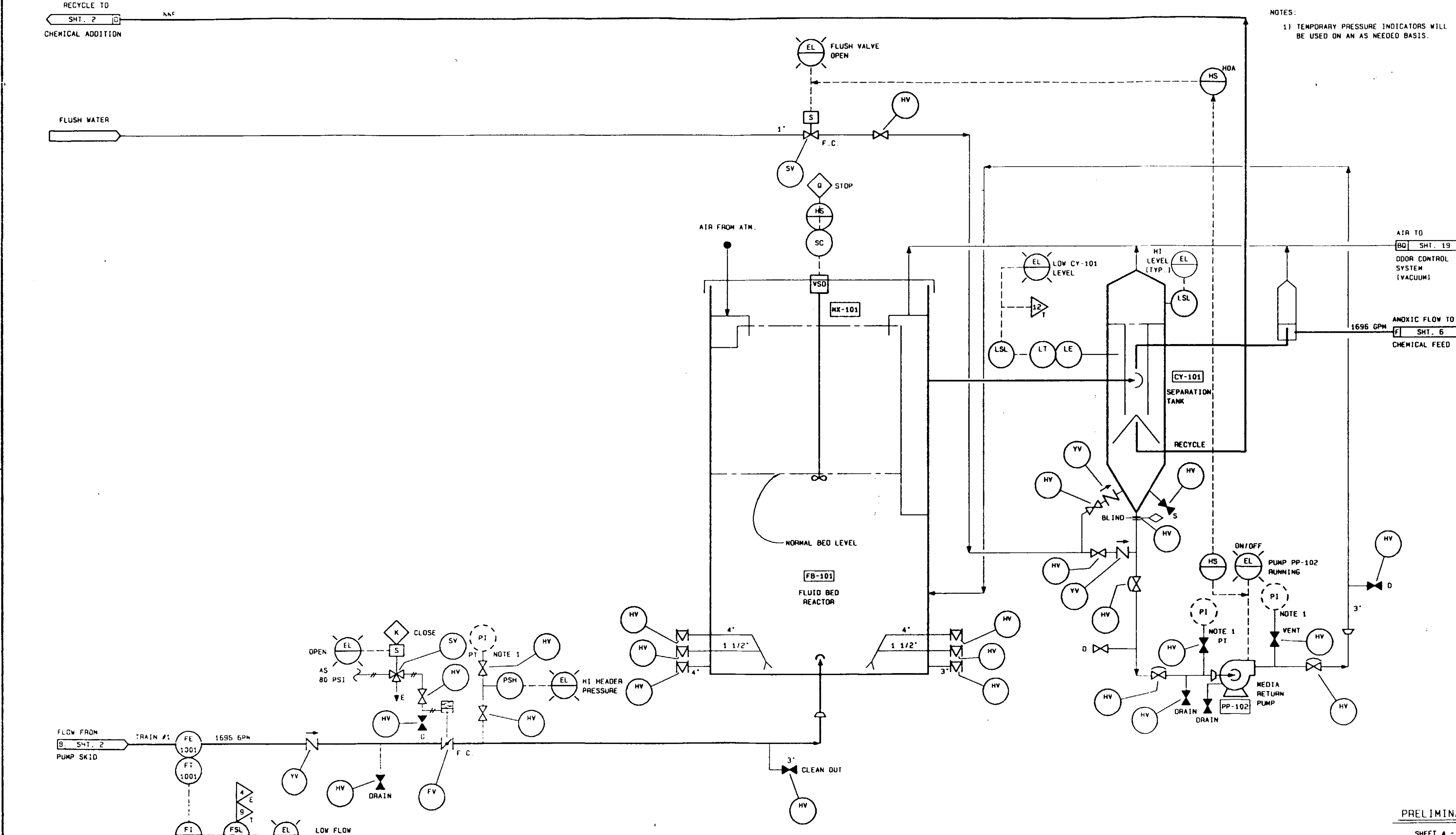

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ENGINEER	ENVIREX LTD.
DRAWN	KMS
TITLE	P & I DRAWING ANOXIC FLUID BED (TRAIN #1)
DRAWING NUMBER	F8009-135

Envirex Ltd.

WAUKESHA, WI 53187

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LOCATION OF REVISION

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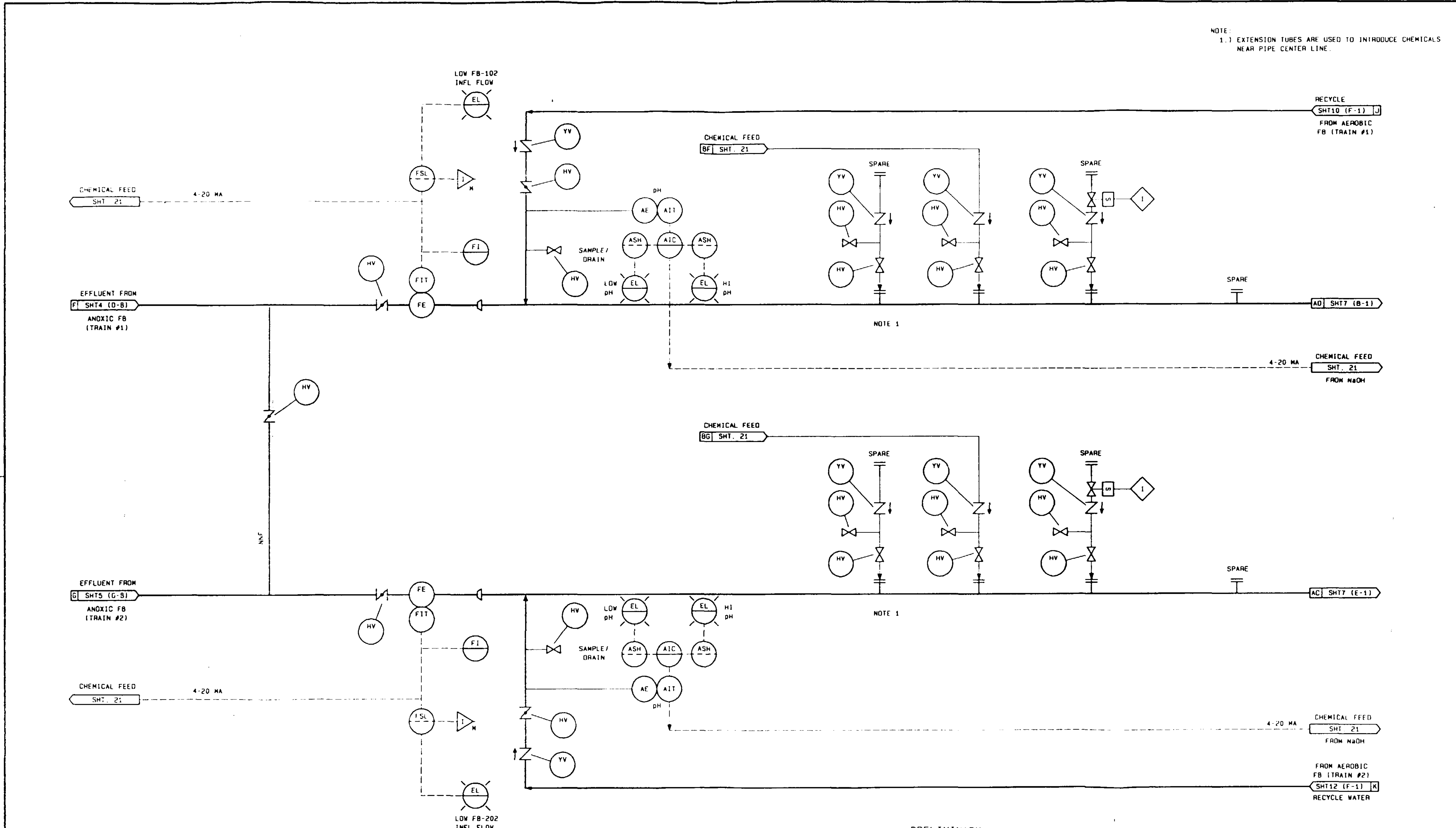

INDUSTRI-PLEX SITE REMEDIAL TRUST
WOBURN, MA.

DATE ISSUED 3-26-92

DRAWN KMS

Envirex Ltd.

WAUKESHA, WI 53187

P & I DIAGRAM
AEROBIC FB
CHEMICAL ADDITION

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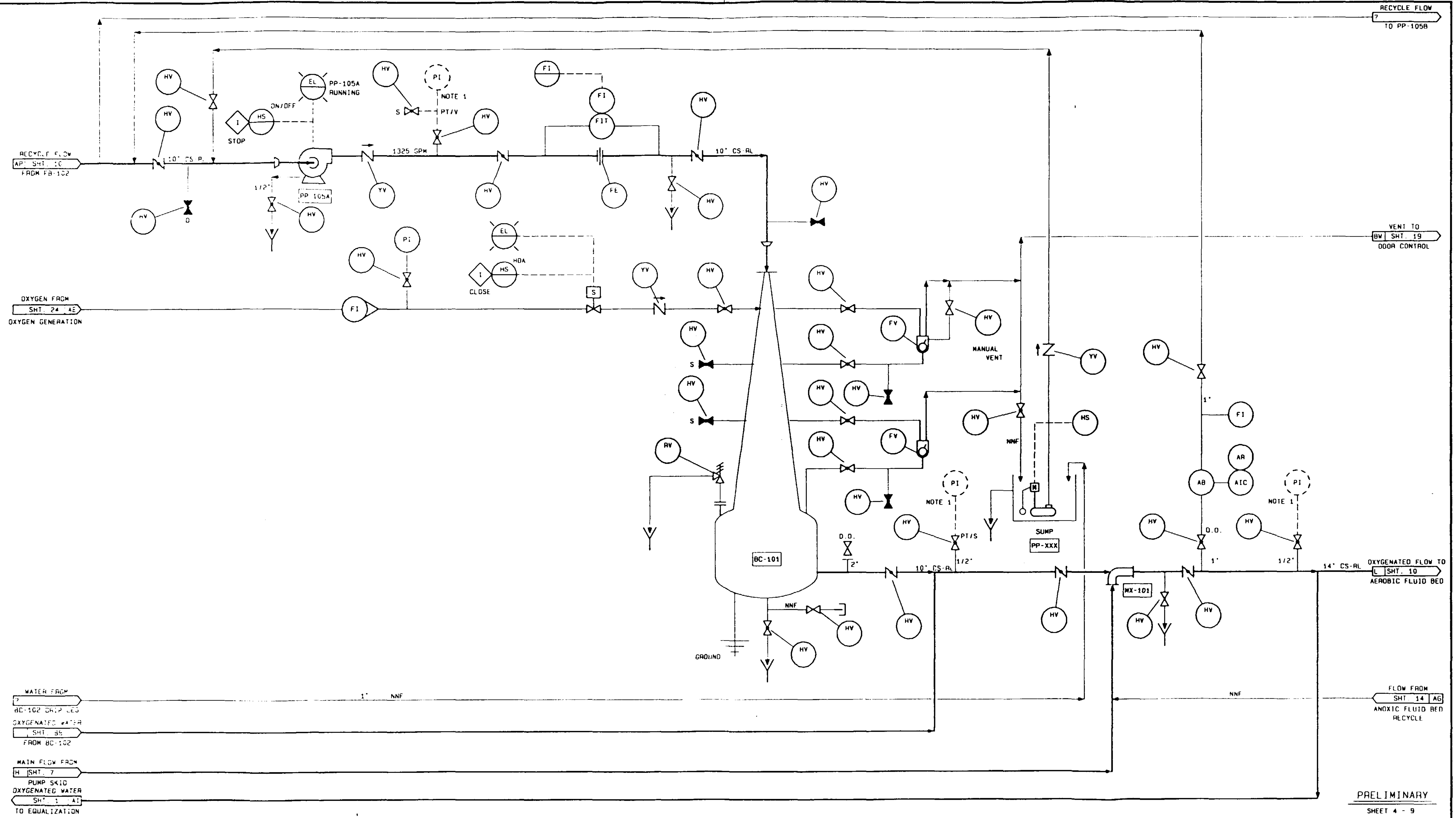

