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Interim Remedial Measures Work Plan, D.C. Rollforms\ Ingersoll-Rand Site, Jamestown, New York Site Code 907019

Ingersoll-Rand Company
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REPORT

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ARCADIS GERAGHTY & MILLER

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1.0 Introduction

1.1 Purpose

On behalf of the Ingersoll-Rand Company, ARCADIS Geraghty & Miller, Inc. prepared this Interim Removal Measures (IRM) Work Plan for the D.C. Rollforms/Ingersoll-Rand Site (site) located in Jamestown, New York (Figures 1 and 2). The site is currently listed by the New York State Department of Environmental Conservation (NYSDEC) on the Registry of Inactive Hazardous Waste Sites (Site No. 907019) with a classification code of 2.

This IRM Work Plan has been prepared based on the results of a remedial investigation (RI) conducted at the site (ARCADIS Geraghty & Miller 1998). The RI defined the extent of impacts to soil and groundwater at the site, and identified three areas consisting of elevated concentrations of volatile organic compounds (VOCs) and separate-phase petroleum hydrocarbons (free product). The IRMs proposed herein are designed to address these areas with the objective of expediting contaminant mass removal, mitigating future subsurface impacts, and achieving site closure and delisting from the registry of inactive hazardous waste sites.

1.2 Organization of Report

This IRM Work Plan is organized into the following sections: Section 2 is a summary of the RI; Section 3 provides information concerning the site areas to be addressed by IRMs; Section 4 describes the proposed IRMs to be implemented; Section 5 contains the references for documents cited in this Work Plan.

2.0 Summary of the Remedial Investigation

The results of the RI conducted by ARCADIS Geraghty & Miller indicated that chlorinated VOCs and separate-phase petroleum hydrocarbons are the primary constituents of concern in the subsurface at the site. The occurrence and distribution of subsurface impacts at the site were described in the draft RI report.

The general findings of the remedial investigation, fish and wildlife impact assessment, human health risk assessment, and evaluation of IRMs are summarized below. Figures 2, 3 and 4 show the locations of samples collected during the RI.

2.1 Hydrogeology

Subsurface geologic conditions at the site consist of mainly two overburden units - a surficial layer of fill materials which overlies a dense, low permeability till. The fill is generally 7 to 15 feet thick and includes silt, sand, gravel, clay, cinders, brick, concrete, and slag. Within the western portion of the site, oily stained soils are present within the fill material. The till is generally dense silt and clay rich material with a permeability on the order of 10^{-6} centimeters per second (cm/s) based on slug testing performed during the RI.

The water table occurs within the overburden material at a depth of approximately 5 to 8 feet below grade. The horizontal direction of groundwater flow is to the northwest discharging to the Chadakoin River, which borders the western perimeter of the site. A slight downward vertical component of flow (vertical gradient of 0.10) to the underlying till is also present in the southern portion of the site as interpreted from water level measurements from well clusters MW-8S/8D and ESI-7/MW-7D.

The results of an assessment of the interaction between groundwater and surface water (Chadakoin River) show that water levels on-site fluctuate (up to 3.5 feet) with the variation in stream flow indicating hydraulic communication between groundwater and surface water. The volume of groundwater discharged from the site, however is only a small percentage (less than 1%) of even the lowest flow events of the river. Stream flow within the Chadakoin River is controlled by a dam located upstream of the site. Flow during the period from May 1997 to February 1998 varied from 43 cubic feet per second (cfs) to 1,100 cfs. with a fluctuation in river stage of 4 feet.

2.2 Laboratory Analytical Results

2.2.1 Soil

Surface soil samples were collected during the RI at fifteen locations throughout the site (see Figure 2). VOCs were not detected in any of the surface soil samples. Analysis of semivolatile organic compounds (SVOCs) indicated concentrations ranging from 2,768 parts per billion (ppb) in SS-2 to 88,961 ppb in SS-13. A number of metals were detected including copper, lead, nickel, and zinc. Cyanide and cadmium were not detected in any of the surface soil samples. PCBs were detected in each sample (mainly Arochlor-1260 and Arochlor-1254) but all at concentrations below standards except for one sample.

Oily stained soils were observed within the soils in the fill material mainly within the western portion of the site. These areas correlated with elevated concentrations of total petroleum hydrocarbons (TPH). Free product in soil consisting of both light non-aqueous phase liquid (LNAPL) and dense non-aqueous phase liquid (DNAPL) were observed in Well ESI-4. LNAPL was also observed in Well ESI-3.

2.2.2 Groundwater

Groundwater samples were collected at 23 Geoprobe^{TM} boring locations and from eleven monitoring wells (Figure X). Tricholorethene (TCE), *cis*-1,2-dichloroethene (DCE), and vinyl chloride (VC) were the VOCs detected most frequently in the samples collected. VOC concentrations were highest in the fill and underlying till in the vicinity of the former TCE, paint, and thinner storage area of the former Proto Tool plant (Wells MW-8S/8D). Concentrations of TCE, DCE, and VC have shown a decrease of three orders of magnitude in concentration over a horizontal distance of 85 feet directly downgradient from Wells MW-8S/8D to Wells ESI-7/MW-7D.

