A Report Prepared for

Exxon Company, USA
P.O. Box 4032
Concord, California 94504

Sep 1991

WORK PLAN
GROUNDWATER EXTRACTION AND TREATMENT
SYSTEM INSTALLATION
EXXON STATION #7-0104
ALAMEDA, CALIFORNIA

HLA Job No. 04167,392.02

by

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LIST OF DRAWINGS

1.0 INTRODUCTION

Harding Lawson Associates (HLA) has prepared this work plan for Exxon Company, U.S.A. (Exxon), Concord, California, to describe the installation of a groundwater extraction and treatment system at Exxon Station #7-0104, 1725 Park Street, Alameda, California (Drawing C1). The proposed scope of work is intended to remediate and control the potential offsite migration of groundwater containing dissolved petroleum hydrocarbon constituents. The design of the groundwater extraction and treatment system is based upon hydrogeologic conditions in the uppermost aquifer, as described in HLA's report *Phase III Evaluation of Petroleum Hydrocarbons, Exxon Station #7-0104, 1725 Park Street, Alameda, California* (*HLA, 1990*) and in quarterly groundwater monitoring events (*HLA, 1991a*).

This phase of work was authorized by Exxon Contract #91064698, Change Order 1, and included the preparation of a design and specification package for installation of the groundwater extraction and treatment system (*HLA, 1991b*), submittal of permit applications, and preparation of this work plan.

2.0 BACKGROUND

2.1 Site Description

Exxon Station #7-0104 is located at the western corner of Park Street and Eagle Avenue in Alameda, California (Drawing C1), approximately 0.5 mile south/southwest of U.S. Interstate 880. San Francisco Bay is approximately 1.5 miles southwest of the site and the Alameda Harbor Tidal Canal is approximately 0.25 mile north/northeast of the site. The surrounding topography is relatively flat with the surface elevation of the site approximately 17 feet above mean sea level (MSL). Land use in the area is residential and commercial. Structures at the site include a building with a convenience store, two multi-pump fuel dispenser islands covered by a canopy, and three underground storage tanks (USTs).

The site was formerly occupied by a Regal Service Station owned by Wickland Oil Company, Sacramento, California. Exxon acquired the property from Wickland Oil Company in 1988.

2.2 Regional Geology and Hydrogeology

The site is located on the island of Alameda at the eastern edge of San Francisco Bay. The uppermost geologic unit in the area consists of fill generally comprised of gravelly clays or clayey gravels that extend to an approximate depth of 5 feet below ground surface (bgs). The fill is underlain by Quaternary age sand, silts, silty and clayey sands, and sandy clays comprising the Merritt Sand and Posey formations. The Merritt Sand blankets the Posey Formation but the units are similar in composition and are commonly grouped together. These sediments extend to an approximate depth of 30 to 40 feet bgs and comprise the uppermost aquifer in the area.

The Merritt Sand and Posey formations are underlain by the Quaternary age San Antonio Formation. The San Antonio Formation consists predominantly of silty clay with occasional thin lenses of fine gravel. The silty clay serves as a confining layer for the overlying aquifer and extends to an estimated depth of 120 feet bgs. The San Antonio Formation overlies the Quaternary age sand, sandy clay, clay, and gravel of the Alameda Formation. The Alameda Formation is a water-bearing unit form 10 to 200 feet thick. The depth of this unit in the area of the site is unknown.

The Franciscan Assemblage underlies the Alameda Formation and consists of tectonically altered graywacke, sandstone, siltstone, shale, metamorphics, and volcanics. The Franciscan Assemblage is estimated to be over 50,000 feet thick and forms the basement complex in the San Francisco Bay Area. The depth to the Franciscan Assemblage in the area of the site is not known.

2.3 Summary of Previous HLA Investigations

HLA has conducted three phases of site characterizations and presented the results to Exxon in reports dated June 24, 1988; March 21, 1989; and May 1, 1990, respectively (*HLA, 1988; HLA, 1989; HLA, 1990*). HLA has also been conducting monthly water-level measurements and quarterly groundwater sampling at the site since June 1989. The following presents a summary of these investigations.

- HLA has installed seven groundwater monitoring wells onsite.
- The site geology consists of 1 to 5 feet of fill overlying interbedded sand, silty and clayey sand, and silt of the Merritt Sand and Posey Formations to an approximate depth of 38 feet. Confining clay of the San Antonio Formation is present at depths deeper than 38 feet.
- Potentiometric surface elevations measured in July 1991 ranged from approximately 10 to 11 feet MSL (approximately 6 to 7 feet below ground surface).

- No free-phase petroleum product has been detected at the site.
- Petroleum constituents have been detected in soil samples collected from all borings drilled at the site. Detected concentrations of total petroleum hydrocarbons (TPH) as gasoline range from 0.6 to 2,600 milligrams per kilogram (mg/kg).
- The highest concentrations of TPH as gasoline were detected in soil samples collected near the tank field and in the downgradient southeast corner of the site.
- Concentrations of benzene in groundwater samples collected from all monitoring wells exceed the California Department of Health Services (DHS) action level of 0.7 micrograms per liter ($\mu g/l$).
- The highest concentrations of benzene in the groundwater are adjacent to and downgradient of the tank field and dispenser islands.
- The geometric mean hydraulic conductivity and transmissivity values derived from slug test results are 0.76 ft/day and 22 ft^2/day, respectively, and are considered representative of the silty sand materials of the uppermost aquifer.
- The horizontal velocity of groundwater flow in the uppermost aquifer ranges from approximately 0.05 to 0.08 ft/day.

HLA has also completed a bioremediation treatability study for remediation of contaminated groundwater at the site. The results of that study were submitted to Exxon in a report dated July 26, 1991 (*HLA, 1991c*). The study found that the existing microbial population in groundwater at the site contains a subpopulation of petroleum hydrocarbon-utilizing microorganisms. The laboratory simulation results indicated that biological treatment of the groundwater resulted in a decrease of TPH and total benzene, toluene, ethylbenzene, and xylenes (BTEX) concentrations of approximately 99 percent. On the basis of these results, biological treatment was selected to remediate contaminated groundwater.

3.0 SCOPE OF WORK

On the basis of lithologic data, calculated hydraulic conductivity and transmissivity values, and computer capture analyses, it appears that effective hydraulic control can be obtained through the installation of five groundwater extraction wells along the downgradient site perimeter (Drawing C1). Based on the results of the treatability study, it appears that groundwater can be effectively treated onsite using a bioreactor treatment system. The groundwater will then either be discharged to the storm or sanitary sewer, depending on the results of the permitting task (described below). The proposed scope of work will be accomplished by completing the following tasks.

3.1 Permitting

Prior to initiating construction activities, HLA and construction subcontractors will obtain necessary permits from the local agency(ies) with jurisdiction over construction, including permits for well installation, electrical, mechanical, and civil construction. HLA is currently preparing permit applications for East Bay Municipal Utility District (EBMUD) for discharge of decontaminated water to the sanitary sewer and National Pollution Discharge Elimination System (NPDES) for discharge of decontaminated water to the storm sewer. At this juncture, HLA anticipates permit approval from EBMUD which will allow the discharge of effluent containing higher petroleum hydrocarbon concentrations than the NPDES permit will allow.

3.2 Extraction Wells

3.2.1 Installation and Development

Five 4-inch diameter groundwater extraction wells, EW-1 through EW-5, will be installed at the locations shown on Drawing C1. These well locations were chosen based on the results of previous computer capture modeling. Prior to the start of drilling, HLA will contact pertinent public and private entities to locate the underground utilities in the area.

The borings for the extraction wells will be drilled using a truck-mounted drill rig equipped with 11-inch-diameter hollow stem augers to an approximate depth of 40 feet. Soil borings will be logged by an HLA geologist or field technician under the supervision of a California-registered geologist. Soils will be classified in accordance with the Unified Soil Classification System. Prior to removal of the augers, 4-inch diameter, Schedule 40 PVC well casing and screen will be installed in the borings. A silt trap consisting of 5 feet of blank PVC casing will be installed at the bottom of the wells. Factory-slotted 0.020-inch well screen will extend from approximately 5 to 35 feet bgs. Blank casing will extend to within 0.5 foot of the ground surface. The annular space between the well casing and borehole wall will be backfilled with Lonestar #3 sand to approximately 1 foot above the top of the screened interval. A 0.5 foot-thick bentonite pellet layer will be placed on top of the sand pack and hydrated with fresh water. The remaining annular space will be filled with a cement/bentonite grout. The well will be completed below grade with a locking cap and watertight, flush mounted well cover.