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NOTE:

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DRAWN	KMS
CHECKED	
PROJECT ENG	
APPROVED	
PRODUCT CODE	
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LOCATION: WOBURN, MA.
ENGINEER: ENVIREX LTD

Envirex Ltd.
WAUKESHA, WI 53187

TITLE: P & I DIAGRAM
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(BC-101)

PART NUMBER:
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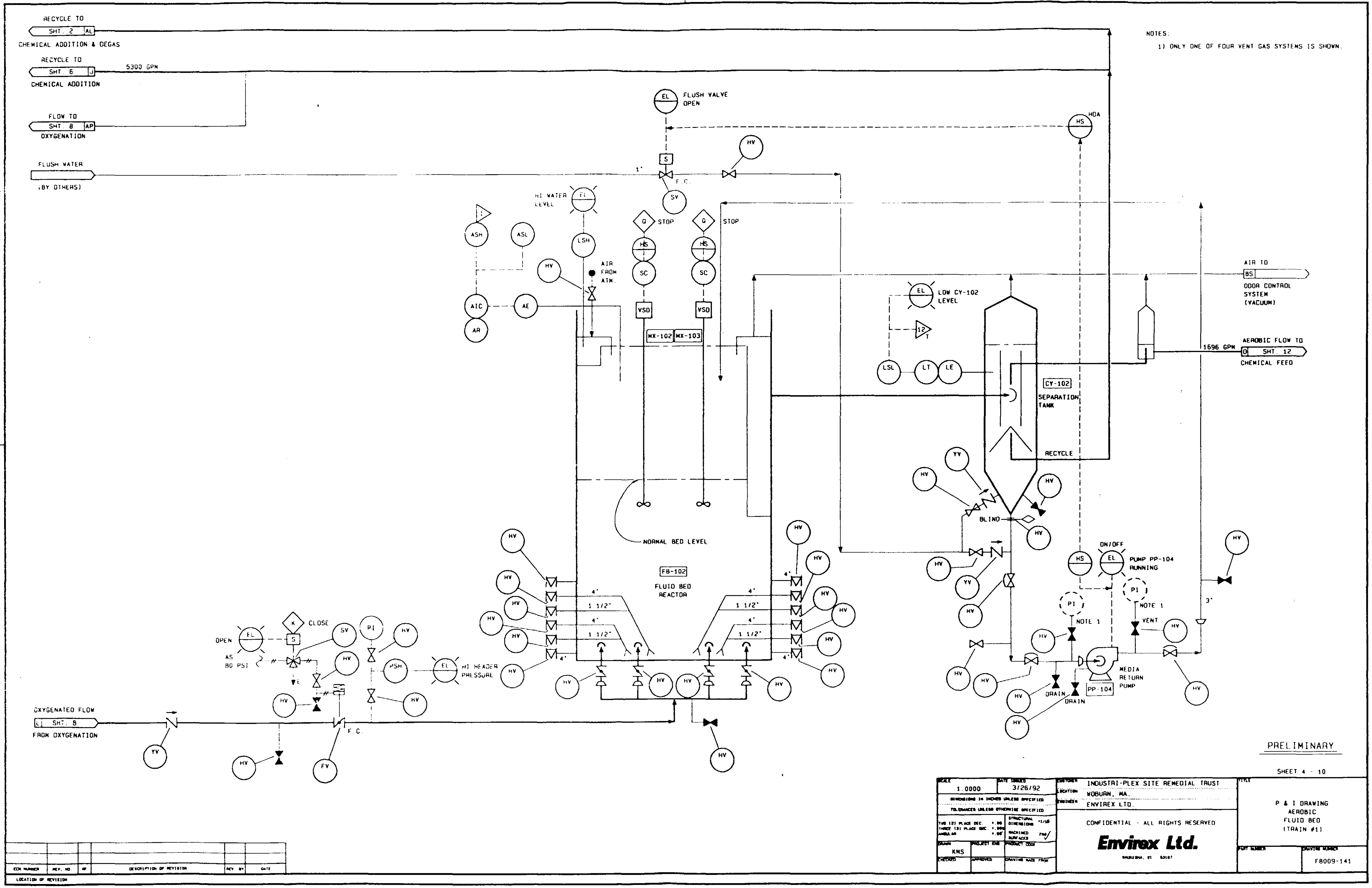

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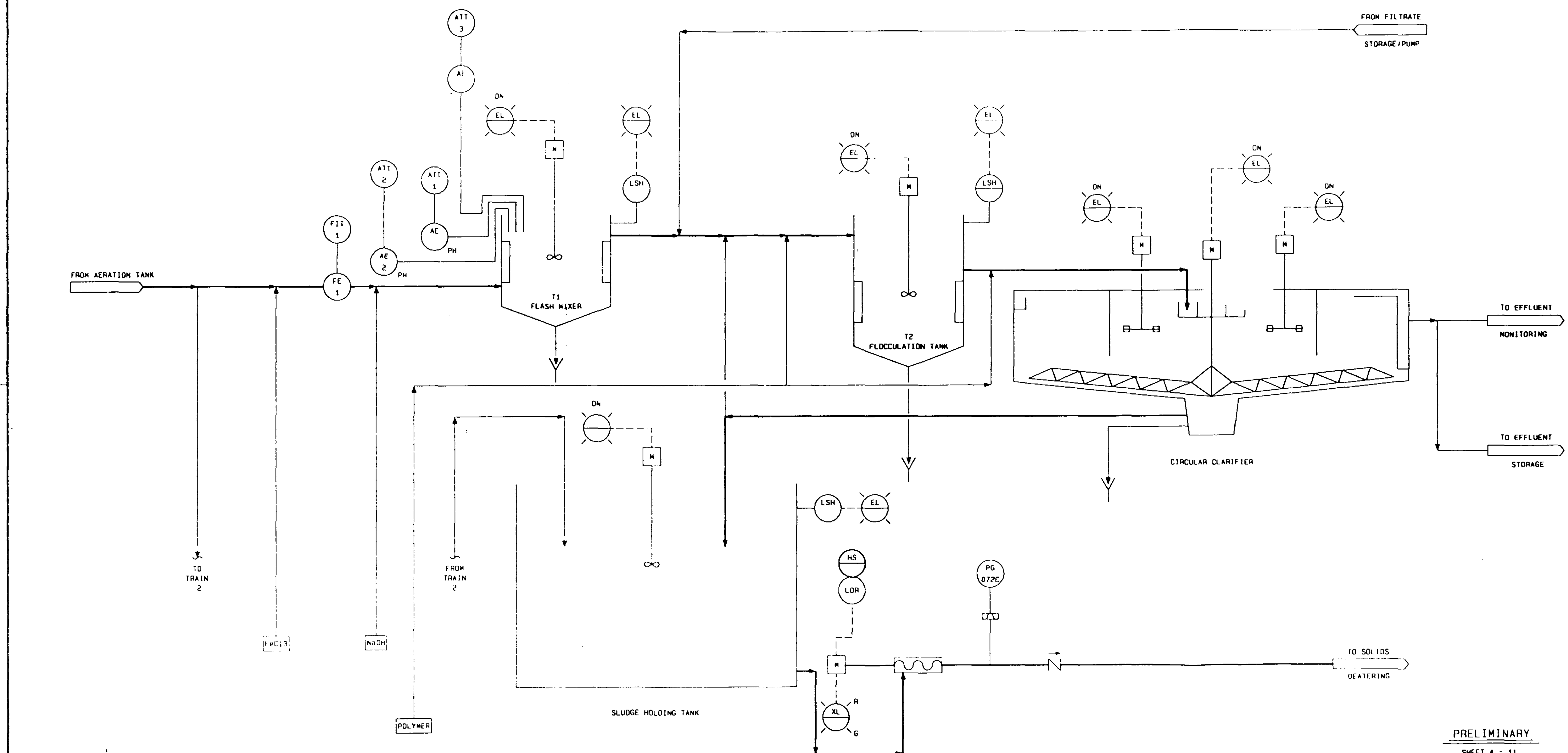

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DRAWING NUMBER	F8009-148

Envirex Ltd.

WAUKESHA, WI 53187

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LOCATION OF REVISION

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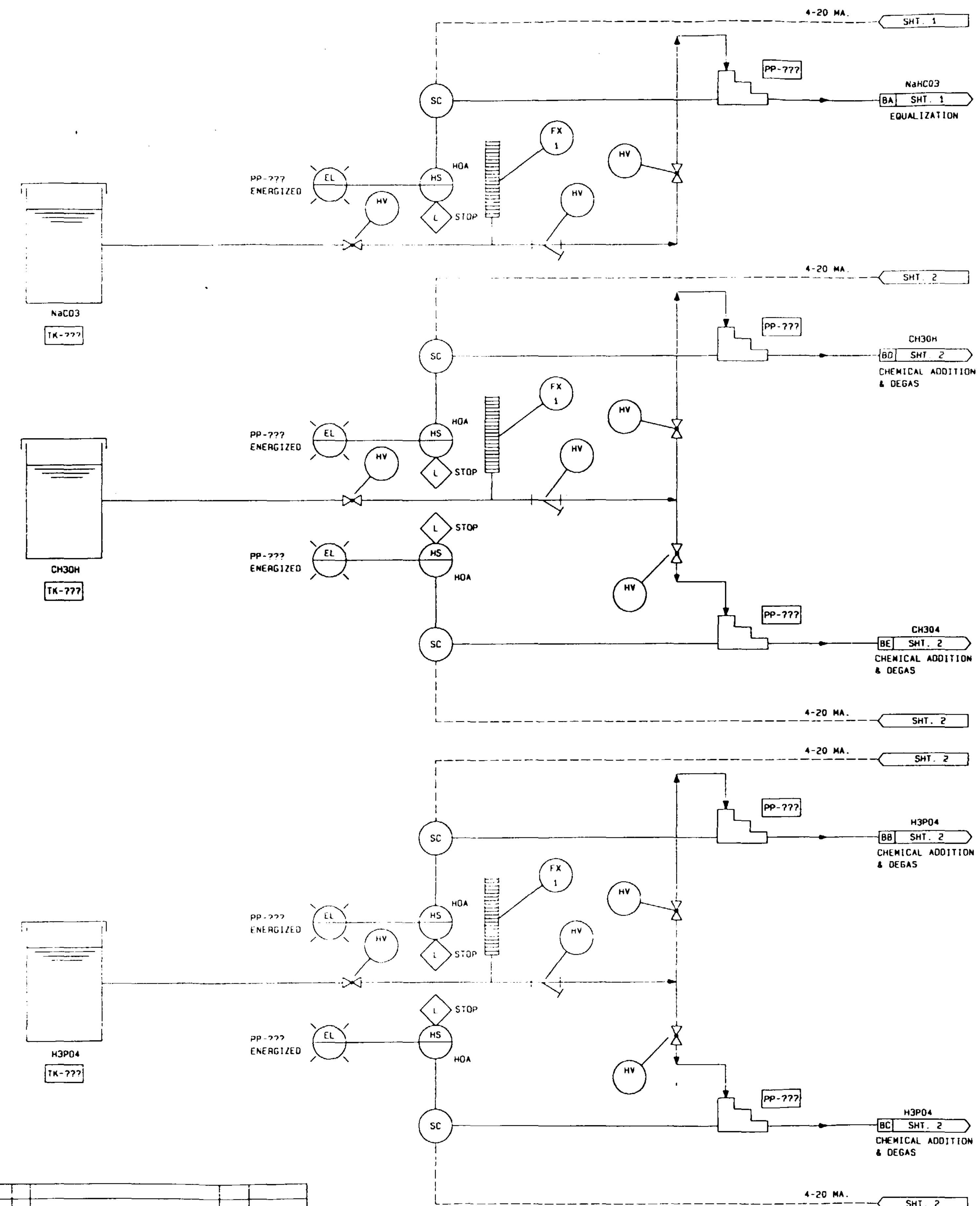