TCE, DCE, and VC were also detected in the Geoprobe^{TM} and monitoring well locations mainly from within the central and western portion of the site as shown on Figures 3 and 4. These levels were lower than observed in the MW-8S/8D area.

Comparison of the TCE, DCE, and VC analytical results from the 1997 RI with analytical from the site monitoring wells in 1990/1991 indicate that natural attenuation of the VOC impacts is occurring on-site. Total concentrations of TCE, DCE, and VC have been reduced by 60% to 80% at two well locations (ESI-1 and ESI-2). The ratios of TCE, DCE, and VC concentrations suggest that the natural attenuation of the VOCs is due predominantly to reductive dechlorination via anaerobic microorganisms present in the subsurface. The biogeochemical parameters measured in the field in September 1997 represent a baseline monitoring event which will be used to evaluate rates of biodegradation for potential remedial options. ARCADIS Geraghty & Miller proposes to monitor for dissolved oxygen and oxidation-reduction potential, as well as for several of the electron acceptors and biodegradation products that are indicative of reductive dechlorination processes (Weidemeyer et al., 1996). These data are essential to demonstrate that a suitable environment is present in groundwater at the site to foster these biodegradation processes.

2.2.3 Surface Water

Analysis of a surface water sample collected from adjacent to the site indicated non-detect concentrations of VOCs, SVOCs, PCBs, and low concentrations of metals (which did not exceed ambient water quality standards) typical of the ambient surface water quality of the Chadakoin River.

2.2.4 Sediment

Comparison of analytical results for the sediment sample collected adjacent to the site (SED-1) with the upstream sample (SED-2) indicates that the concentrations of VOCs, SVOCs, PCBs and certain metals were all higher in the upstream sample. VOCs were not detected in the sediment sample SED-1 collected adjacent to the site. Concentrations of SVOCs and PCBs in the upstream sample were more than twice the concentrations in the sediment sample adjacent to the site. Several metals exceeded their respective NYSDEC sediment criteria levels in the samples collected adjacent to the site (SED-1) and in the samples collected upstream of the site (SED-2).

2.3 Fish and Wildlife Impact Assessment

The Fish and Wildlife Impact Assessment was conducted following NYSDEC (1994) guidance and included Steps I and II as recommended in the guidance document. A field investigation conducted at the site to characterize the ecological communities present indicated that flora and fauna at the site and immediately adjacent areas appeared to be in good condition. Two terrestrial communities and one aquatic community were identified. These communities possess a diverse assemblage of vegetation and provide a variety of habitats for wildlife species. No evidence of stressed vegetation nor animal mortality was noted at the site. No protected species, as identified by the United States Fish and Wildlife Service (USFWS) and New York Natural Heritage Program (NYNHP), were observed during the survey.

Wildlife and aquatic resources may potentially contact the chemical constituents detected at the site. Applicable screening criteria for chemical constituents and media at the site were reviewed; the potential toxic effects were discussed for media (e.g. soil) when applicable screening criteria were not available. A number of metals detected in sediment samples collected from adjacent to the site as well as upstream of the site exceeded available criteria. Ambient water quality standards were not exceeded for constituents detected in the surface water sample (SW-1) collected adjacent to the site, while the metals iron and aluminum slightly exceeded the surface water standards in the upstream sample (SW-2).

2.4 Human Health Risk Assessment

The risk assessment evaluated potential risks to human health under potential current and future exposure conditions due to site related constituents detected in soil and shallow groundwater at the D.C. Rollforms/Ingersoll-Rand site, and sediment and surface water from the Chadakoin River. Contaminants of potential concern (COPCs) selected for these media included VOCs, petroleum hydrocarbons, PAHs, SVOCs, PCBs, and inorganics.

The exposure scenarios and estimated cancer and non-cancer risks were as follows:

- Adolescent trespasser contact with soil via incidental ingestion, dermal contact, and inhalation of vapors and particulates -- total excess lifetime cancer risk (ELCR) = 7×10^{-7} and total hazard index (HI) = 0.04.

- Excavation worker contact with soil via incidental ingestion, dermal contact, and inhalation of vapors and particulates -- total ELCR = 1×10^{-6} and total HI = 0.4.

- Site worker contact with soil via incidental ingestion, dermal contact, and inhalation of vapors and particulates -- total ELCR = 3×10^{-5} and total HI = 0.8.

- Residential contact with soil via incidental ingestion and dermal contact -- total ELCR = 2×10^{-4} and total HI = 3. Target-organ HIs were all less than or equal to 1.

- Excavation worker contact with shallow groundwater via incidental ingestion, dermal contact, and inhalation of vapors -- total ELCR = 9×10^{-5} and total HI = 0.8.

- Adolescent trespasser wading contact with sediment and surface water adjacent to the site -- total ELCR = 3×10^{-7} and total HI = 0.002.