Following installation, the extraction wells will be developed by bailing and/or pumping with a submersible or centrifugal pump. Development will continue until a minimum of 10 well volumes are removed from each well and the purged water contains few fine-grained sediments. During development, the conductivity, temperature, pH, and turbidity of the purge water will be monitored and recorded.

Pneumatic pumps (QED Pulse Pumps) and vault boxes will be installed at each extraction well as shown on the drawings. A description of the pumps is included in

Appendix A. Each pump will be suspended from the well cap and will be placed approximately 3 feet above the bottom of the well. After extraction system startup, the depth of the pumps may be adjusted to obtain the optimum extraction volumes from the wells. The traffic covers will be replaced with 17" x 30" x 24" traffic-rated precast-concrete vault-boxes (Drawing C2). The wellheads will be modified to accommodate the air supply and water discharge lines, sampling ports, and associated fittings.

Following well completion, the top of casing elevation of each well will be surveyed to an accuracy of 0.01 foot and referenced to mean sea level by a California-licensed surveyor.

3.2.2 Equipment Decontamination

To minimize the possibility of cross-contamination, all downhole drilling and sampling equipment will be decontaminated prior to use. The augers will be steam cleaned prior to drilling each boring. Soil and water sampling equipment will be washed in a low-phosphorus soap solution and double rinsed with deionized water before each sample is collected.

3.2.3 Waste Material Storage and Disposal

Soil cuttings produced during drilling of the well borings, water derived during well development, and decontamination fluids will be contained in 55-gallon drums and stored onsite. Based on the results of the analytical testing, the material will later be disposed in accordance with state and local regulations.

3.3 Conveyance Piping and Trenches

Pipe trenches linking the extraction wells, sewer and storm drain discharge points, and the treatment system will be constructed as shown on Drawings C1 and C4. The pipe trenches will be excavated through the existing asphalt and concrete pavement. Lines between the extraction wells and the treatment system will be installed in the trenches to transport compressed air and extracted groundwater. Primary piping between the extraction wells and the treatment system will be encased in 4-inch-diameter Schedule 80 PVC pipe for secondary containment. Extracted groundwater will be transported within the containment through a combination of 3/4-inch and 1-inch inside diameter (ID) reinforced nylon tubing. Compressed air will be directed from a compressor in the treatment system to the extraction pumps through a combination of 3/4-inch and 1/2-inch ID reinforced nylon tubing.

Separate tie-ins to the sanitary sewer and storm drain will be installed as shown on Drawing C1 to allow effluent from the treatment system to be discharged to either point. Treatment system effluent will gravity-flow from the treatment system to the sewer lateral through a 2-inch-diameter SDR-35 pipe, sloped at a 1 percent grade. If an NPDES discharge permit is obtained, treatment system effluent will gravity-flow to the storm drain on Park Street through a 2-inch Schedule 80 PVC discharge line.

Trenches will be backfilled with clean imported soil and compacted. The asphalt and concrete pavement will be repaired as shown on Drawing C4 to its original condition or better.

3.4 Treatment System Compound

A bermed concrete pad will be constructed as shown on the drawings to contain a skid-mounted groundwater treatment unit and a set of polishing carbon canisters (Drawings C3 and C4). The treatment system area will be enclosed within a 7-foot high fence with gates placed to provide access to the carbon storage area and the control panel on the skid-mounted treatment unit. The area will replace two parking spaces next to the building on the site. The treatment pad area must be leveled and existing asphalt removed before construction of the concrete pad.

3.5 Groundwater Treatment System

Dissolved hydrocarbon constituents will be removed from extracted groundwater with a skid-mounted Fluid Treatment System manufactured by Envirex LTD, Waukesha, Wisconsin. This system uses microbial populations to degrade the hydrocarbons biologically coupled with granular activated carbon (GAC) media to adsorb hydrocarbons from the water. A description of the system is provided in Appendix B.

The treatment system as installed will be comprised of the following:

- Compressor - The compressor supplies pressurized air for feeding the oxygen generator.
- Chemical Feed System - The chemical feed system supplies nutrients to the extracted groundwater and includes a storage tank and a metering feed pump.
- Dual Fluidization Pumps - These pumps ensure a steady fluidization flow to the reactor.
- Oxygen Bubble Contactor - This predissolves oxygen into the fluidization flow and prevents bubbles form escaping into the system.
- Pressure Swing Adsorption (PSA) Oxygen Generator - The PSA Oxygen Generator supplies a 90-95 percent pure oxygen gas to dissolve with water before entering the fluid bed reactor. This eliminates off-gas and potential stripping.

- Fluid Bed Reactor - The fluid bed reactor houses the GAC used in groundwater treatment.

- Effluent/Recycle Structure - This structure is an overflow system which automatically controls recycle.

- Control Panel - The control panel houses the controls, switches, motorstarters, etc. in a weathertight panel.

- Dissolved Oxygen Meter - This meter monitors the system effluent dissolved oxygen to prevent under- or over-oxygenation of the treated groundwater.

Pending approval of discharge to the EBMUD sanitary sewer, no carbon polishing is anticipated to be necessary. However, in the event that the effluent will be discharged to the storm drain under a NPDES permit, a separate skid-mounted carbon polishing unit may be required.

3.6 Treatment System Start Up

Once the extraction and treatment systems are installed, HLA will perform the following activities:

- Start up the extraction system
- Check the piping systems for leaks
- Monitor the bioreactor for growth of organisms.

3.7 System Monitoring

Following installation and startup of the groundwater treatment system, its performance and effectiveness will be evaluated by performing short term monitoring of water levels in the extraction and monitoring wells and performing chemical analysis of water samples collected from the groundwater extraction and treatment system. The proposed groundwater treatment monitoring will be performed to meet NPDES permit requirements.

Treatment system and water-level monitoring will include the following activities:

- Daily sampling of the treatment system and monitoring water levels in extraction and monitoring wells for the first five days of operation, including two rounds on the first day

- Weekly sampling of the treatment system and water-level monitoring for the duration of the first month

- Monthly sampling of the treatment system and water-level monitoring thereafter for the remainder of one year.

For each of the treatment system sampling events, the following will occur:

- Samples will be collected from four locations: influent to the bioreactor, effluent from the bioreactor, effluent from the carbon treatment modules, and a sample will be collected monthly from the port between carbon modules.

- A field blank will be submitted with each sampling round and a duplicate sample will be submitted once per month.

- All samples will be analyzed for TPH as gasoline by EPA Test Method 8015 (modified) and for BTEX by EPA Test Method 8020.

- Samples will be analyzed in the field for pH, temperature, and conductivity; flow rates will be recorded as part of each sampling event.

In addition to monitoring the treatment system, a groundwater monitoring program will be performed to track the progress of groundwater cleanup. Samples from onsite monitoring wells will be collected quarterly for one year and analyzed for TPH as gasoline by EPA Test Method 8015 (modified) and for BTEX by EPA Test Method 8020. Treatment system field blanks and duplicates will be used for well sample quality assurance/quality control.

3.8 System Maintenance

As part of HLA's system maintenance program, the following tasks will be performed:

- HLA will track nutrient usage in the equalization tank and will replenish nutrients as warranted
- HLA will track carbon usage and will replace carbon as required
- HLA will monitor and adjust well extraction rates
- HLA will maintain and service the extraction and treatment systems as warranted.

4.0 SCHEDULE

HLA can initiate extraction well installation and treatment system procurement upon work plan approval by Exxon and the appropriate agencies. HLA anticipates that the extraction wells can be installed within 3 weeks of authorization to proceed. Treatment system installation is anticipated to occur in early November.

5.0 REFERENCES

Harding Lawson Associates (HLA), 1991a. *Groundwater Monitoring Results, Third Quarter 1991, Exxon Station #7-0104, Alameda, California.* August 28.

________, 1991b. *Construction Package, Groundwater Extraction and Treatment System, Exxon Station #7-0104, 1725 Park Street, Alameda, California.* September 6.

________, 1991c. *Bioremediation Treatability Study, Exxon Station #7-0104, 1725 Park Street, Alameda, California.* July 26.

________, 1990. *Phase III Evaluation of Petroleum Hydrocarbons, Exxon Station #7-0104, 1725 Park Street, Alameda, California.* May 1.