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TOLERANCES UNLESS OTHERWISE SPECIFIED		ENGINEER ENVIREX LTD	
TWO (2) PLACE DEC. ±.06 THREE (3) PLACE DEC. ±.005 ANGULAR ±.5°	STRUCTURAL DIMENSIONS ±1/16 MACHINED SURFACES	CONFIDENTIAL - ALL RIGHTS RESERVED	
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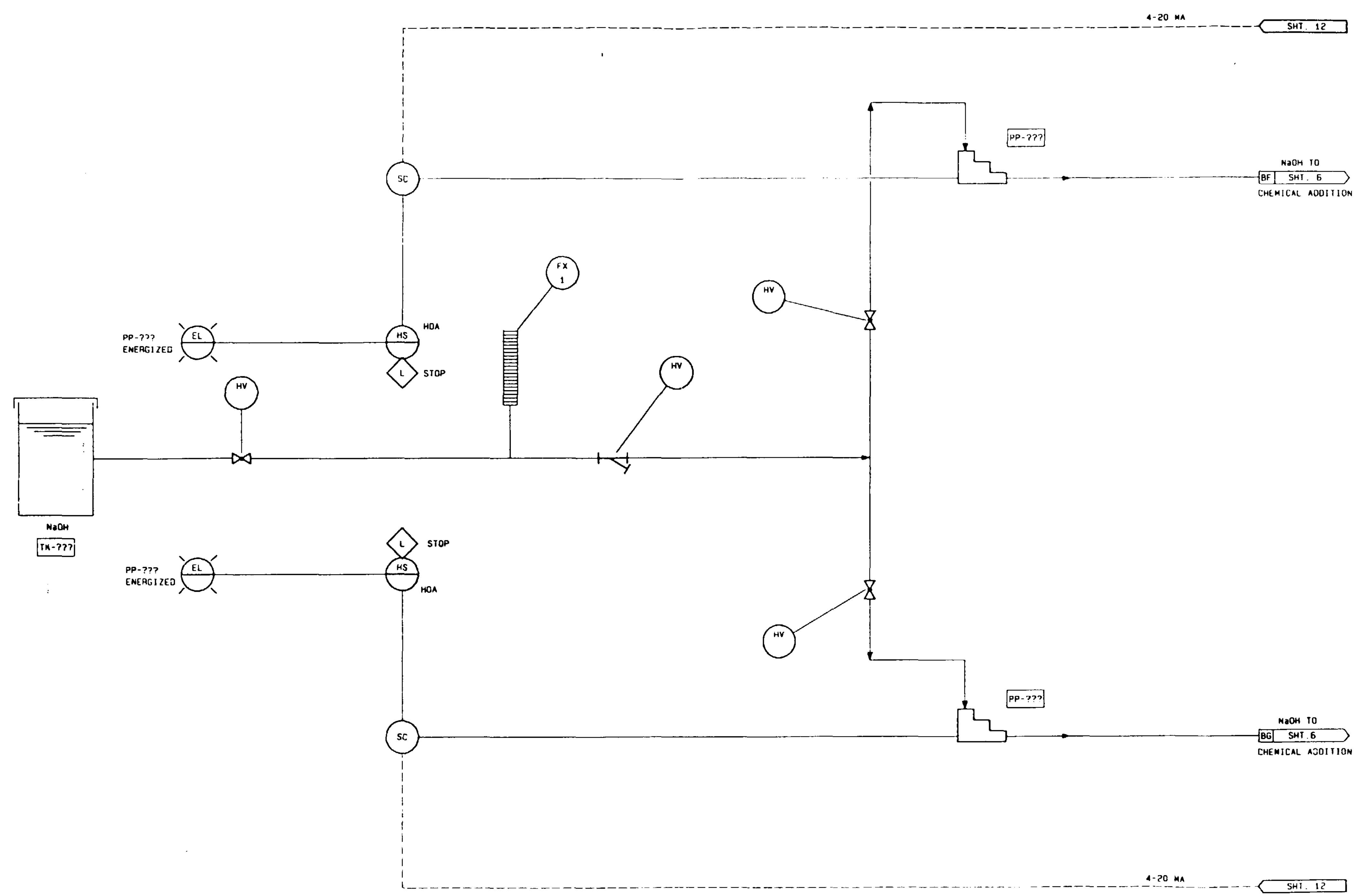

PRELIMINARY

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LOCATION	WOBURN, MA.
ENGINEER	ENVIREX LTD.
TITLE	CHEMICAL FEED
DRAWING NUMBER	F8009-152

Envirex Ltd.

WAUKESHA, WI 53187

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LOCATION OF REVISION

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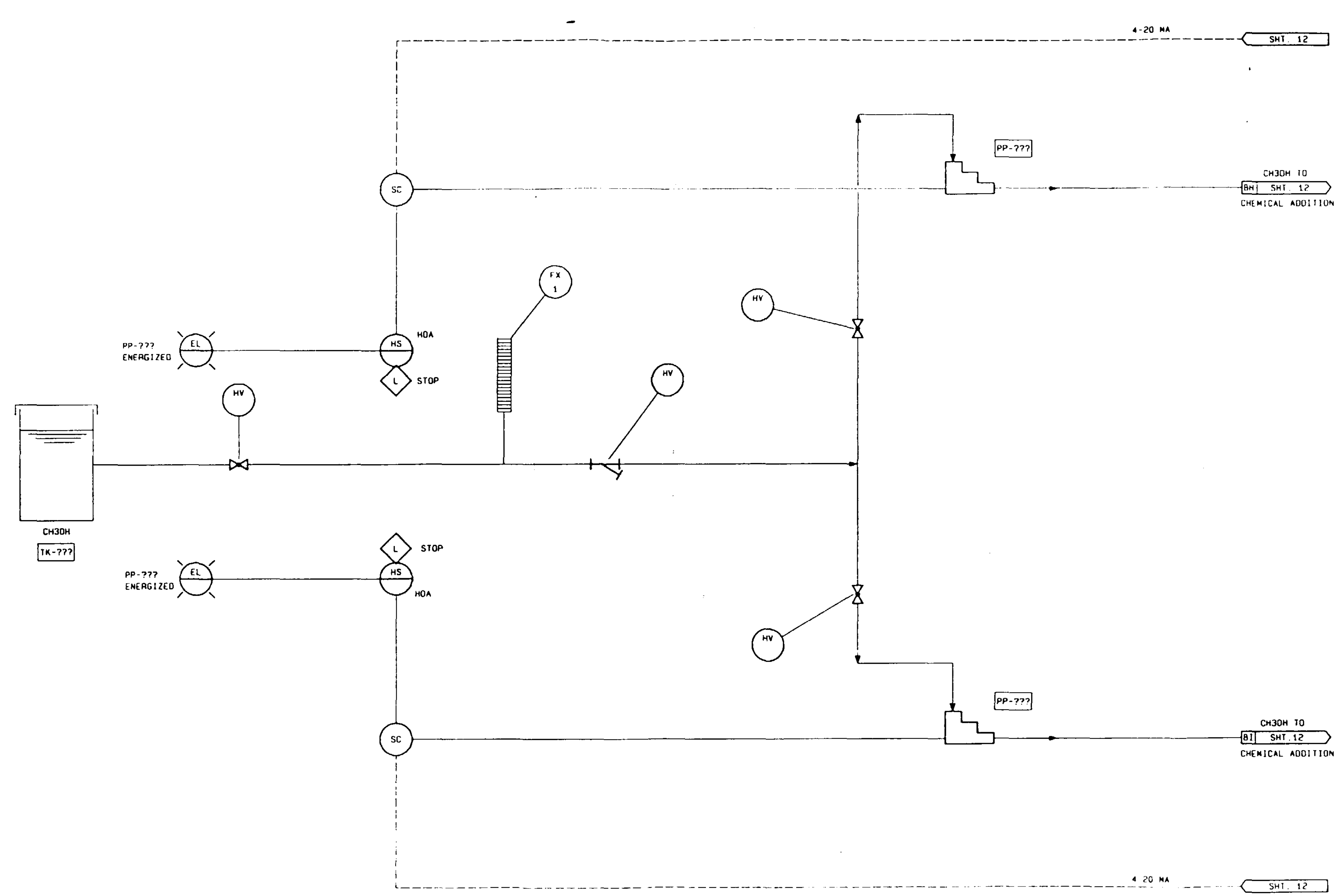

PRELIMINARY
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LOCATION OF REVISION

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TOLERANCES UNLESS OTHERWISE SPECIFIED	
DRAWN KMS	PROJECT ENG. / PRODUCT CODE
CHECKED	APPROVED / DRAWING MADE FROM