All of the calculated cancer and non-cancer risks (ELCR and HI, respectively) associated with the potential exposure scenarios are within or below the USEPA benchmarks for cancer risk (10^{-6} to 10^{-4}) and non-cancer risk (1) (USEPA 1991c) with the exception of hypothetical future resident contact with soil. Development of the site for residential use is unlikely; therefore, inclusion of the residential exposure scenario is highly conservative. The total cancer risk for hypothetical excavation worker contact with shallow groundwater (9×10^{-5}) is near the upper limit of the target range for cancer risk. This exposure scenario also is very conservative since, if excavation activity were to occur at the site, the workers would wear personal protective equipment to minimize potential contact with the soil and groundwater. Nevertheless, remedial goal objectives (RGOs) were calculated for soil and groundwater COPCs based on these two conservative exposure scenarios. Calculated soil RGOs for the carcinogenic PAHs (the primary drivers of cancer risk for the site) are below normal urban background levels.

3.0 Areas to be Addressed by Interim Remedial Measures

The proposed IRMs are intended to focus on the on-site areas in which the greatest levels of impacts are present. The IRMs proposed are designed with the objective of expediting contaminant mass removal, mitigating future subsurface impacts, achieving site closure, and delisting from the registry of inactive hazardous waste sites. Based on an evaluation of the nature and extent of the impacts, IRMs will be considered for the following areas on-site:

1) The area impacted by VOCs (predominantly TCE) around wells MW-8S and MW-8D

The primary constituents of concern in the MW-8S/8D area are chlorinated VOCs (including TCE and the associated degradation or "daughter" products DCE and VC). RI groundwater sampling results indicate the impacts in this area reside both in the overburden fill and upper portion of the till material. TPH (predominantly in the gasoline range) was also detected in the groundwater samples from this area analyzed as part of the RI, but generally at lower levels than the VOCs.

2) The areas impacted by LNAPL and DNAPL around wells ESI-3 and ESI-4.

The primary constituents of concern in the ESI-3 and ESI-4 areas are LNAPL (ESI-3 and ESI-4) and DNAPL (ESI-4 only). The LNAPL has been observed on the water table in the fill zone, and the DNAPL has been observed in the fill zone at the interface between the fill and till zones due to the low permeability and density of the till. RI sampling results have characterized the LNAPL from wells ESI-3 and ESI-4, as similar to No.2 and No.4 fuel oils, respectively. DNAPL sampling results have been inconclusive. TPH (predominantly in the diesel range) has been detected in the groundwater samples collected from wells ESI-3 and ESI-4 as were low levels of VOCs. The presence of the diesel range TPH compounds are consistent with the presence of the LNAPL in both wells.

3) Oil seep on the bank of the Chadakoin River.

An area of oily stained soil was observed at the base of the stream bank of the Chadakoin River adjacent to Well ESI-1. This area of stained soils occurred within a relatively small area (approximately 1 foot by 1 foot). Evidence of seepage from this area or sheens on the river were not observed. No other oily stained areas were observed by ARCADIS Geraghty & Miller during low flow events.

4.0 Proposed Interim Remedial Measures

This section presents a description of the proposed IRMs to be applied in areas identified in Section 3.0.

4.1 Proposed IRM for Well MW-8S/8D Area

ARCADIS Geraghty & Miller, Inc. proposes to use enhanced reductive dechlorination (ERD) as the IRM for the Well MW-8S/8D area. ERD is founded on the concept of enhancing the natural conditions in the subsurface system in order to drive the conditions to a state that is more conducive to reductive dechlorination of the VOCs present at the site. The proposed IRM will be applied in the most impacted area around Well MW-8S/8D, and rely on natural attenuation of residual impacts outside of this "hot spot". This approach is warranted in the MW-8S/8D area given the relative concentrations of TCE, DCE and VC in the downgradient fill and till monitoring wells (ESI-7 and MW-7D, respectively) which indicate that reductive dechlorination is already occurring naturally.

This enhanced bioremediation technique utilizes an in-situ reactive zone that is established in the groundwater in order to enhance the natural biodegradation of chlorinated VOCs, such as TCE (and its associated degradation [daughter] products). The biodegradation mechanism that will be enhanced is reductive dechlorination (or dehalogenation). Evidence of an anaerobic, reducing environment and the natural occurrence of this reductive dechlorination process was presented in the RI report. ERD will be accomplished by supplying the groundwater system with a carbon source in the form of a mixture of molasses and water to create conditions amenable to the desired processes. Molasses is a inexpensive, innocuous, and easily degradable amendment to the subsurface environment and its use has been accepted by both federal and state regulatory agencies to enhance bioremediation at approximately 20 sites throughout the United States including New York State.

The following sections describe the biogeochemical processes that are responsible for the enhanced biodegradation of the VOCs, as well as the rationale for implementing the in-situ reactive zone technology in this impacted area of the site. This IRM has been developed to provide the NYSDEC with:

- specific details associated with the enhanced bioremediation technology;
- a conceptual design outlining system installation and operation;
- a system performance monitoring program; and
- a system installation schedule.