________, 1989. *Phase II Evaluation of Petroleum Hydrocarbons, Exxon Station #7-0104, 1725 Park Street, Alameda, California.* March 21.

________, 1988. *Phase I Evaluation of Petroleum Hydrocarbons, Exxon Station #7-0104, 1725 Park Street, Alameda, California.* June 24.

LARGE MAP REMOVED

Appendix A

QED PUMP DESCRIPTION

Solo™ Controllerless Remediation Pump

Revolutionary pump eliminates controllers, for the simplest system ever to specify, install, and operate.

OPTIMUM PERFORMANCE—WITH NO CONTROLLERS!

Solo™ is going is going to change the way you think about ground water cleanup. One of the earliest users, a major east coast remediation contractor, says it is "the simplest pump available at this time".

Solo (patent pending) is an intelligent high-rate pneumatic displacement pump for total fluids applications. It runs itself, with an internal float system and a magnetic "brain" cartridge. The brain—about the size of a roll of Life Savers®—senses liquid level in the pump without liquid contact, turning the air supply on when the pump is full, and turning it off as soon as the pump empties.

EASY SET-UP, AUTO-OPTIMIZING

With its built-in brain, Solo doesn't require air cycle or on-off level control at the wellhead, greatly simplifying system design. All you need above the well cap is a compact, inexpensive air filter/pressure control.

Solo is easier to install than other pumps. You don't have to connect controllers or set timing cycles. And system specification is less complex—just run air to each well, drop in Solo and walk away.

Continued operation is truly hands-off. Solo constantly reacts to changes in well recovery rate, so it's always pumping at the highest rate possible. It also shuts down automatically if water in the well drops below the pumping level.

EFFICIENT, TROUBLE-FREE OPERATION

Because cycling is controlled at the pump, Solo is either refilling or discharging 100% of the time. There's no waiting between active phases of the cycle for the entire length of air supply tubing to re-pressurize.

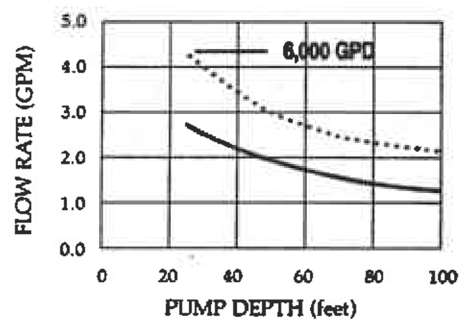
This operating efficiency enables Solo to deliver high pumping rates while reducing air supply requirements.

The pumping mechanism in Solo uses the same high-clearance design that has made Pulse Pump the standard for field performance without clogging or breakdowns. The controller mechanism uses a magnetic link to isolate it from pumped fluids, and is streamlined into a removable cartridge to simplify service. All parts, including the brain cartridge, are rated for at least 5,000,000 cycles and are field-replaceable if necessary.

COST-EFFECTIVE CLEANUP

By eliminating controllers and delivering consistently superior performance, Solo will significantly lower the cost of many cleanup projects. And its simple installation and "hands-off" operation will allow you to handle more jobs in less time.

FLOW PERFORMANCE CURVES:



DEPTH (feet): ········ 10 ft. Submergence/100 psi
——— 2 ft. Submergence/100 psi

On Pump Flow Curves: Flow curves are for a pump at the stated conditions, and will vary under other conditions. Flow rate will also be affected by discharge and air tube sizes and run length. QED's technical service department will check your discharge and air system design and select pump and control equipment to meet your requirements.

CHEMICAL COMPATIBILITY CHART:

	GASOLINE	FUEL OILS	CHLORINATED SOLVENT	NON-CHLORIDE ACIDS	HYDROCHLORIC ACID	BASES
S.S./TEFLON/ NYLON	•	•				•

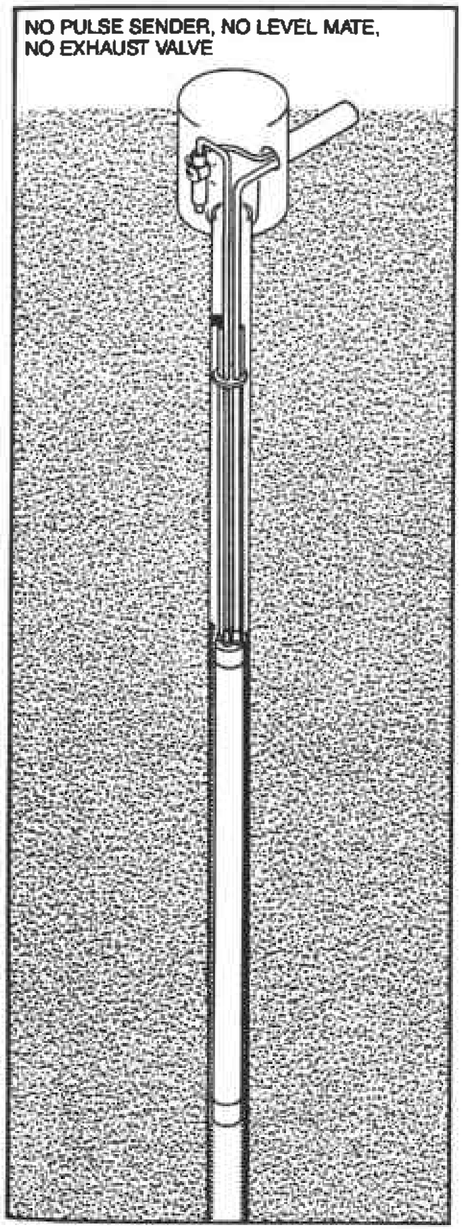
SPECIFICATIONS:

MODEL NO.	PUMP MATERIAL	MIN. WELL I.D. (inches)	PUMP O.D. (inches)	LENGTH (inches)	PUMP VOL. (ml)	WT. (lbs)	FITTING SIZE (inches) & MATERIAL
SP4000	S.S./Teflon/ Nylon	4	3.00	48	2000	14	.25 - .75 (four sizes) S.S. Barb & Clamp

TUBING/HOSE PACKAGES:

MODEL NO.	LENGTH (feet)	TYPE	PUMP* DISCHARGE	PUMP* AIR SUPPLY	PUMP* EXHAUST	BRAIN* EXHAUST
SP25H	25	Hose	.63 Flexible	.25 Flexible	.50 Nylon	.25 Nylon
SP25T	25	Tubing	.75 Nylon	.38 Nylon	.50 Nylon	.25 Nylon
SP50H	50	Hose	.63 Flexible	.25 Flexible	.50 Nylon	.25 Nylon
SP50T	50	Tubing	.75 Nylon	.38 Nylon	.50 Nylon	.25 Nylon
SP100H	100	Hose	.63 Flexible	.25 Flexible	.50 Nylon	.25 Nylon
SP100T	100	Tubing	.75 Nylon	.38 Nylon	.50 Nylon	.25 Nylon

Note: All-nylon tubing is more economical. Flexible hose allows easier coiling for depth adjustment and portability.
* Dimensions in inches



SOLO PUMP PACKAGES:

MODEL NO.	WELL DIAM (inches)	CAP ACCEPTS
SP4000A	4	Hose
SP4000B	4	Tubing
SP4000C	6	Hose
SP4000D	6	Tubing
SP4000E	8	Hose
SP4000F	8	Tubing

Each package contains: Solo pump, well cap and fittings, filter/regulator with autodrain.

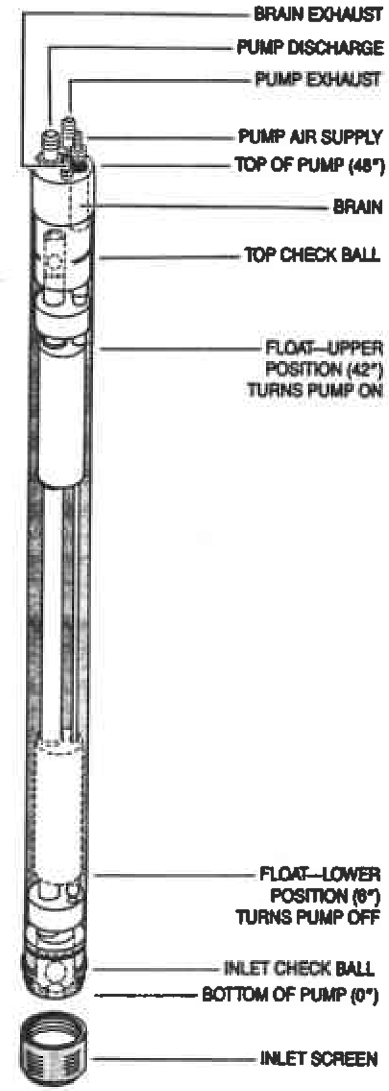
OPERATING REQUIREMENTS:

Minimum Depth of Liquid: 48" above pump bottom

Recommended Air Pressure Not To Exceed: 100 psi

Recommended Air Flow Depending On Pump Conditions: 2-4 SCFM

Besides the pump, each basic Solo package include a well cap with attached filter/regulator and a flexible hose (shown) or tubing set.