CUSTOMER: INDUSTRI-PLEX SITE REMEDIAL TRUST
LOCATION: WOBURN, MA.
ENGINEER: ENVIREX LTD

Envirex Ltd.
WAUKESHA, WI 53187

TITLE: CHEMICAL FEED

PART NUMBER:
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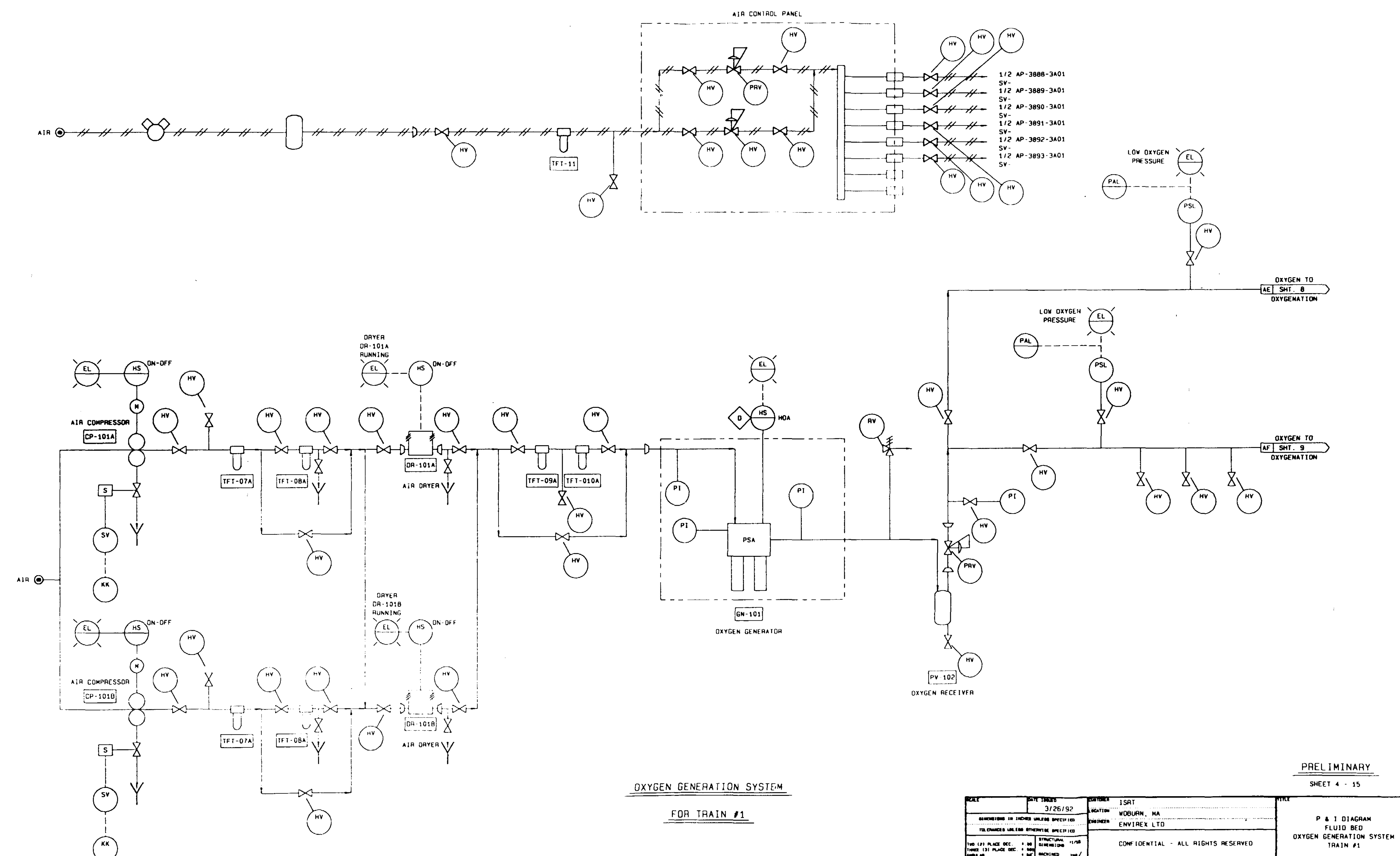

PRELIMINARY

SHEET 4 - 15

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TOLERANCES UNLESS OTHERWISE SPECIFIED	
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CUSTOMER	ISAT
LOCATION	WOBURN, MA
ENGINEER	ENVIREX LTD

Envirex Ltd.

WAUKESHA, WI 53187

TITLE: P & I DIAGRAM
FLUID BED
OXYGEN GENERATION SYSTEM
TRAIN #1

DRAWING NUMBER: F8009-155

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LOCATION OF REVISION

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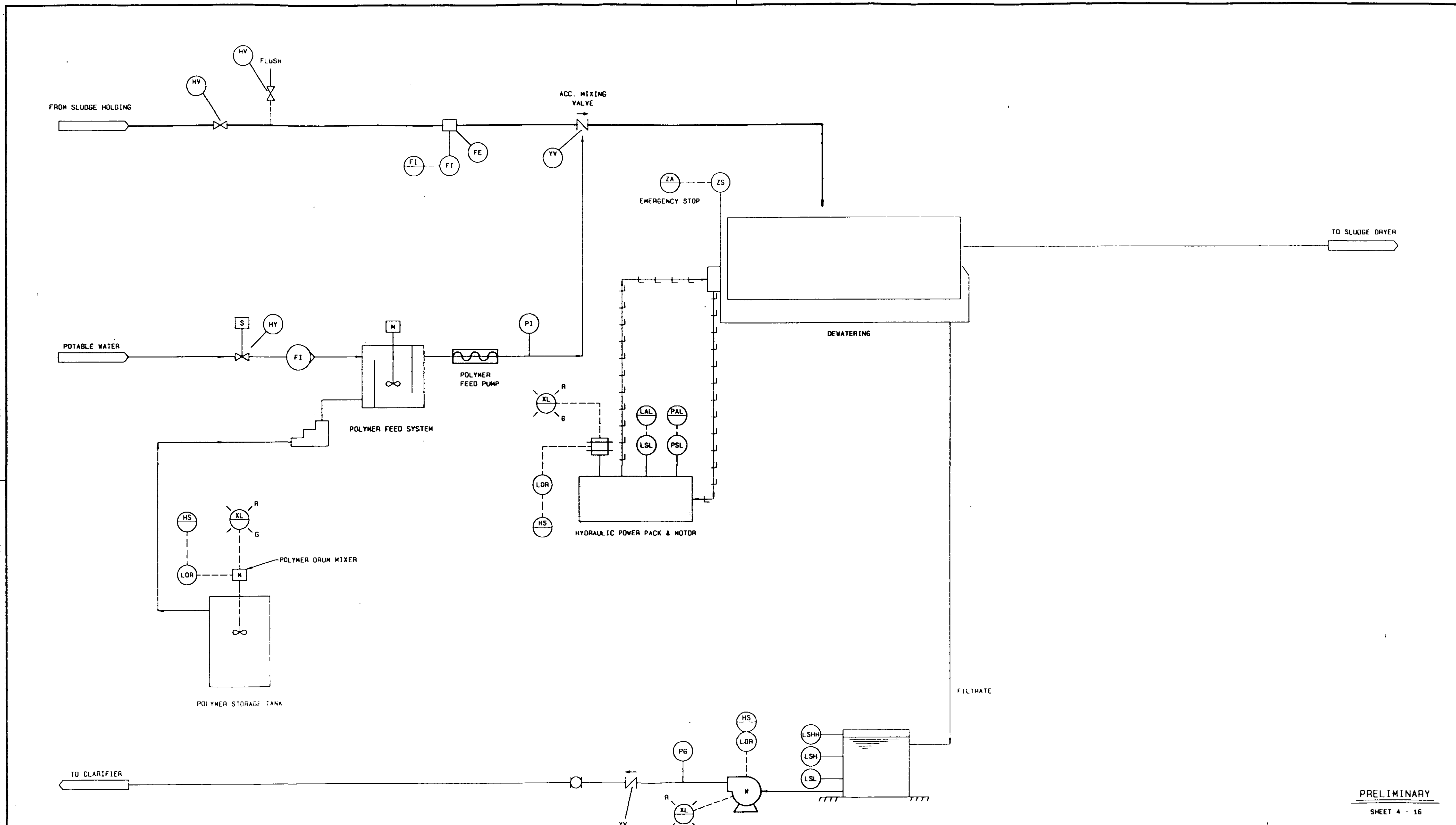

SCALE	DATE ISSUED	CUSTOMER	INDUSTRI-PLEX SITE REMEDIAL TRUST	TITLE
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DIMENSIONS IN INCHES UNLESS SPECIFIED		ENGINEER	ENVIREX LTD.	
TOLERANCES UNLESS OTHERWISE SPECIFIED				
DRAWN: JL	PROJECT ENG			PART NUMBER
CHECKED	APPROVED	DRAWING MADE FROM		DRAWING NUMBER: F8009-157

Envirex Ltd.

ECN NUMBER	REV. NO	BY	DESCRIPTION OF REVISION	REV. BY	DATE

LOCATION OF REVISION

$Project-Fluidbed/WOBURNSHT3 March 27, 1992 08:36:07 AM

CHAPTER 5

EFFLUENT LIMITS AND IMPACT EVALUATION

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 5
EFFLUENT LIMITS AND IMPACT OF DISCHARGE

5.1 EFFLUENT LIMITS

Effluent limits were developed for the constituents detected in groundwater at the Industri-Plex Site (Site) by modelling the interaction between the surface waters of Hall's Brook, the ponded portion of the Hall's Brook Holding Area (HBHA), and the Groundwater Treatment Plant (GWTP) effluent stream using computer programs available in the public domain. Input for the programs used information available from the Groundwater/Surface Water Investigation Plan (Roux Associates, 1991) and the 60% Design Report (Golder Associates, 1991). The output of the models provided in-stream concentration gradients (concentration in HBHA divided by concentration in the GWTP effluent) within the HBHA. The GWTP effluent limits were then calculated by dividing the Ambient Water Quality Criteria (adjusted using USEPA methodology; USEPA, 1985) for each respective constituent by the predicted in-stream dilution calculated above using the northern end of the HBHA (upper third of the pond) as the point of compliance.

5.1.1 Methodology

Two computer models, originally developed at the Massachusetts Institute of Technology (Westerink *et al.*, 1984; Kossik *et al.*, 1987), were coupled to estimate the steady-state concentration distribution expected in the HBHA. TEA (Tidal Embayment Analysis) was the computer code used to perform the steady-state, two-dimensional (depth-averaged) hydrodynamic calculations. The two-dimensional constituent transport simulations were performed using the code ELA (Eulerian-Lagrangian Analysis), which was designed to use the velocity field input computed by TEA. Details of the site-specific model implementation and computational results are presented below.

5.1.2 Hydrodynamic Model

A numerical technique referred to as the finite element method (FEM) was used in both TEA and ELA to solve the governing flow and transport equations. The FEM required that the HBHA be divided into a series of two-dimensional triangular (linear) elements (Figure 5-1), with each element representing a discrete portion of the water body. These elements were assigned an average water depth (Figure 5-1), based on field measurements taken during the Phase 1 GSIP (Roux Associates, 1991). Each element contained three corner nodes at which both surface water elevation and velocity are calculated. The completed grid system for the HBHA contains 1,137 nodes and 2,112 elements.

The two influent sources included in the steady-state hydrodynamic model were Hall's Brook (2.3 cfs or 1032 gpm) and the proposed GWTP discharge (0.67 cfs or 300 gpm). The Hall's Brook flow rate is representative of average conditions based on measurements taken during the Phase I GSIP (*op. cit.*). Given that the proposed GWTP discharge becomes mixed across the entire cross-section of the HBHA upon reaching the southern end of the same, the maximum steady-state dilution (D) of the GWTP effluent concentration would be equal to the ratio of the combined discharge (approximately 3 cfs) to the GWTP effluent discharge (i.e., D = 3/0.67 = 4.5).

Figure 5-2 presents the computed steady-state velocity vectors using TEA and the hydraulic input data generated from the model above. The results show elevated velocities, as expected, at the point where Hall's Brook and the GWTP culvert enter the HBHA. The velocities observed in these areas are primarily a result of the concentrated volumetric flow rates and the shallowness of the mixing zones. Similarly, at the southern portion of the HBHA, velocities increase due to a decrease in the depth and volume of the channel, with large increases seen as the flow converges into the narrow berm separating the pond from the marsh.