4.1.1 Objectives

ERD is intended to address groundwater in the vicinity of Well MW-8S/8D impacted by TCE, DCE and VC. The enhanced biodegradation system, consisting of injection wells, will be designed and operated to enhance the already naturally occurring degradation of the VOCs. Using ERD, the VOCs will be degraded to much less toxic compounds such as carbon dioxide, water, and chloride. The in-situ reactive zone technology will not generate air emissions, thereby eliminating the potential for transfer into another media, as well as the need to pretreat an air discharge vapor stream. The impacts to the environment will be reduced with time as the VOCs are degraded to less toxic compounds.

4.1.2 Overview of Enhanced Reductive Dechlorination (ERD)

Chlorinated VOCs are relatively insoluble and once discharged to the environment, typically migrate through soils to reach underlying groundwater. The prevalent chlorinated solvent found at the site is TCE. TCE can be transformed by naturally occurring chemical and biological processes in the subsurface to form a variety of other VOC daughter products, including *cis-* and *trans-* 1,2 dichloroethene, VC, ethene, ethane and, finally, to carbon dioxide, water and chloride ions. The degradation mechanism for TCE, beginning with its parent tetrachloroethene, is discussed below.

Tetrachloroethene was originally considered nonbiodegradable (or recalcitrant); however, research completed in the last 10 years has demonstrated that, under the proper conditions, tetrachloroethene can be naturally degraded. Tetrachloroethene is degraded through reactions involving indigenous microbes naturally present in the subsurface. Tetrachloroethene is thus degraded via reductive dechlorination, which involves the sequential removal of a chlorine atom from tetrachloroethene and the substitution with a hydrogen atom. The degradation sequence for tetrachloroethene is as follows: tetrachloroethene → trichloroethene → dichloroethene→ vinyl chloride → ethene→ ethane → carbon dioxide, water and chloride.

Figure 5 is a schematic identifying the degradation steps. By monitoring for the relative levels of these daughter compounds, it can be demonstrated that the complete degradation of trichloroethene is occurring.

The later steps of this process, such as degradation of DCE (*cis-* -isomer) to VC, and degradation of VC to ethene, generally require more strongly reducing conditions (redox conditions typically in the range of -200 to -400 mV) than do the initial degradation steps. The more highly chlorinated compounds are most susceptible to reductive dechlorination because of their higher state of oxidation (McCarty 1995). Often a subsurface environment is not reducing enough (i.e. the oxidation-reduction potential is not low enough) to allow for the complete degradation to occur and an accumulation of daughter products (such as DCE and VC detected in several wells on site) is observed. As a result, the oxidation-reduction potential (redox) of the subsurface system is dependent on, and can influence, the specific reductive dechlorination processes (Wiedemeier 1996). Generally, stronger reducing conditions, and the depletion of electron acceptors, are needed to foster the latter processes in this sequence. ORP measurements above 0 mV indicate the transition to oxidizing conditions that are not favorable for most anaerobic reductive reactions. Nitrate, iron and manganese reduction are most efficient in the ORP range of 0 to - 150 mV, while sulfate reduction and methanogenesis are most efficient in the -150 to -350 mV range. Reductive dechlorination of the lesser daughter products, such as VC, has been observed at redox potentials corresponding to nitrate- and iron- reducing conditions. However, the reactions are most prevalent and quicker under sulfate-reducing and methanogenic conditions.

ORP

Reductive dechlorination mechanisms are primarily co-metabolic processes that occur in anaerobic (oxygen-deficient) environments. Oxygen is the most thermodynamically preferred electron acceptor for degradation, but in its absence, alternate electron acceptors can be utilized in anaerobic subsurface environments to degrade theVOCs. That is, the indigenous microbes utilize an organic carbon source as a primary substrate for obtaining energy. The organic carbon serves as an electron donor and is oxidized during this process. The VOCs serve as electron acceptors and are subsequently reduced, while nitrate, iron, manganese, sulfate, and carbon dioxide also serve as electron acceptors and are also reduced in these reactions. Enzymes and co-factors produced during these reactions fortuitously degrade the source chlorinated VOCs (McCarty 1995). For reductive dechlorination to occur, there must be a sufficient source of carbon to support microbial growth. The organic carbon necessary for these reactions to occur can either be natural (i.e. in the formation) or anthropogenic (such as in the form of other contaminants).