HOW IT WORKS

Controllerless Remediation Pump

In the intake cycle, the inlet check ball allows liquid to enter the pump, while the top check ball keeps it from coming back into the pump from the discharge tubing. Rising liquid carries the float to the upper position, where it moves the actuator rod up, signalling the brain to allow air to enter the pump, beginning the discharge cycle.

The air pressure seats the inlet check ball and forces the liquid in the pump into the fill tube and up the discharge line, unseating the top check ball with the upward force of the discharging liquid.

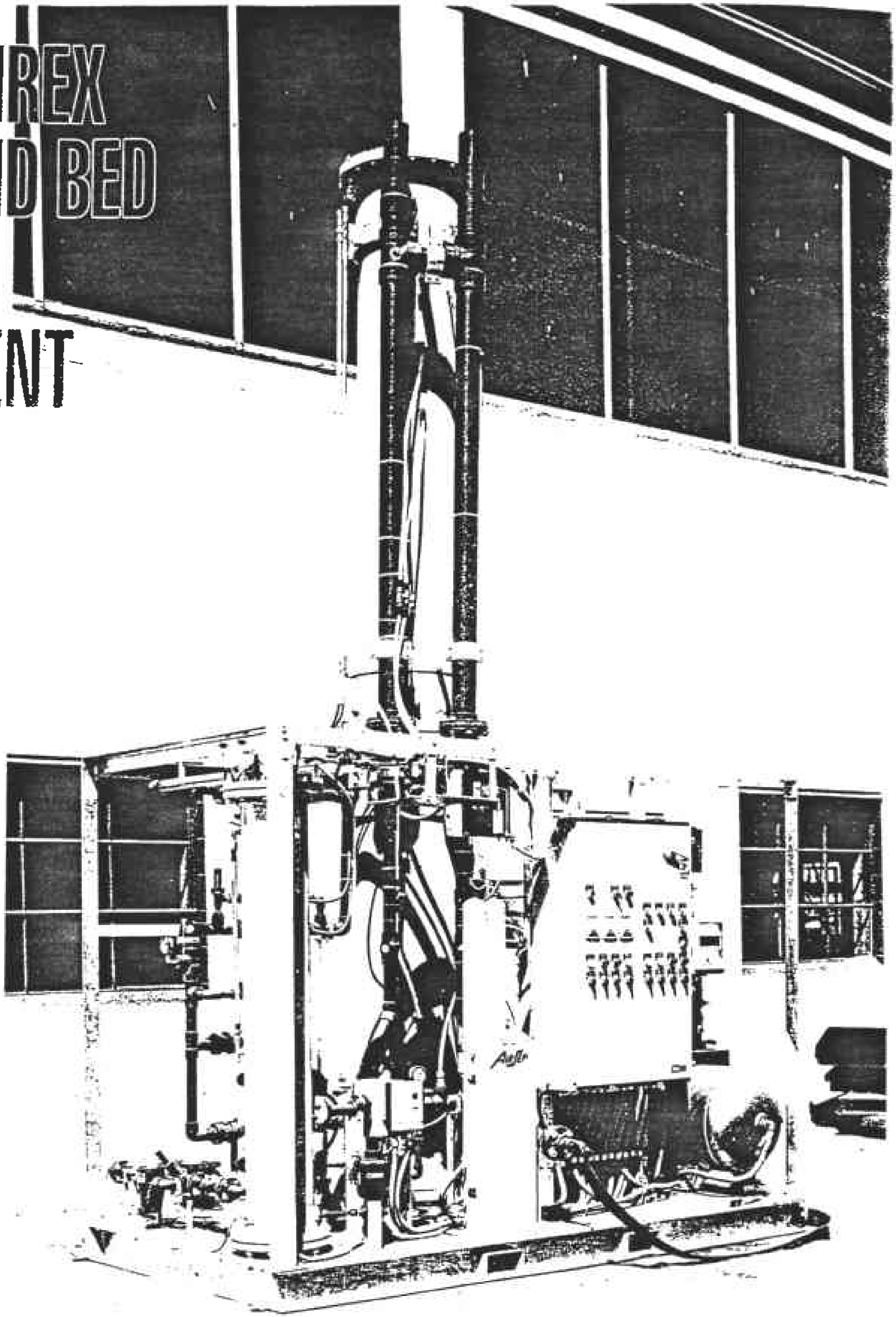
As the liquid level falls in the pump, the float drops down, eventually pulling the actuator rod down, signalling the brain to shut off the air supply. Then the entire cycle repeats.

The Solo requires a minimum depth of 4.0 feet of liquid, and shuts itself off when the well liquid level is pumped down. The pumping action automatically begins again when the well has recharged.

Appendix B

ENVIREX TREATMENT SYSTEM DESCRIPTION

THE ENVIREX GAC-FLUID BED BTEX TREATMENT SYSTEM



High rate process treats contaminated groundwater

- low ppb BTEX effluents
- no off gas
- surge buffering
- small, portable

From Envirex Ltd. Your single source for water and wastewater solutions.

1901 South Prairie Ave.
Waukesha, WI 53186
414/547-0141

GAC-FLUID BED

FLUID BED REACTOR - Small skid (shown) treats up to 30 GPM at 10 ppm BTEX and is 20 inches dia. by 16 ft. tall. Package units are available up to 14 ft. dia., and up to 1850 GPM.

EFFLUENT/RECYCLE STRUCTURE - This convenient overflow system automatically controls recycle.

NEMA 4X CONTROL PANEL - Houses controls, switches, motor starters, etc., in a weathertight, chemical duty panel. Skid is pre-wired.

PRESSURE SWING ADSORPTION OXYGEN GENERATOR (PSA) - Generates a 90-95% pure oxygen gas to pre-dissolve with water before entering the Fluid Bed reactor. Use of pure oxygen enhances treatment and eliminates off-gas and potential stripping.