5.1.3 Transport Model

The FEM grid system (Figure 5-1) was also used for the transport calculations. Additional nodes, however, were added to each triangular element (not shown) to construct the six-node, quadratic elements required by ELA. The primary additional input data requirement for the transport analysis was a value for the dispersion coefficients. A constant value of 0.1 ft^2/sec was found to most reasonably represent the expected mixing characteristics in the HBHA, based on qualitative field observations. Smaller values of the dispersion coefficient generated pronounced lateral concentration gradients in the HBHA discharge stream, a result that was considered to reflect an underestimate of the transverse mixing rate. Dispersion coefficient values greater than 0.1 ft^2/sec resulted in approximately the same computed concentration distribution determined using a value of 0.1 ft^2/sec. Note that, as discussed above, the average steady-state concentration at the downstream (south) end of HBHA does not depend on the dispersion coefficient, only the inflow rates.

Figure 5-3 shows the calculated steady-state concentration distribution in the HBHA resulting from a dimensionless GWTP effluent concentration of 1.0. The concentration in the Hall's Brook influent was assumed to be zero. For illustrative purposes, Figure 5-4 is presented as a combined map of the computed velocity and concentration field. The major trends in Figure 5-3 and 5-4 are: 1) a gradual reduction (a factor of @2-4) in the unit concentration between the point of initial mixing and Hall's Brook and 2) a further reduction (close to a factor of 5) downstream of Hall's Brook due to a more complete intermixing with the Hall's Brook effluent.

5.1.4 Proposed Effluent Limits

Table 5-1 presents the effluent limits for constituents identified in groundwater that would be expected to be present in the GWTP effluent stream. The first column presents the expected instrument detection limits, as cited in Standard Methods (APHA, 1980) and various methodologies required by USEPA. The second column presents the Chronic Ambient Water Quality Criteria, as derived from USEPA documentation (USEPA, 1986). The third column presents the proposed effluent limit concentrations, also derived using USEPA water quality documentation (USEPA, 1985; 1986). The effluent limits for metals were derived as follows:

1) The chronic Ambient Water Quality Criteria (AWQC) were determined from the USEPA documentation (USEPA, 1986), using a site-specific (mean) hardness value of 101.6 mg/l (Roux Associates, 1991; Table 4.5) in the estimation of the criteria for chromium and lead; and,

2) The bioavailability of each metal in the water column, i.e. the fraction of total metal that is in the dissolved phase, was determined using Federal water quality screening methods (USEPA, 1985). This methodology assumes that the partitioning of metals in the water column is dependent on the concentration of total suspended solids (TSS). The final effluent limits were calculated by a) determining the fraction of dissolved metal in the water column, using a site-specific TSS of @5 mg/l (Roux Associates, 1991; Table 4.5) and linear partition coefficients of 0.48×10^6, 3.38×10^6, and 0.31×10^6 for arsenic, chromium and lead, respectively; b) determining percent dilution in the mixing zone and zone initial dilution (25%, derived from model above) and; c) dividing the chronic AWQC (1) by

the product of (a) and (b). This number is then statistically transformed to achieve a 30 day average concentration for the proposed GWTP effluent limit. The transformation insures that the permit limits will not be exceeded as a result of a sampling error (p = 0.01, or 1%) and assumes a) that the effluent concentrations are log normally distributed and b) a coefficient of variation of 0.6. The dilution in the mixing zone assumes that the point of compliance for effluent dilution is the upstream end of HBHA (i.e the point where Hall's Brook enters the upper third of the ponded area).

5.2 IMPACT OF GWTP DISCHARGE ON SURFACE WATER QUALITY

The northern (ponded) portion of the HBHA (HBHAP) intercepts groundwater moving from the Site. This groundwater flow contributes a substantial percentage of the total surface water discharge from the HBHA into the Aberjona River south of Mishawum Road (GSIP Phase I, Roux Associates, 1991). Consequently, any Constituents of Concern (COC) that may be dissolved in groundwater moving from the Site have the potential to impact water quality. The groundwater recovery and treatment system is designed to capture this groundwater through a series of extraction wells (Golder Associates, 1991), treat this water to remove COC (The Advent Group, 1991), and discharge treated effluent (@300 gpm or 0.67 cfs) into the HBHAP (Golder Associates, 1992). The purpose of this section is to describe 1) the current status, based on field observations made during the fall/winter of 1991/1992, of the water quality within the HBHAP and, 2) the potential changes that may take place within the pond subsequent to the installation of the Groundwater Treatment Plant (GWTP).

5.2.1 Field Investigation

The Phase I GSIP identified a decrease in abundance and diversity (relative to other sampling stations) of fish and benthic macroinvertebrates within the HBHAP. Although the type of habitat (man-made impoundment) may partially explain the depauperate community observed within the pond, the possibility of a decrease in water quality as a result of groundwater discharge must also be entertained. This field investigation focused on two parameters which could be adversely affecting water quality: turbidity and ammonia. Measurements of these parameters also allow the establishment of a baseline against which future changes, subsequent to the installation of the Groundwater Treatment Plant, can be compared.

Phillip's Pond (Figure 5-5) was used as a control site for turbidity measurements, as previous investigations have shown that it is not affected by site-related constituents. Ammonia/nitrate measurements were also performed on samples taken from this pond, as well as from other sampling stations throughout the Study Area (Roux Associates, 1991).

5.2.2 Turbidity

Two methods were chosen for the measurement of turbidity: a Secchi disk was used to determine the turbidity of the water column, while a nephelometer was used to measure turbidity within individual grab samples. A Secchi Disk is a colored (black on white) plexiglass disk, attached to the end of a calibrated rope. It is lowered into the water body until the image of the disk is no longer visible from the water surface. This depth is read from the calibrated rope and recorded. Secchi disk measurements were taken during the month of October (1991) in the center of Phillip's Pond and the northern and southern end (currently marked by fluorescent orange buoys) of the HBHAP. A nephelometer (turbidimeter) was the second method used for measuring the transmissivity of light through water samples. Turbidity measurements were performed during the month of January (1992) using a Monitek Model 21PE Battery Operated Nephelometer (calibrated using Formazan standards according to the manufacturer Operating and Maintenance Instructions). Water sampling locations are presented in Figure 5-1, and include samples taken from Phillip's Pond (outlet to Aberjona River), Hall's Brook (SW-10), and the HBHAP (the eastern shoreline, adjacent to the Digital parking lot, and the outlet to the marsh, SW-13).

5.2.3 Ammonia/Nitrate

Water samples for the measurement of ammonia/nitrate were taken area wide to develop a more complete database with regard to groundwater/surface water interaction. Water sampling locations are presented in Figure 5-5, and include samples taken from Phillip's Pond (outlet to Aberjona River), New Boston Street Drainway (SW-06, SW-07, SW-18), HBHAP (SW-09 and SW-13), Hall's Brook (SW-10, SW-19), and the Aberjona River (SW-02, SW-04, SW-14, SW-24). Both ammonia and nitrate were measured using an Ion Selective Electrode (Hach, Model 44470 and 44560, respectively) according to the manufacturers instruction manual.

5.2.4 Surface Water Quality (Current)

5.2.4.1 Turbidity

Turbidity is a measure of water clarity. Turbidity is caused by suspended material, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and plankton and other microscopic organisms. Increased turbidity decreases light transmittance through the water column, which in turn will interfere with photosynthesis and, ultimately, primary (autotrophic) productivity.

Initial observations of aerial photographs taken of the Site (LIU Aerial Surveys, 1989, currently on file with ISRT), show a marked difference in the reflective properties of Phillip's Pond (considered "background") versus the HBHAP, even though both ponds are similar in mean depth (@10 feet). From the photograph, Phillip's Pond appears dark, while HBHAP is much lighter in color. Secchi disc measurements confirm these differences: measurements made in Phillip's Pond (@2.56 m) were approximately two times higher than those observed in HBHAP (@1.25 m).

Figure 5-6 presents results of turbidity measurements (nephelometric) performed on water samples taken in January. Samples taken from the HBHAP (SW-09 and SW-13) are twice as high as those taken in Hall's Brook (SW-10) or Phillip's Pond. The results of both methods (Secci vs. nephelometric) are in agreement, which is to be expected (USEPA, 1985).

5.2.4.2 Ammonia/Nitrate

The groundwater treatability study (The Advent Group, 1991) identified "odors, benzene, toluene, arsenic, chromium, and ammonia" as COC in groundwater. During groundwater treatment, ammonia will be converted to nitrate/nitrite (nitrification), which will then be converted to nitrogen gas (denitrification). Nitrate, while much less toxic to fish than ammonia, may present other problems within impoundments because it acts as a nutrient that may stimulate the growth of indigenous algae, causing "blooms" which consume dissolved oxygen. This oxygen demand within a lake or impoundment can be great enough to cause the death of large numbers of fish. This process, occurring over a long period of time, is known as eutrophication, which will limit the vitality of the ecosystem.

Phosphate, however, is generally recognized as the limiting nutrient and must also be present in sufficient quantity for algal growth to occur. USEPA (1985) Water Quality Assessment Screening documentation presents an excellent review of the literature and best describes this relationship as follows:

> "an average algal cell has an elemental composition for the macronutrients of $C_{106}N_{16}P_1$. With 16 atoms of nitrogen for each atom of phosphorus, the average composition by weight is 6.3 percent nitrogen and 0.87 percent phosphorus, or an N/P ratio of 7.2/1. Although other nutrient considerations must be met, the relative rate of supply is significant and must be determined to know which nutrient is limiting. For N/P ratios

greater than 7.2, phosphorus would be less available for growth ("limiting") and when less than 7.2, nitrogen would be limiting. In practice, values of less than 5 are considered nitrogen limiting, greater than 10 are phosphorus limiting, and between 5 and 10, both are limiting".

Figure 5-7 presents ammonia concentrations (NH_3-N, pH 11) for selected surface water stations within the GSIP Study Area. With the exception of SW-18, which represents ammonia migrating from sources off-Site, the "background" concentrations are relatively low (@0.5 mg/@). Stations SW-06 and SW-07, which intercept groundwater migrating from the Woburn Landfill (Roux Associates, 1991), have elevated concentrations of ammonia relative to the other sampling stations.

Figure 5-8 presents nitrate concentrations in the same samples in which ammonia was measured (above). Again, the highest concentrations were detected in SW-06, SW-07, and SW-18, all located within the New Boston Street Drainway. Other than these samples, concentrations of nitrate in surface waters are unremarkable, a finding confirmed by The Advent Group (1991) for groundwater. At this point, one may conclude that:

1) representative "background" concentrations of nitrate in groundwater are between 0.5 and 1.0 mg/@; and,

2) the metabolic conversion of ammonia to nitrate (nitrification) by indigenous heterotrophic organisms in soil or groundwater does not appear to be occurring at the Site.