The chemical redox equations that control degradation of VC through the reduction of dissolved oxygen, denitrification, iron and manganese reduction, sulfanogenesis, and methanogenesis are shown below (Wiedemeier et al. 1996). Stochiometry is provided for VC due to the scrutiny often placed on the fate and transport of VC. The reaction for oxidation of VC (C_2H_3Cl) by oxygen (O_2) is:

$CH_2{=}CHCl$

$$C_2H_3Cl + 2.5O_2 \rightarrow 2CO_2 + H_2O + H^+ + Cl^-$$

A set of chemical equations can also be written for the other redox reactions that degrade VC as follows (Wieidemeier et al. 1996):

$$C_2H_3Cl + 2NO_3^- + H^+ \rightarrow 2CO_2 + 2H_2O + N_2 + Cl^- \text{ (denitrification)}$$

$$10Fe^{3+} + 3(OH)^- + C_2H_3Cl + 4H_2O \rightarrow 2CO_2 + 11H^+ + Cl^- + 10Fe^{2+} \text{ (iron reduction)}$$

$$C_2H_3Cl + 5MnO_2 + 9H^+ \rightarrow 2CO_2 + 6H_2O + 5Mn^{2+} + Cl^- \text{ (manganese reduction)}$$

$$C_2H_3Cl + 1.5H^+ + 1.25SO_4^{=} \rightarrow 2CO_2 + 1.25H_2S + H_2O + Cl^- \text{ (sulfanogenesis)}$$

$$C_2H_3Cl + 1.5H_2O \rightarrow 0.75CO_2 + 1.25CH_4 + H^+ + Cl^- \text{ (methanogenesis)}$$

4.1.3 ERD Through In-Situ Reactive Zones

ERD is founded on the concept of enhancing the natural conditions in the subsurface system in order to drive the conditions to a state that is more conducive to degradation of the VOCs. Often, natural degradation is limited or stalled at a site due to one or more of the following limiting conditions:

- Aerobic or oxidizing conditions.
- Weak reducing conditions.
- Deficiency of organic carbon.
- Deficiency of electron acceptors.
- Deficiency of nutrients.
- Stressed bacterial population.

Typically, the most common rate-limiting factors that result in slow or little degradation are a lack of organic carbon and relatively mild redox conditions (often slightly aerobic). It has been reported that an excess of 100 times the contaminant concentrations of total organic carbon (TOC) is needed for optimal degradation rates. Degradation is often slowed due to the depletion of natural organic carbon and the less than optimal reducing conditions (less than -200 mV).

In order to overcome the lack of any adequate natural carbon and insure an adequately reducing environment for the reductive dechlorination of TCE and its daughter products, the use of molasses injection is proposed for the site. The addition of the molasses solution to the subsurface provides both an ample supply of dissolved organic carbon, and the rapid depletion of dissolved oxygen via aerobic bacteria degrading the molasses, thus creating strongly reducing conditions.

4.1.4 Conceptual Design

The following is a description of the conceptual design for the D.C Rollforms/Ingersoll-Rand site. ARCADIS Geraghty & Miller is proposing to apply our patented enhanced biodegradation system in a phased approach, as necessary. Phase 1 will consist of the installation of two injection wells (IW-1 and IW-2; see Figure 6). The performance data collected during Phase 1 (estimated operational period of 3 to 6 months) will be used to refine the system design and the installation of Phase 2, if necessary.

4.1.4.1 Delivery System

The in-situ reactive zones used to enhance the biodegradation of the VOCs will be established by a system of two injection wells designed to deliver the molasses solution to the impacted soil and groundwater. A description of the delivery system is provided in the next three sections.

4.1.4.2 Proposed Injection Wells

Two proposed injection wells (IW-1 and IW-2) will be installed adjacent to Well MW-8S/BD to convey the molasses solution into the subsurface in order to create an effective reactive zone. Each well will be constructed of 4-inch diameter, schedule 40 PVC casing and screen (0.020 slot). IW-1 will be installed within the fill material and screened from 5 to 10 feet below land surface to effect the impacted zone. IW-2 will be installed within the till and screened from 14 to 24 below land surface. Figures 7 and 8 are schematics of the injection wells.

4.1.5 Molasses Solution Injection

A typical food-grade blackstrap molasses solution containing sucrose, reducing sugars, ash, organic non sugars, and water, (all of which are soluble in water) will be used on-site. The molasses solution will be initially be mixed with potable water to achieve 1 to 10 dilution (1 part molasses and 10 parts water). This mixture may be altered during the course of the project in order to achieve the desired results.

It is anticipated that a small molasses solution storage vessel (10 to 20 gallons in volume) will be deployed near each injection well, and enclosed in a small wooden structure to protect against freezing and damage/vandalism. During each injection event, the molasses solution (at the desired molasses/water ratio) will be prepared in a mixing tank. The prescribed volume of solution for the injection will then be added to each storage vessel. The molasses solution will then be allowed to flow via gravity from the injection vessel and into the well.

During the first month of operation, it is anticipated that the feed solution will be injected at a frequency of once per week at a minimum. Following this, injections will be reduced to bi-weekly or monthly. The injection frequency may further be altered following evaluation of the biogeochemical sampling data collected during the project.

4.1.6 System Performance Monitoring

Phase 1 of the enhanced biodegradation system will be conducted for a period of approximately 3 to 6 months. Phase 2, if necessary, can begin as soon as sufficient data has been collected from the Phase 1 operation to assess the effectiveness of the technology. A system performance monitoring program has been developed consisting of baseline sampling and periodic monitoring to measure the effectiveness of the system in the soil and groundwater.