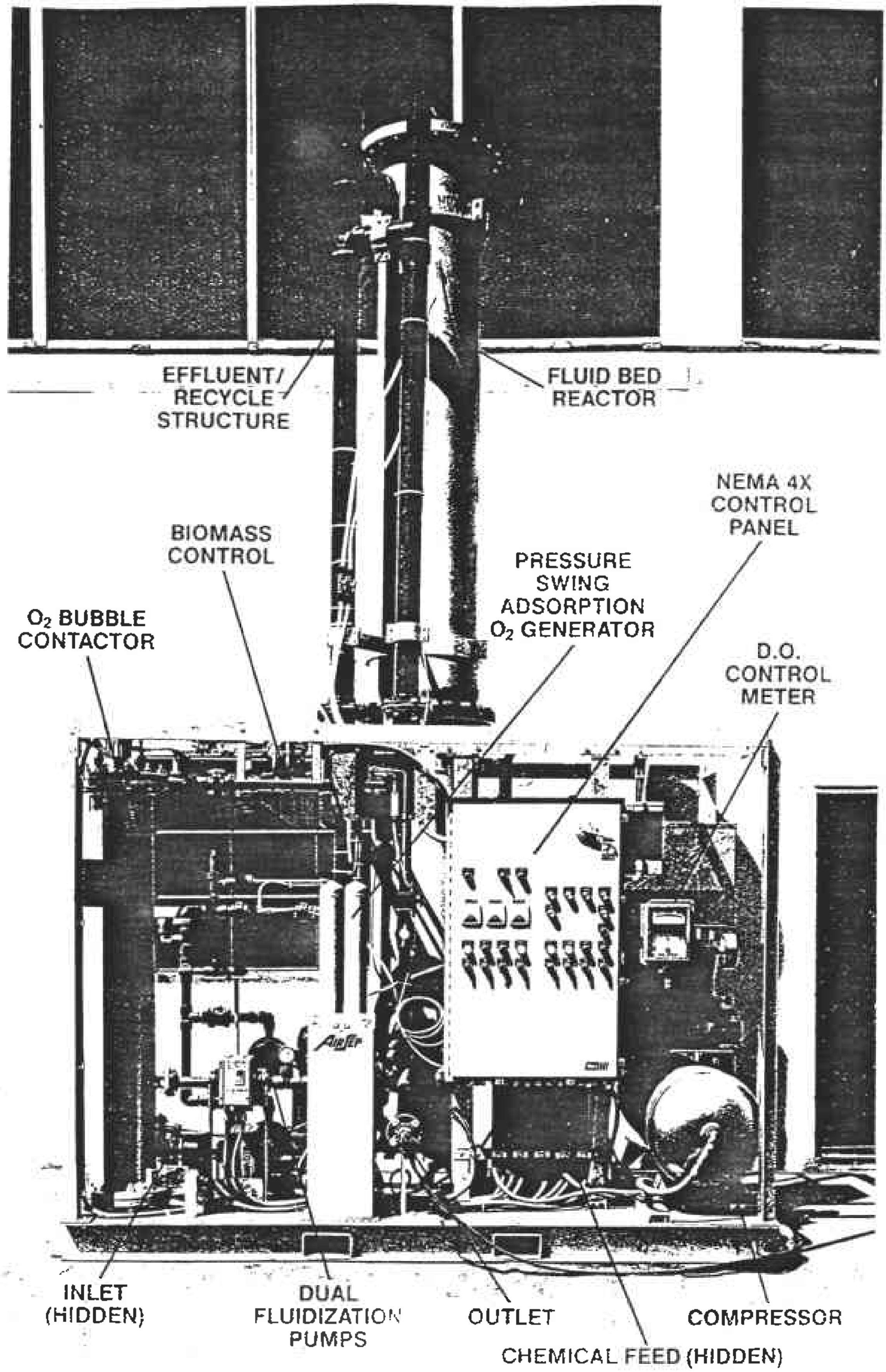
COMPRESSOR - Provides pressurized air for feeding the PSA oxygen generator.

D.O. CONTROL METER - Monitors system effluent dissolved oxygen to prevent under/over oxygenation of the treated water.

O_2 BUBBLE CONTACTOR - Provides for pre-dissolution of oxygen into the fluidization flow and prevents bubbles from escaping the system.

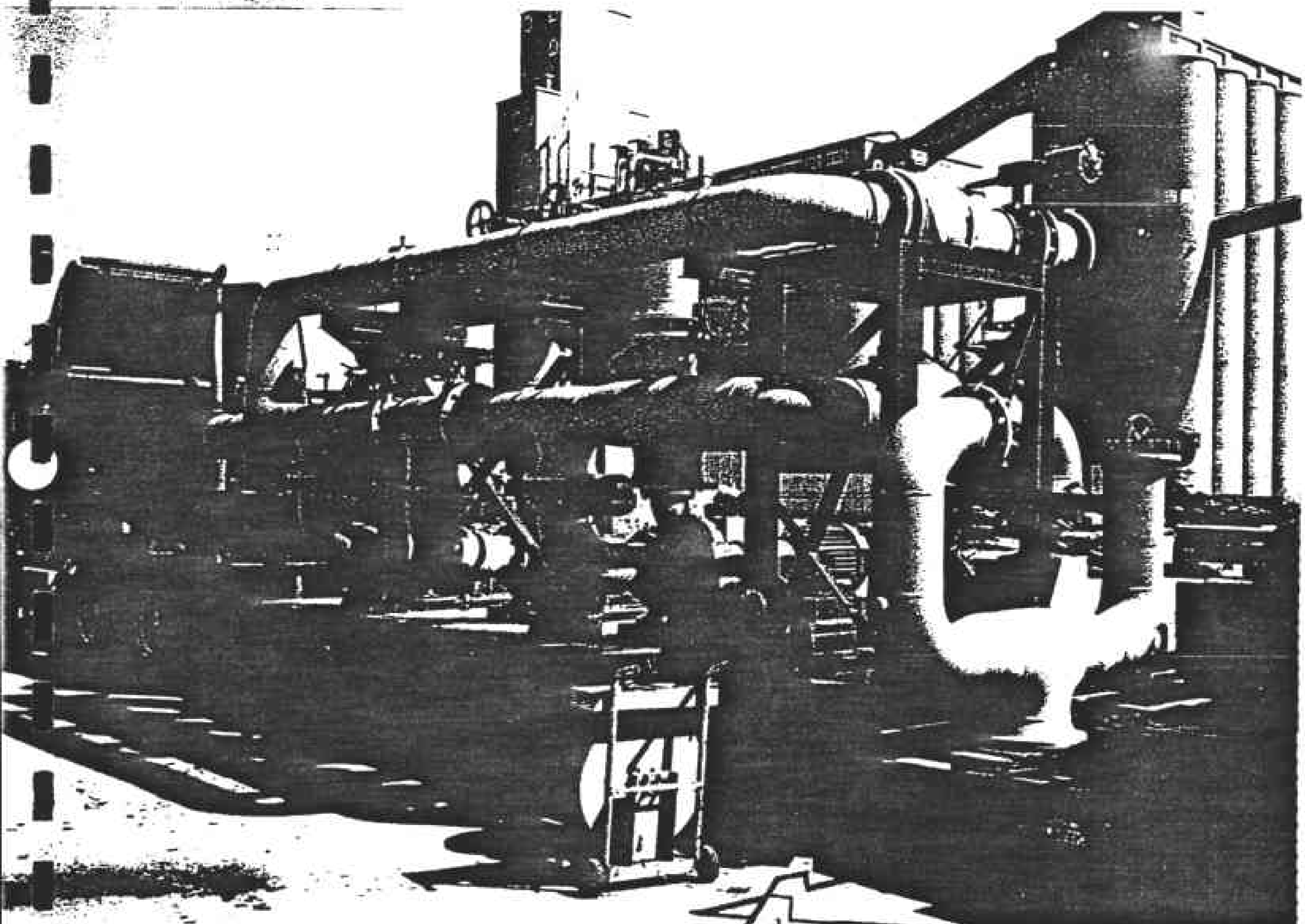
DUAL FLUIDIZATION PUMPS - Provide a steady fluidization flow to the reactor, eliminating sensitivity to fluctuations in inlet flow. The second pump is provided as a pre-piped spare.

CHEMICAL FEED - A nutrient feed system, including storage tank and metering feed pump, is provided since most groundwater will be nutrient deficient.


EFFLUENT/
RECYCLE
STRUCTURE
FLUID BED
REACTOR
NEMA 4X
CONTROL
PANEL
BIOMASS
CONTROL
PRESSURE
SWING
ADSORPTION
O_2 GENERATOR
O_2 BUBBLE
CONTACTOR
D.O.
CONTROL
METER
INLET
(HIDDEN)
DUAL
FLUIDIZATION
PUMPS
OUTLET
COMPRESSOR
CHEMICAL FEED (HIDDEN)

5M 4/91

GAC Fluid Bed
Efficient, economical bioremediation of BTEX groundwater



Envirex
fluidized bed process

- Biological reduction and adsorption in a single reactor
- Effective treatment of low ppm wastes
- Low ppb BTEX effluents in extremely short detention times
- Small, portable and inexpensive
- Environmentally sound, true destruction of organics

An inexpensive, high rate bioremediation system

Small, low cost and flexible, the Envirex GAC (Granular Activated Carbon) Fluid Bed provides an easy, environmentally sound method of remediating groundwater and process waters contaminated with BTEX (benzene, toluene, ethylbenzene and xylene) compounds.

This system combines the best of two remediation techniques—an aerobic biological process and an activated carbon column—in one reactor. It actually destroys the BTEX compounds rather than merely transferring them into another phase.

The GAC Fluid Bed meets the lowest parts per billion standards quickly, economically and reliably, in the smallest space possible. Packaged systems, available up to 4,000 gpm, are easy to move, set up and operate.

Biologically viable and stable at low BTEX concentrations

The extremely low organic concentrations found in most BTEX sites pose special treatment problems for biological systems.

Biomass attrition often exceeds the rate of new biomass production. Suspended growth systems, including those using powdered carbon, simply cannot maintain viable biomass populations at such low concentrations.