5.2.5 Impact Of GWTP On Surface Water Quality

In addition to data gathered for this evaluation, Table 5-2 summarizes physical and chemical parameters taken (or derived) from other studies (Roux Associates, 1991; The Advent Group, 1991) performed at the Site. Based on the available data, it can be seen that the N/P ratios (with the exception of the "composite groundwater", which will be treated) for Hall's Brook, HBHAP, and the GWTP effluent all exceed 10. Thus, given ideal conditions within the impoundment, phosphorus appears to be the limiting nutrient in controlling primary productivity within the HBHAP.

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USEPA, 1986. Quality Criteria for Water. Office of Water Regulations and Standards, Washington, D.C. USEPA 440/5-86-001 (NTIS#PB87-226759). Westerink, J.J., Connor, J.J., Stolzenbach, K.D., Adams, E.E., and Baptista, A.M., 1984. "TEA: A Linear Frequency Domain Finite Element Model for Tidal Embayment Analysis", Energy Laboratory Report No. MIT-EL 84-012, Massachusetts Institute of Technology, Cambridge, MA.

TABLE 5-1

PROPOSED EFFLUENT LIMITS FOR GROUNDWATER TREATMENT PLANT BASED ON AWQC AND SURFACE WATER FLOW MODELLING

INDUSTRI-PLEX SUPERFUND SITE
Woburn, MA

CONSTITUENT OF CONCERN	INSTRUMENT DETECTION LIMIT (ppb)	EPA AMBIENT WATER QUALITY CRITERIA (chronic, ppb)	PROPOSED GWTP EFFLUENT LIMITS (ppb)
Ammonia	20	2,100	8,400
Benzene	1		1,060 *
Nitrate/Nitrite	50		10000
Phosphorus (total)	50		2000
Toluene	1		3,600 *
Arsenic	3	190	984
Chromium	3	11	120
Lead	2	3.2	35

1

Quality Criteria for Water, U.S. Environmental Protection Agency, May 1986.

2

Waste Load Allocation for the GWTP Effluent Limits for metals are calculated by a) determining the Chronic Ambient Water Quality Criteria (using site-specific hardness of 101.6 mg/L for chromium and lead) b) determining the fract[illegible] metal that is in the dissolved phase (USEPA, 1985, see text) c) determining the percent dilution in the mixing zone (25%) and d) dividing (a) by the product of (b) and (c). The Proposed GWTP Effluent Limits are then transformed statistically (assuming a log normal sampling distribution and a C.V. = 0.6) to account for monthly sampling error (p = 0.01, i.e. the chance of exceedance of permit limits, based on a sampling error, is 1%).

*

An asterisk indicates that no chronic criterion was available. A chronic value was calculated by dividing the dilution adjusted acute criterion by 20 (a factor of 20 was chosen as a conservative value for an acute/chronic ratio).

TABLE 5-2

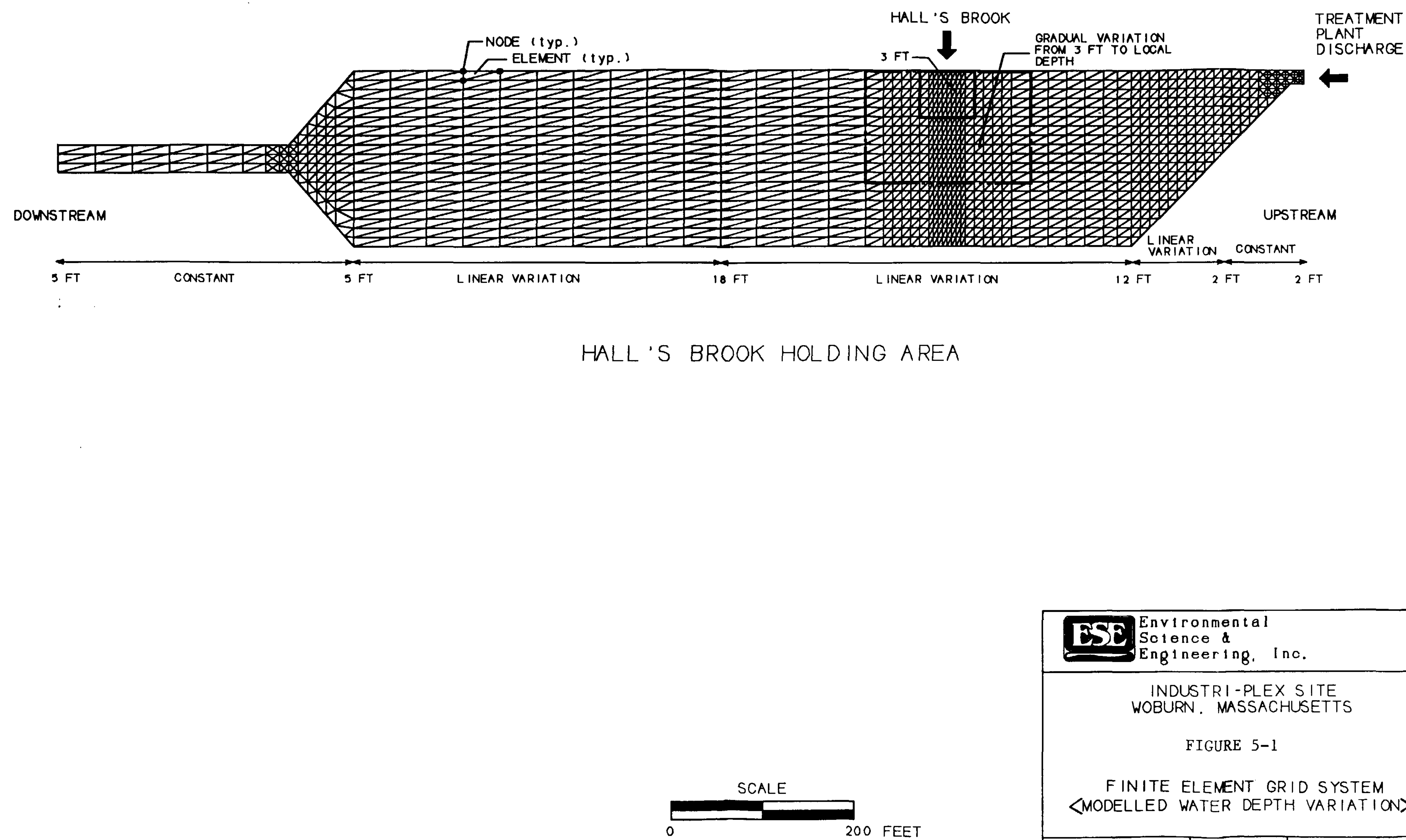
PHYSICAL AND CHEMICAL CHARACTERISTICS
OF SURFACE WATER AND GROUNDWATER

Industri-Plex Superfund Site
Woburn, MA

	Units	HALL'S BROOK [1]	HALL'S BROOK HOLDING AREA POND [1]	COMPOSITE GROUNDWATER [2]	GWTP EFFLUENT [2]
CHEMICAL PARAMETERS					
Total Organic Carbon	mg/L	9.1	8.6	79	14.0
Orthophosphate as P	mg/L	0.061	<0.01	--	--
Phosphorous, total	mg/L	0.090	0.06	5	0.1
Ammonia	mg/L	0.6	9.7	440	1
Nitrate	mg/L	0.8	1	1	100-200
Nitrite	mg/L	--	--	2	175-250
N/P Ratio	--	13.1	16.3	0.2	1750-2500
PHYSICAL PARAMETERS					
Length	feet	9-10,000	1070		
Width	feet	5-10	191		
Area (A)	sq.ft.	--	185946		
Depth (Z)	feet	0.55	9.66		
Volume (V)	cu.ft.	--	1,796,826		
Discharge (Q)	cfs	2.78	3.28	0.5	0.67
Hydraulic Dilution Rate (D)	1/years	--	57.57		
Hydraulic Residence Time (T)	years	--	0.02		
Hydraulic Loading (qs)	m/yr	--	170		
Phosphorus Loading	g/m2 yr		3.46		
Net Rate of Removal (K)	--	--	7.59		

1
Obtained or derived from "Groundwater/Surface Water Investigation Plan", Roux Associates, Huntington, NY (1991).
Nitrate and ammonia values were determined for this report in December, 1992, using a Hach Ion Selective Electrode.

2
Obtained or derived from "Groundwater Treatability Study", The Advent Group, Brentwood, TN (1992).



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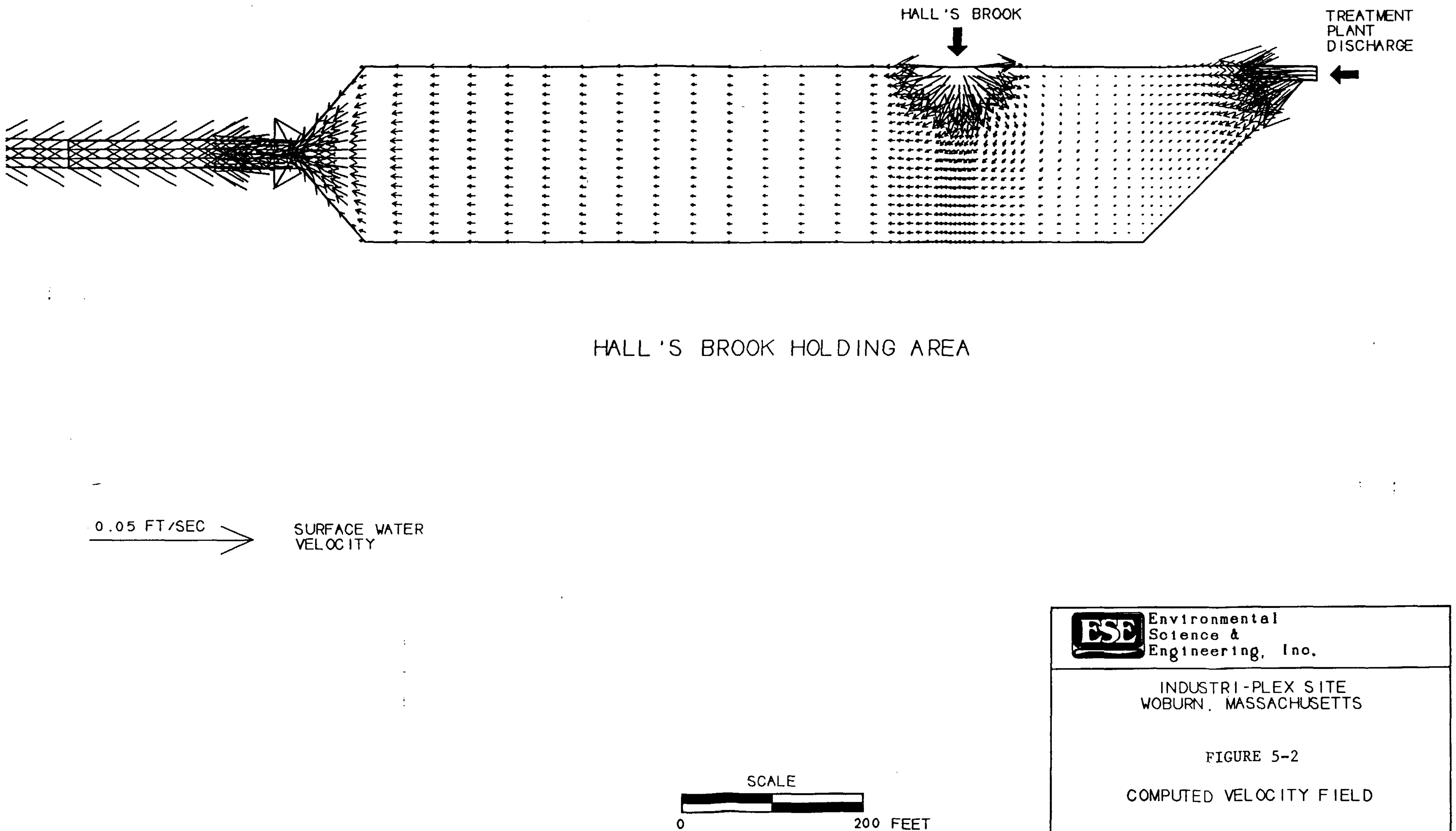
INDUSTRI-PLEX SITE
WOBURN, MASSACHUSETTS