4.1.6.1 Groundwater

To establish baseline groundwater conditions prior to the start of the ERD IRM, an initial round of groundwater samples will be collected for laboratory analysis and field parameters measurements from monitoring wells MW-8S, MW-8D, ESI-7, MW-7D, ESI-6 and a new proposed well MW-12. Due to the sensitive nature of many of the parameters being measured in the groundwater each well will be sampled using low flow techniques. Water samples from these wells will be collected and analyzed for VOCs using USEPA Method 8260A, total and dissolved iron and manganese using USEPA Method 6010, total and dissolved organic carbon using USEPA Method 9060, BOD using USEPA Method 405.1, COD using USEPA Method 410.1, ethene and ethane using Method AM-18, carbon dioxide using AM-15.01, chloride using USEPA Method 9250, sulfate using USEPA Method 9036, sulfide using USEPA Method 9031, and nitrate/nitrite using USEPA Method 9200. Groundwater samples will be collected on a monthly basis for the first year. An evaluation of the data will be performed at the end of the first year to determine the future sampling frequency.

The following indicator field parameters will also be measured in groundwater using field equipment:

- Dissolved oxygen (DO);

- Ferrous iron;
- Sulfide;
- Oxidation/reduction potential (ORP);
- pH;
- temperature; and
- specific conductance.

Water extracted from each well using low-flow sampling methods previously described will be directed into a flow-through chamber for DO, redox, and pH measurements. Monitoring of DO and redox in the monitoring wells will help to determine whether microbial-induced reducing conditions have developed within the impacted area. The DO and redox levels are expected to decrease as reducing conditions develop. All field monitoring results will be recorded on log forms. Field parameters will be collected during the baseline groundwater sampling event, bi-weekly thereafter for the first 2 months, and quarterly for the remainder of the first year. An evaluation of the data will be performed at the end of the first year to determine the future sampling frequency.

4.1.7 Data Evaluation

Evaluation of the monitoring data will be conducted to determine the effectiveness of the in-situ reactive zone. The results obtained during the monitoring events will be used for adjusting the molasses solution composition, feed rate, and injection frequency to achieve the desired strongly reducing conditions in the subsurface environment necessary to enhance the biodegradation of the VOCs.

4.1.8 System Installation Schedule

ARCADIS Geraghty & Miller anticipates installing Phase 1 in late October - early November 1998 and begin system operations by late November of 1998. Phase 2 system design, if necessary, would be scheduled for the first quarter of 1999 with installation following immediately thereafter. Actual timing of the design and installation of the ERD System will depend on NYSDEC review and approval.

4.2 Proposed IRMs for Well ESI-3 and ESI-4 Areas

The IRM selected for these related areas will address the LNAPL and DNAPL. NAPL recovery, specifically recovery of DNAPL is often a complicated task due to many site-specific factors, and therefore the IRM selected may be revised and require an increased level of effort.

Passive recovery of NAPL is the proposed IRM in which both the LNAPL and DNAPL would be periodically recovered from the wells in the impacted areas via manual means. Manual NAPL recovery will consist of installation of specially designed passive recovery canisters, which would recover only NAPL (no groundwater) from the wells. The proposed oil recovery unit is the PetroTrap™. Literature describing the PetroTrap™ is provided in Appendix A.

In areas in which NAPL occurrence is fairly limited in areal extent, such as this site, passive recovery of NAPL is often an efficient and cost effective method of recovery. This is especially true in the case of DNAPLs which due to there location (i.e. below the groundwater at the base of the formation) make them hard to mobilize through any active means (such as groundwater extraction).

The passive NAPL recovery approach for the ESI-3 and ESI-4 areas will employ the existing monitoring wells for recovery. The PetroTrap™ canisters will checked initially on a weekly basis and then monthly. Product within the canisters will be transferred to a temporary storage container for later disposal. Use of an automatic recovery system in place of manual recovery would be based on the recovery rates observed initially, since in most cases NAPL recovery is not limited by the speed at which the NAPL is removed from the well, but rather by the speed at which it will migrate into the well. The presence of DNAPL in Well ES-4 would also be monitored during each site visit. Any DNAPL that is present would be removed using a bailer or a peristaltic pump. Based on results of the manual recovery, it may be determined that the recovery system should be upgraded to potentially include a larger diameter recovery well.

4.3 Proposed IRM for Chadakoin River Bank Oil Seep

The proposed IRM for the oil seep will consist of a temporary containment structure covering the impacted area. Implementation of this IRM will require low flow stream conditions so that the surface of the water is below the elevation of the seep. The proposed IRM will consist of a applying one to two layers of fast curing hydraulic concrete over the seep location and surrounding areas. This concrete layer will present a barrier between the stained soils of the seep area and the surface water and will prevent possible discharge or erosion of the stained soils.