The GAC Fluid Bed's use of activated carbon as a truly immobilized cell carrier is critical to the biosystem's long term stability. Organics are physically held by the carbon in close proximity to microorganisms growing in and on it, allowing sufficient time for those microorganisms to degrade the material. The activated carbon also serves as a driving force in moving organics from the liquid phase onto the carbon and into contact with the microorganisms.

In the event contaminant levels drop so low that good biological growth cannot be maintained (levels in the very low ppb range), the GAC Fluid Bed will continue to function much like a conventional carbon column.

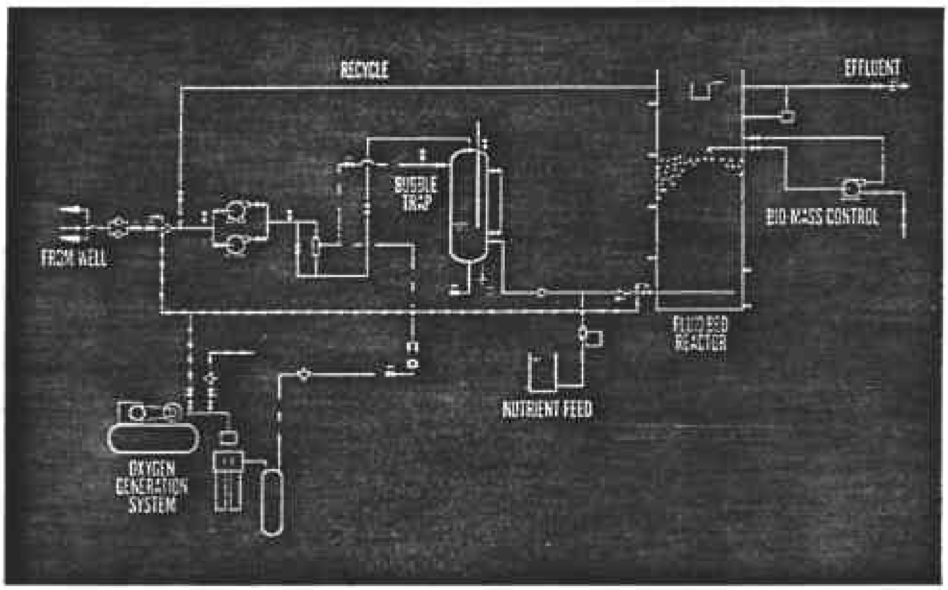
No carbon hauling, minimal carbon replacement

The carbon carrier in the GAC Fluid Bed is biologically regenerated within the bed. There's no need to thermally regenerate carbon or dispose of spent carbon, which may be considered a hazardous waste when contaminated with benzene.

Unlike powdered carbon systems, the GAC Fluid Bed doesn't waste carbon with the sludge, so carbon replacement costs are kept to a minimum. Any carbon loss is due solely to natural attrition and the adsorption of refractory materials. This may eventually exhaust the carbon, but in much lower quantities than in conventional systems since biodegradable organics are destroyed biologically.

Elimination of off gas production

By economically utilizing pure oxygen predissolved in water about to enter the reactor, the GAC Fluid Bed system eliminates the stripping of BTEX by aeration.



The GAC Fluid Bed Treatment Process

High surface areas for higher removal rates

The design of the GAC Fluid Bed provides extremely high surface areas for biological growth—an order-of-magnitude advantage over other processes making this a very effective, high rate treatment system.

Shorter detention and reaction times

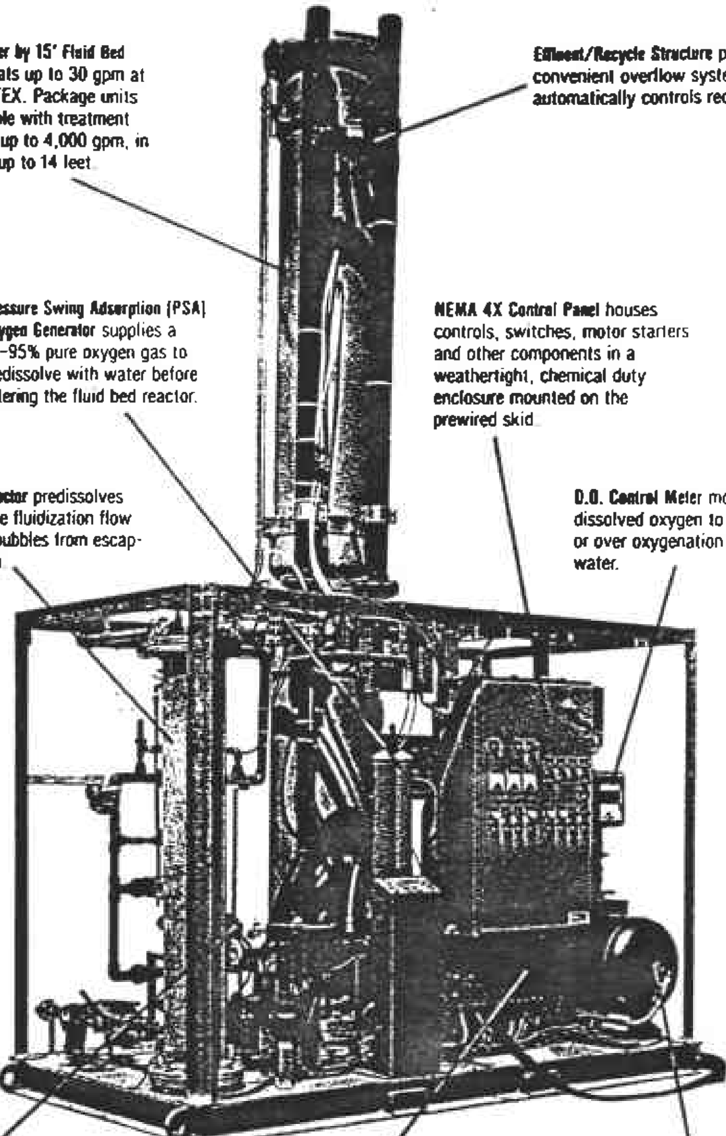
While other biological systems rely on hydraulic detention time and mass transfer of organics to ensure good removal rates, the GAC Fluid Bed merely adsorbs the organics onto the carbon, a much faster reaction. Single pass detention times of 8 minutes are common (compared to 8–24 hours in conventional biological systems). Under certain soil conditions, the oxygen-rich BTEX acclimated effluent can be reinjected into the ground to speed in situ activity and further reduce cleanup times and costs.

Adsorptive removal of refractory material

Adsorption on the carbon removes non-biodegradable or slow-to-degrade organics, including many materials that would pass through other biosystems untouched. Oxidized iron precipitates in and on the biomass, providing iron control without the pretreatment and maintenance required in physical chemical systems.

Compact and fully portable

Significantly smaller than other process equipment, the GAC Fluid Bed is a truly portable system. Skid mounted and self contained, it can be moved easily to another site at the completion of a remediation. Other processes require permanent, field erected systems at flow rates that still fit into the GAC Fluid Bed package systems.



20"-diameter by 15' Fluid Bed Reactor treats up to 30 gpm at 10 ppm BTEX. Package units are available with treatment capacities up to 4,000 gpm, in diameters up to 14 feet.

Effluent/Recycle Structure provides a convenient overflow system that automatically controls recycle.

Pressure Swing Adsorption (PSA) Oxygen Generator supplies a 90–95% pure oxygen gas to predissolve with water before entering the fluid bed reactor.

NEMA 4X Control Panel houses controls, switches, motor starters and other components in a weathertight, chemical duty enclosure mounted on the prewired skid.

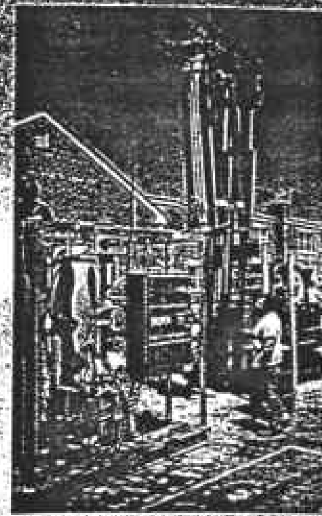
O_2 Bubble Contactor predissolves oxygen into the fluidization flow and prevents bubbles from escaping the system.