FIGURE 5-1

FINITE ELEMENT GRID SYSTEM
<MODELLED WATER DEPTH VARIATION>

SCALE: AS SHOWN	REVISION: 1	DATE: 7-25-91



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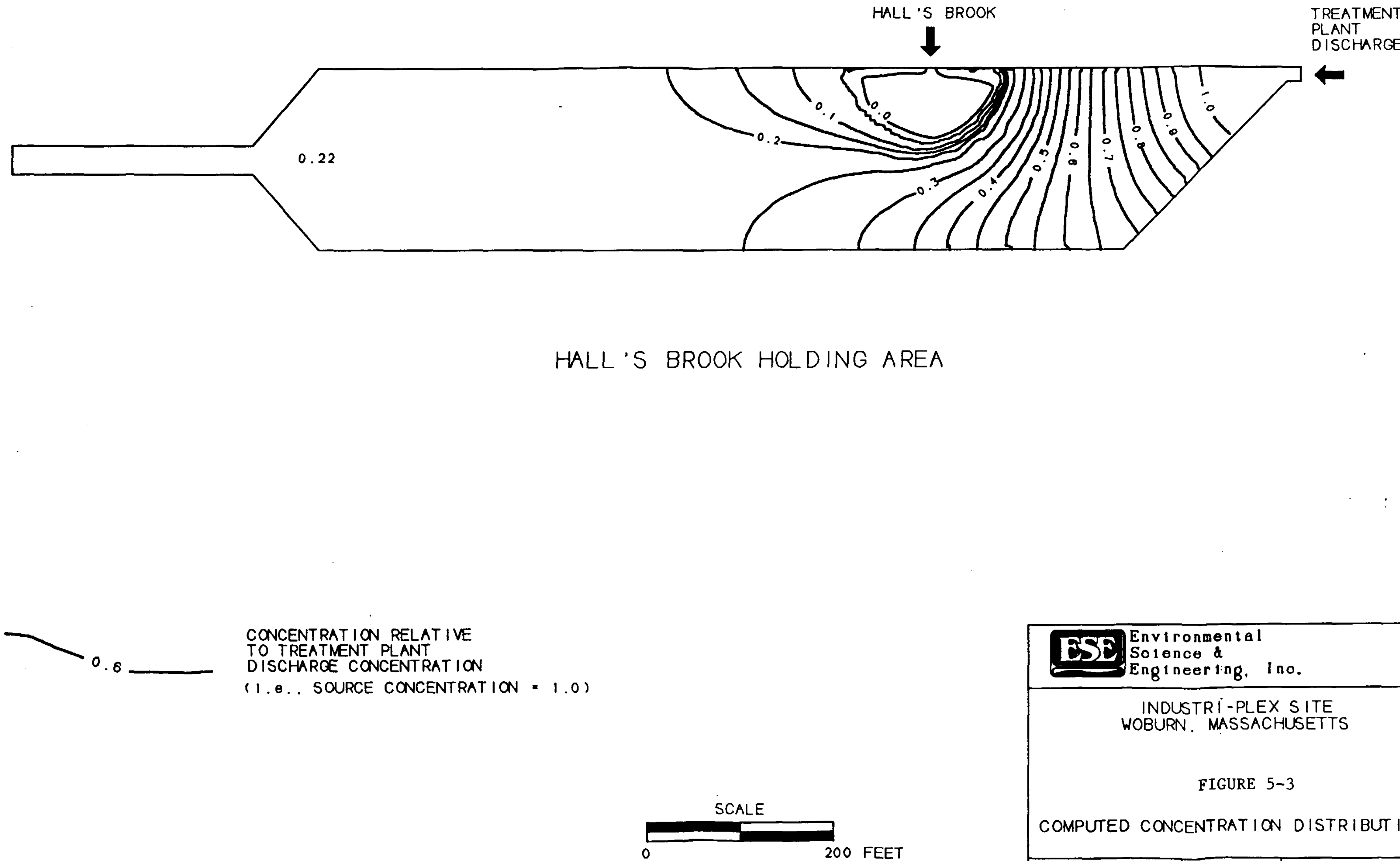
INDUSTRI-PLEX SITE
WOBURN, MASSACHUSETTS

FIGURE 5-2

COMPUTED VELOCITY FIELD

SCALE: AS SHOWN | REVISION: 1 | DATE: 7-25-91

FILE: HBALL.DWG



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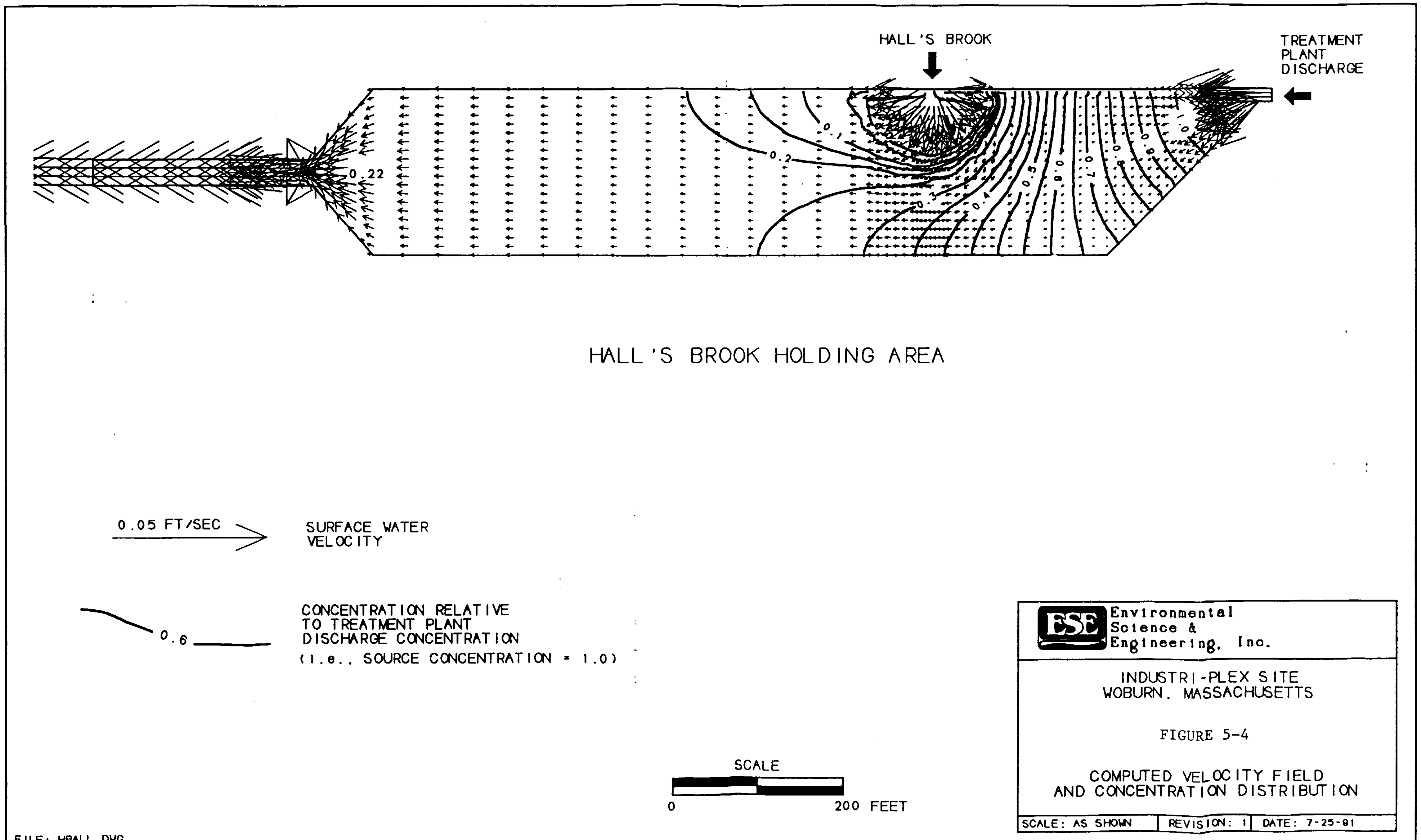
INDUSTRI-PLEX SITE
WOBURN, MASSACHUSETTS

FIGURE 5-3

COMPUTED CONCENTRATION DISTRIBUTION

SCALE: AS SHOWN | REVISION: 1 | DATE: 7-25-91

FILE: HBALL.DWG



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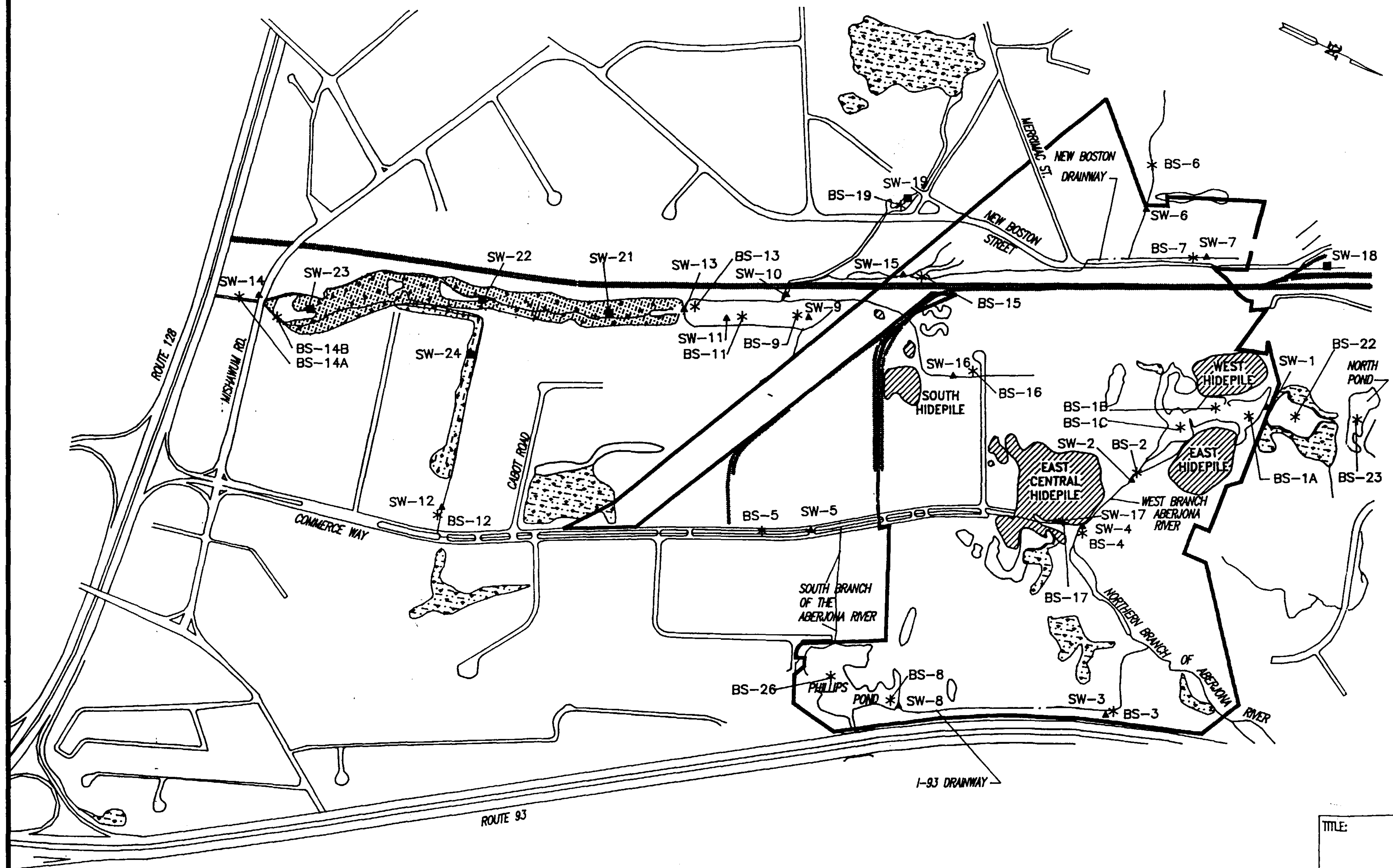
INDUSTRI-PLEX SITE
WOBURN, MASSACHUSETTS