During a low-flow event, the concrete will be applied to the desired area via specialized concrete spraying equipment. The area over which the concrete will be applied will be large enough to give the concrete sufficient strength and to avoid any potential for increased velocity and erosion. Following the initial application, a second application may be performed, to reinforce and strengthen the barrier.

5.0 Interim Remedial Measures Report

Following implementation of the proposed IRMs, an IRM report will be prepared summarizing the field activities associated with installation of the injection wells, installation of PetroTrap™ canisters for oil recovery, and the temporary containment structure for the oil seep. The report will be certified by a professional engineer licensed in the state of New York and will include recommendations for modifications to the IRMs or additional phases as necessary. The report will be submitted within 30 days following completion of three months of groundwater monitoring and receipt of all associated laboratory analytical data.

6.0 References

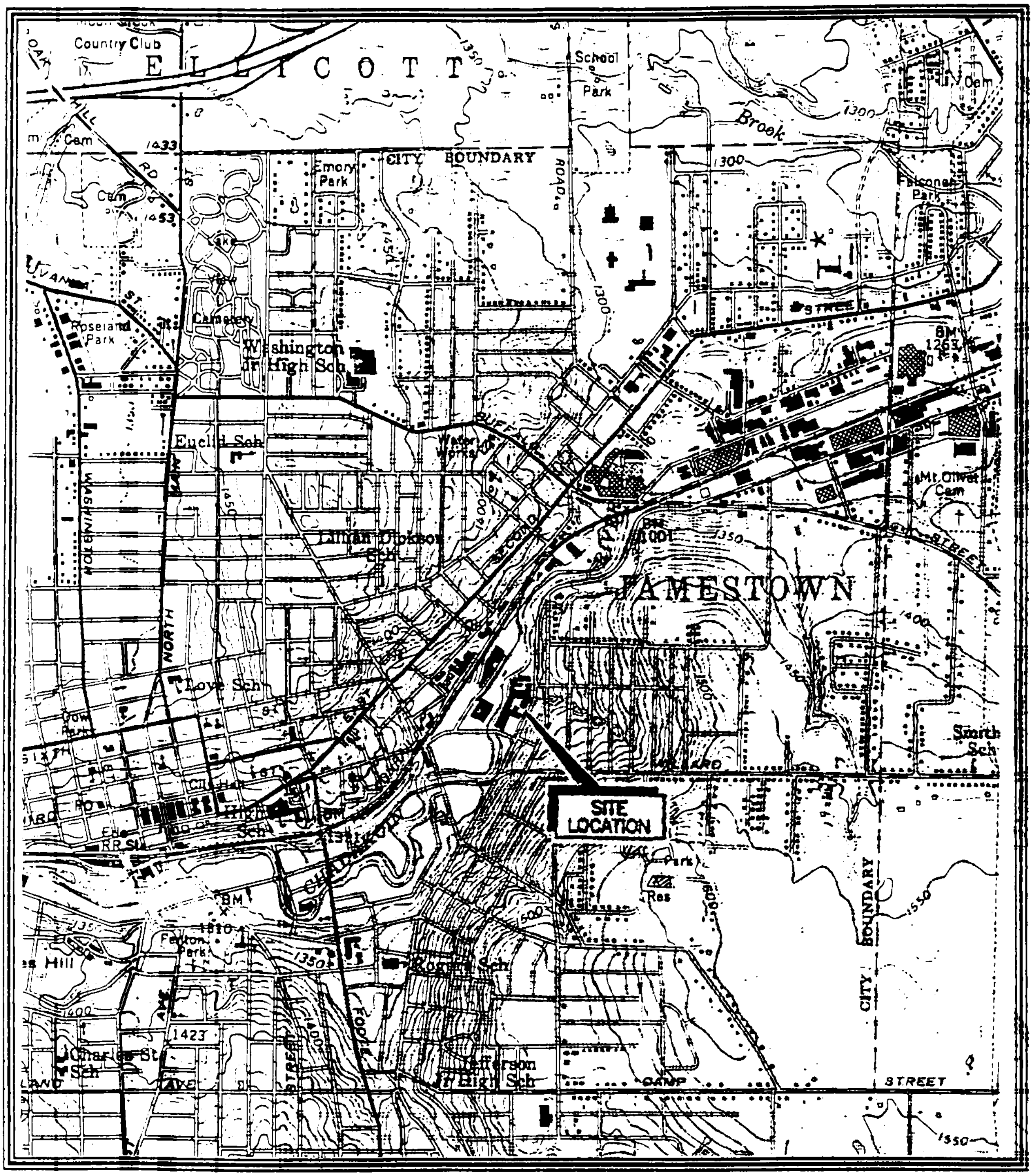
ARCADIS Geraghty & Miller, Inc., 1998. Focused Remedial Investigation Report, D.C. Rollforms/Ingersoll-Rand Site, Jamestown, New York.