D.O. Control Meter monitors system dissolved oxygen to prevent under or over oxygenation of the treated water.

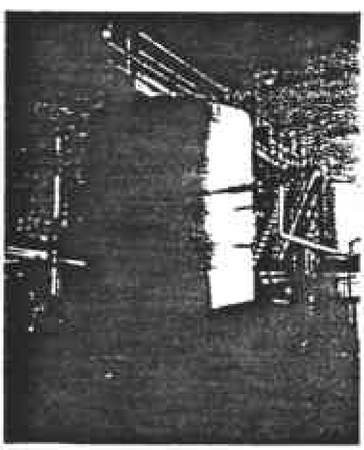
Dual Fluidization Pumps ensure a steady fluidization flow to the reactor, eliminating sensitivity to fluctuations in inlet flow. The second pump provides the reliability of a prepiped spare.

Chemical Feed System for nutrient deficient groundwater includes storage tank and metering feed pump.

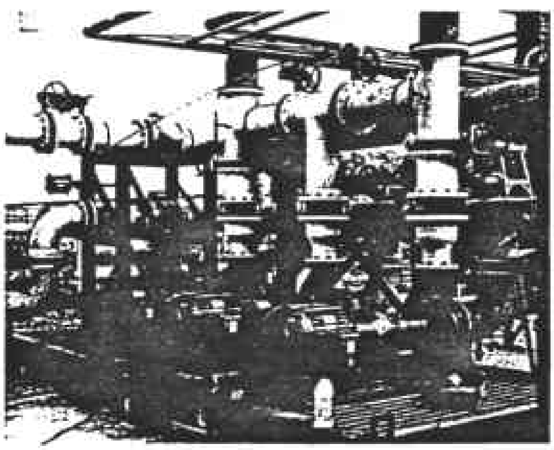
Compressor supplies pressurized air for feeding the PSA oxygen generator.



A 30 GPM service station GAC Fluid Bed package plant.



Two 14 foot diameter GAC Fluid Beds treating 4,000 GPM of BTEX contaminated groundwater.



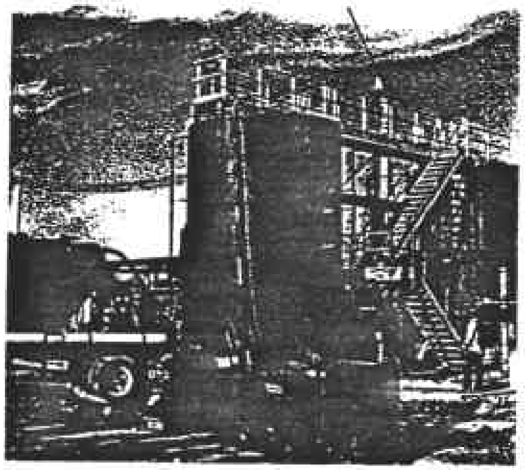
Part of the 4,000 GPM package system is this fluidization pump skid, with a piped in spare pump.

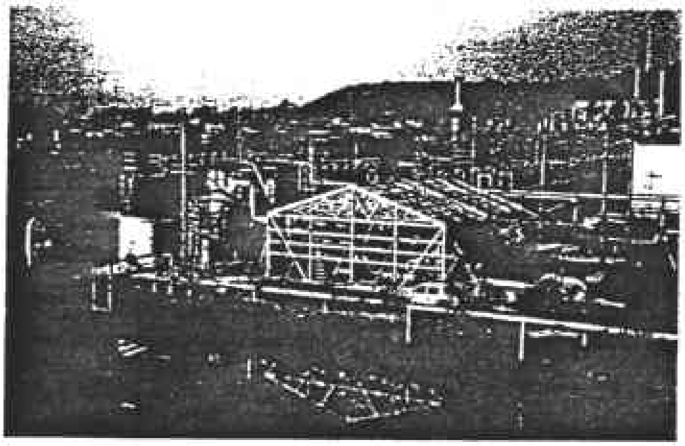
Benefits of GAC Fluid Bed Over Standard Bioremediation Processes

- *Fast reactions*
- *Highly stable*
- *High removal rates at low ppm*
- *Low ppb effluents*
- *No stripping*
- *No carbon disposal*
- *Low carbon replacement*
- *Refractory material removal*
- *Flexible operation*
- *In situ remediation*
- *Self contained and portable*

Type of Treatment	Influent			Capital Costs	Operating Costs Yearly @ $0.10/KWHR			Yearly Operating Costs	$ per 1000 Gallons (5 Year Straight Line Depreciation of Capital)
	Flow	BTEX PPM	BTEX #/Day		Power	Carbon	O_2		
Carbon Only	100 GPM	10	12	125,000	2,352	126,290	—	128,642	2.92
Air Stripping With Vapor Phase Recovery				70,000	3,919	67,475	—	71,394	1.62
GAC Fluid Bed				145,000	3,919	200	679	4,798	.64
Carbon Only	100 GPM	25	30	125,000	2,352	274,000	—	276,352	5.73
Air Stripping With Vapor Phase Recovery				95,000	5,487	168,000	—	173,487	3.66
GAC Fluid Bed				245,000	7,839	600	1,703	10,147	1.13
Carbon Only	2,000 GPM	10	240	600,000	23,516	2,271,000	—	2,295,416	2.21
Air Stripping With Vapor Phase Recovery				535,000	27,433	1,406,000	—	1,433,433	1.41
GAC Fluid Bed				585,000	31,355	5,000	14,244	50,599	.15

Loading carbon during start up of a GAC Fluid Bed Reactor.





Shop fabricated reactors combined with prepiped pump and control skids permit rapid installation and start up.