FIGURE 5-4

COMPUTED VELOCITY FIELD AND CONCENTRATION DISTRIBUTION

SCALE: AS SHOWN | REVISION: 1 | DATE: 7-25-91



EXPLANATION

SW-3 ▲ SURFACE WATER/STREAM SEDIMENT SAMPLE LOCATION AND DESIGNATION

SW-25 ■ GSIP PHASE 2 SAMPLING LOCATIONS AND DESIGNATION

BS-3 * BIOLOGICAL SAMPLING LOCATION AND DESIGNATION

TITLE:

FIGURE 5-5

LOCATIONS OF SAMPLING STATIONS FOR SURFACE WATER, SEDIMENT, & BIOTA

PREPARED FOR:

INDUSTRI-PLEX SITE REMEDIAL TRUST

ROUX ROUX ASSOCIATES, INC. ENVIRONMENTAL CONSULTING & MANAGEMENT	COMPILED BY: M.S.	DATE: 3/92	FIGURE
	PREPARED BY: C.L.	SCALE: SHOWN	
	PROJECT MANAGER: D.S.	REVISION: 0	
	PROJECT NO. 4915422		

FIGURE 5-6

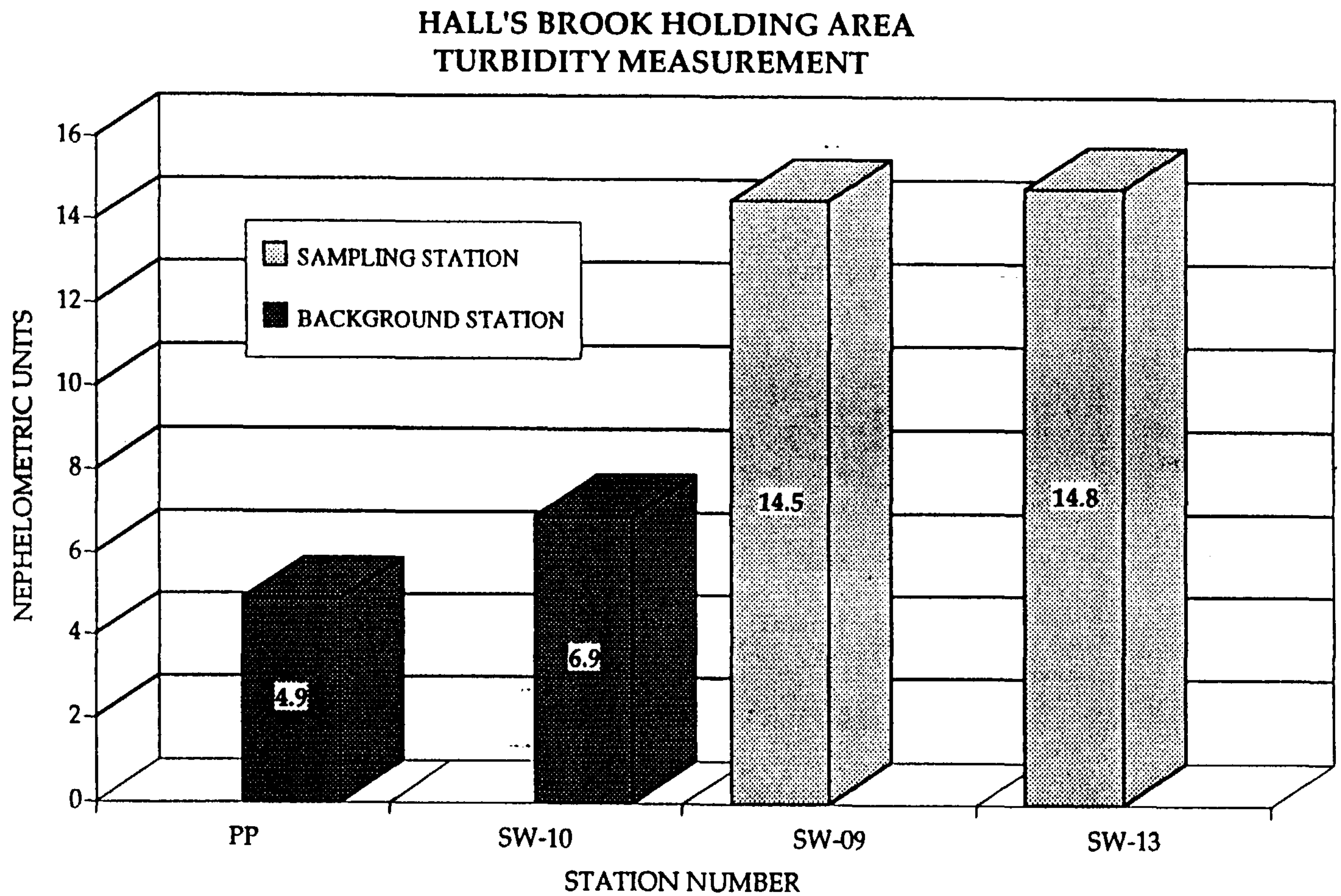
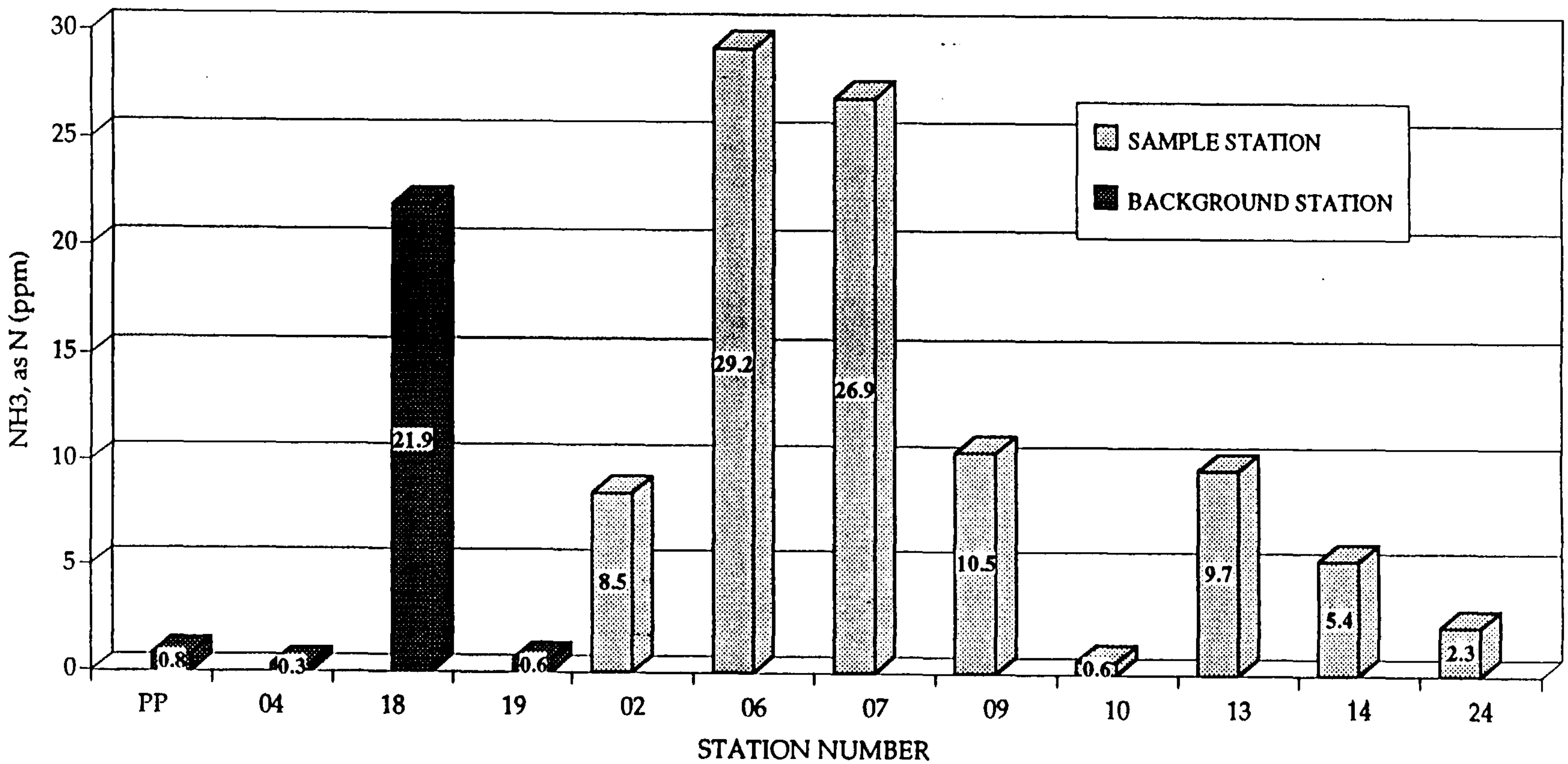

HALL'S BROOK HOLDING AREA
TURBIDITY MEASUREMENT
NEPHELOMETRIC UNITS
0
2
4
6
8
10
12
14
16
SAMPLING STATION
BACKGROUND STATION
4.9
6.9
14.5
14.8
PP
SW-10
SW-09
SW-13
STATION NUMBER

FIGURE 5-7

AMMONIA CONCENTRATION AT SELECTED SURFACE WATER SAMPLING STATIONS



ESE
A CILCORP Company

FIGURE 5-8

NITRATE CONCENTRATION AT SELECTED SURFACE WATER SAMPLING STATIONS