Envirex Ltd.
Fluid Bed Group
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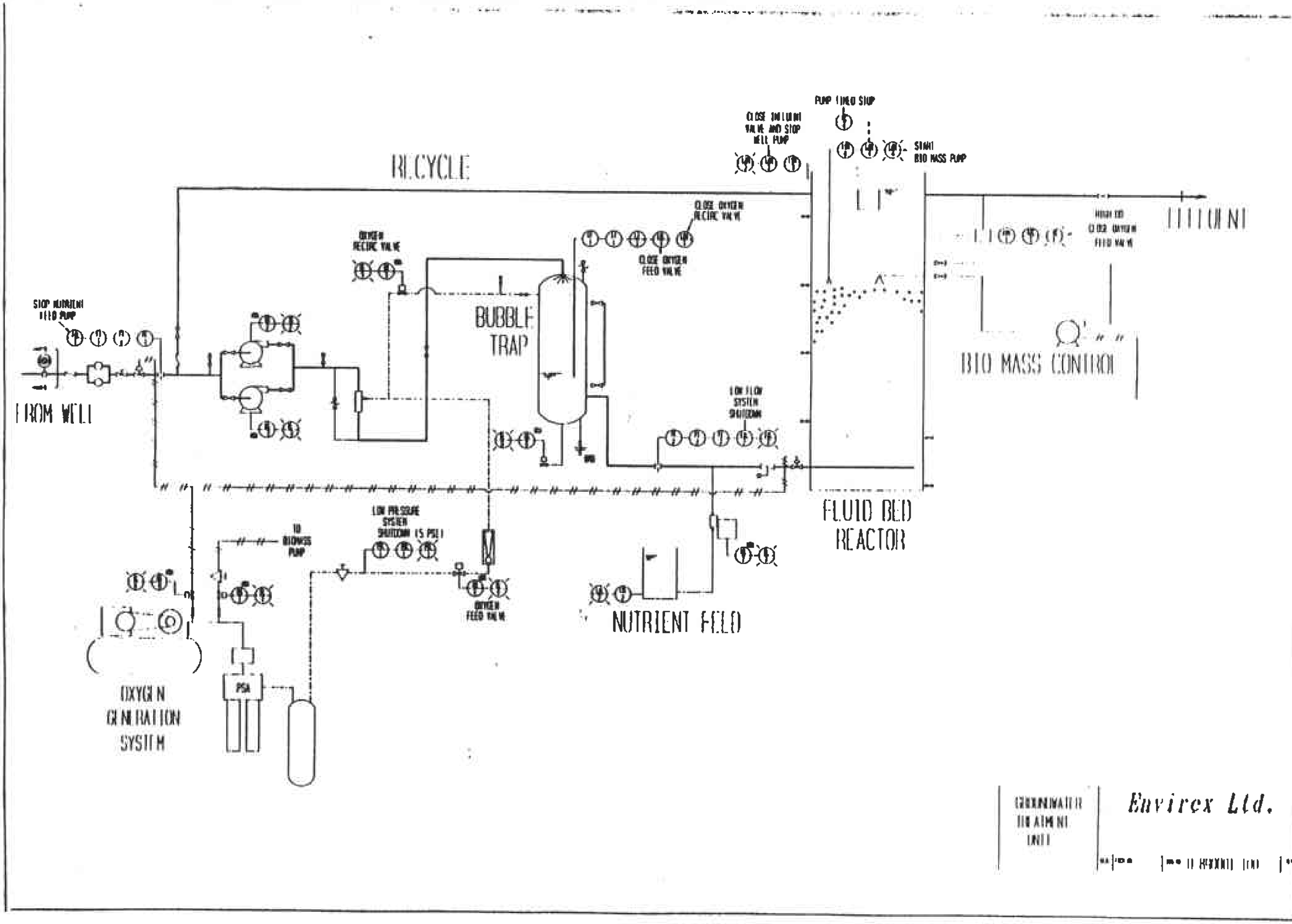
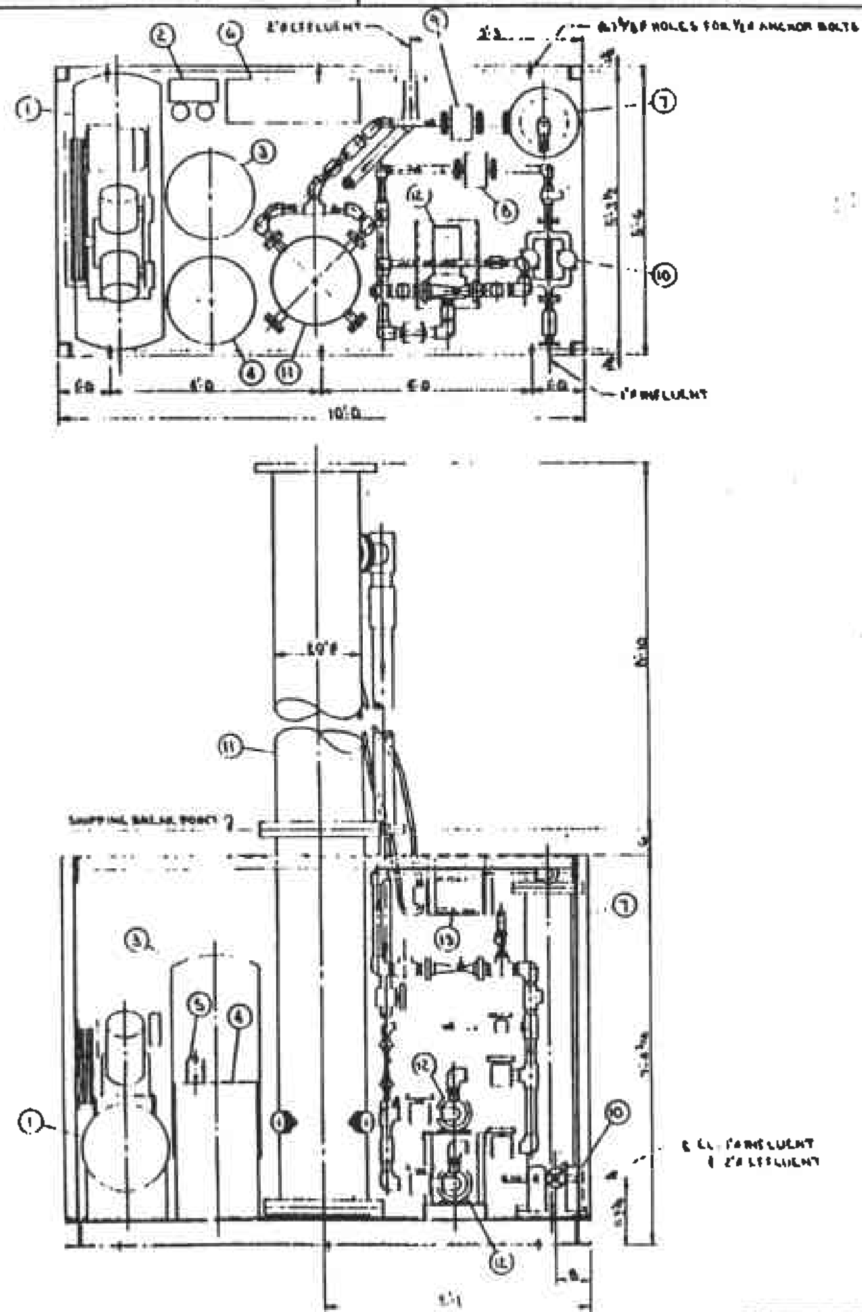
Phone: 414/547-0141
Fax: 414/547-4120

Envirex fluidized bed technology is protected by patents issued and pending in the U.S.A. and other countries.



RECYCLE
STOP NUTRIENT FEED PUMP
FROM WELL
OXYGEN RECIRC VALVE
BUBBLE TRAP
CLOSE OXYGEN RECIRC VALVE
CLOSE OXYGEN FEED VALVE
CLOSE INFLUENT VALVE AND STOP WELL PUMP
START BIO MASS PUMP
EFFLUENT
HIGH DO CLOSE OXYGEN FEED VALVE
BIO MASS CONTROL
LOW FLOW SYSTEM SHUTDOWN
FLUID BED REACTOR
TO BIOMASS PUMP
LOW PRESSURE SYSTEM SHUTDOWN (5 PSI)
OXYGEN FEED VALVE
NUTRIENT FEED
PSA
OXYGEN GENERATION SYSTEM
GROUNDWATER TREATMENT UNIT
Envirex Ltd.



LIST OF COMPONENTS

ITEM	QTY.	DESCRIPTION
1	1	[illegible] AIR COMPRESSOR, [illegible] WITH AIR DRYER, FACTORY MOUNTED ON [illegible]
2	1	AIRSEP MODEL AS-10 PSA OXYGEN GENERATOR.
3	1	20"Ø, 60 GAL. VERTICAL SURGE TANK.
4	1	19"Ø, 30 GAL. NUTRIENT FEED TANK, POLYETHYLENE.
5	1	NUTRIENT FEED PUMP, PROMINENT, 115V, 60HZ.
6	1	42"H x 30"W x 10" DP NEMA 4X ELECTRICAL POWER PANEL, 460V, 3PH, 60HZ POWER SUPPLY.
7	1	10"Ø BUBBLE SEPARATION TANK WITH LIQUID LEVEL GAUGE GLASS AND RELIEF VALVE.
8	1	E+H MODEL FT1 MAS VARIOMAG MAGNETIC FLOWMETER, 1" SIZE, FULL SCALE - 30 GPM, 115V, 60HZ.
9	1	E+H MODEL FT1 MAS VARIOMAG MAGNETIC FLOWMETER, 1½" SIZE, FULL SCALE - 30GPM, 115V, 60HZ.
10	1	PVC DUPLEX BASKET STRAINER, 1" SIZE.
11	1	20"Ø REACTOR VESSEL, PVC, WITH PVC FLOW DISTRIBUTION SYSTEM, EFFLUENT COLLECTION SYSTEM AND ACTIVATED CARBON MEDIA.
12	1	RECYCLE PUMP, GOULDS MODEL NPE, 1¼" x 1½"-6, 1HP, 230V, 3PH, 60HZ TEFC.
13	1	BIO MASS PUMP ¼HP, 115V, 60HZ.

CUSTOMER NOTE:
1) ALL MAIN PIPE, VALVES & FITTINGS WILL BE UV PROTECTED PVC.
2) ALL FLANGE BOLT HOLE PATTERNS WILL MEET ANSI B16.1, 150 LB.
3) STRUCTURAL STEEL SKID FRAME WORK, PIPE SUPPORTS, PUMP MOUNTING BASES & BUBBLE SEPARATION TANK WILL BE [illegible] GALVANIZED.

SCALE ½"=1'-0"

Envirex

GENERAL ARRANGEMENT - FLUID BED GROUNDWATER TREATMENT UNIT

DISTRIBUTION

WORK PLAN
EXXON STATION 37-0104
1725 PARK STREET
ALAMEDA, CALIFORNIA
September 10, 1991

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QUALITY CONTROL REVIEWER

Michael A. Jacobvitz
Project Hydrogeologist