McCarty, P., 1996. Biotic and Abiotic Transformations of Chlorinated Solvents in Groundwater, Symposium on Natural Attenuation of Chlorinated Organics in Groundwater, EPA, September 11-13, Dallas, Texas.

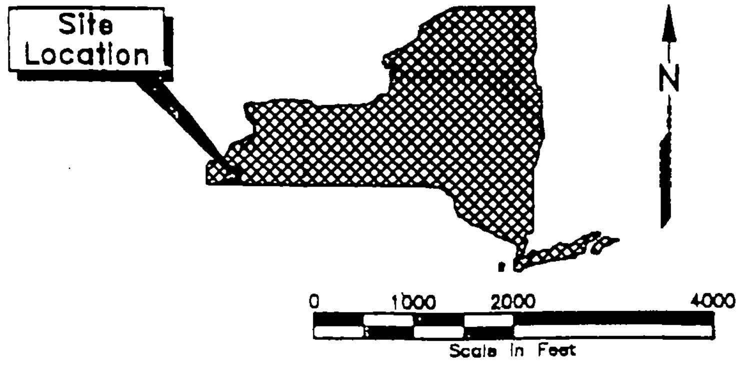
Wiedemeier, Todd H., et al., 1995. Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater, Air Force Center for Environmental Excellence.

Wiedemeier, Todd H., et al., 1996. Draft - Revision No. 1, Technical Protocols for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater, USEPA, Air Force Center for Environmental Excellence.

FIGURES



Reference: U.S. Geological Survey, 7.5 Minute Quadrangle, Jamestown, New York, Edited 1954.

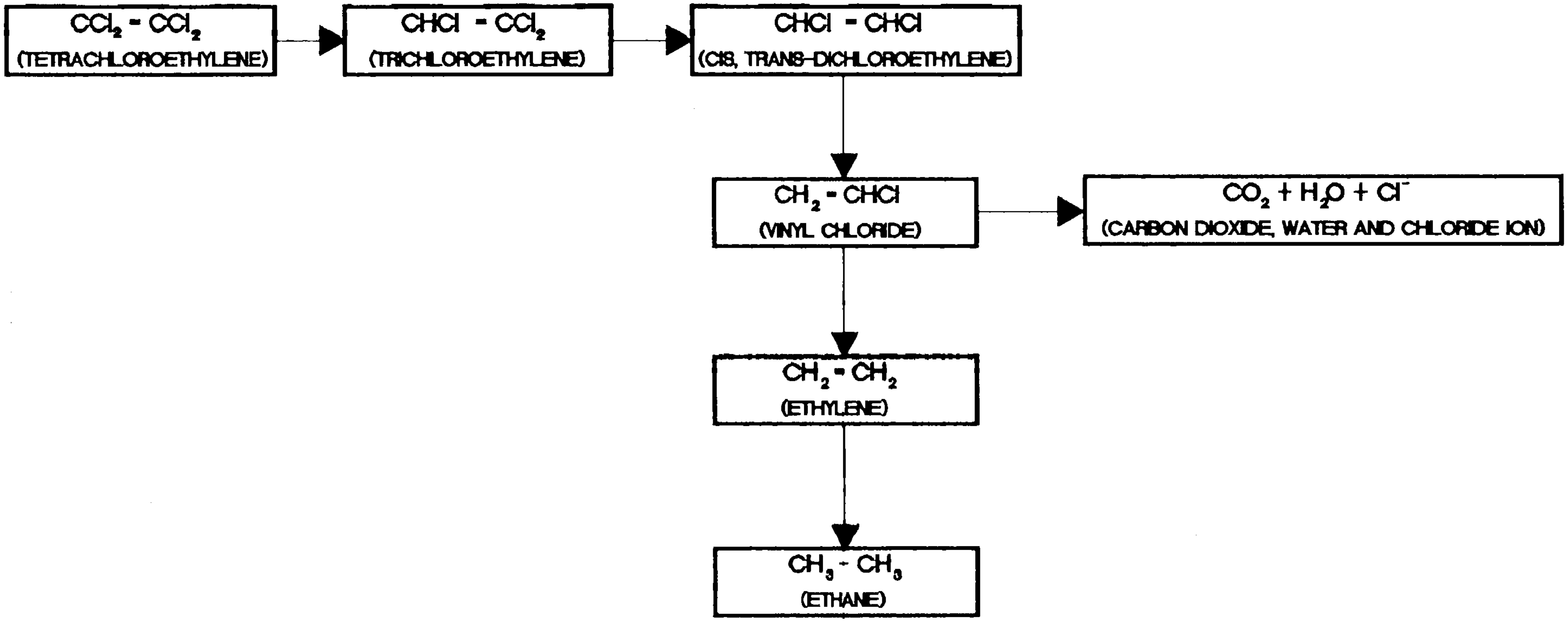


SITE LOCATION

D.C. ROLLFORMS/INGERSOLL-RAND SITE
Jamestown, New York

DRAWN: TAD/G248A	DATE:	FIGURE 1
APP'D:		

ARCADIS GERAGHTY&MILLER



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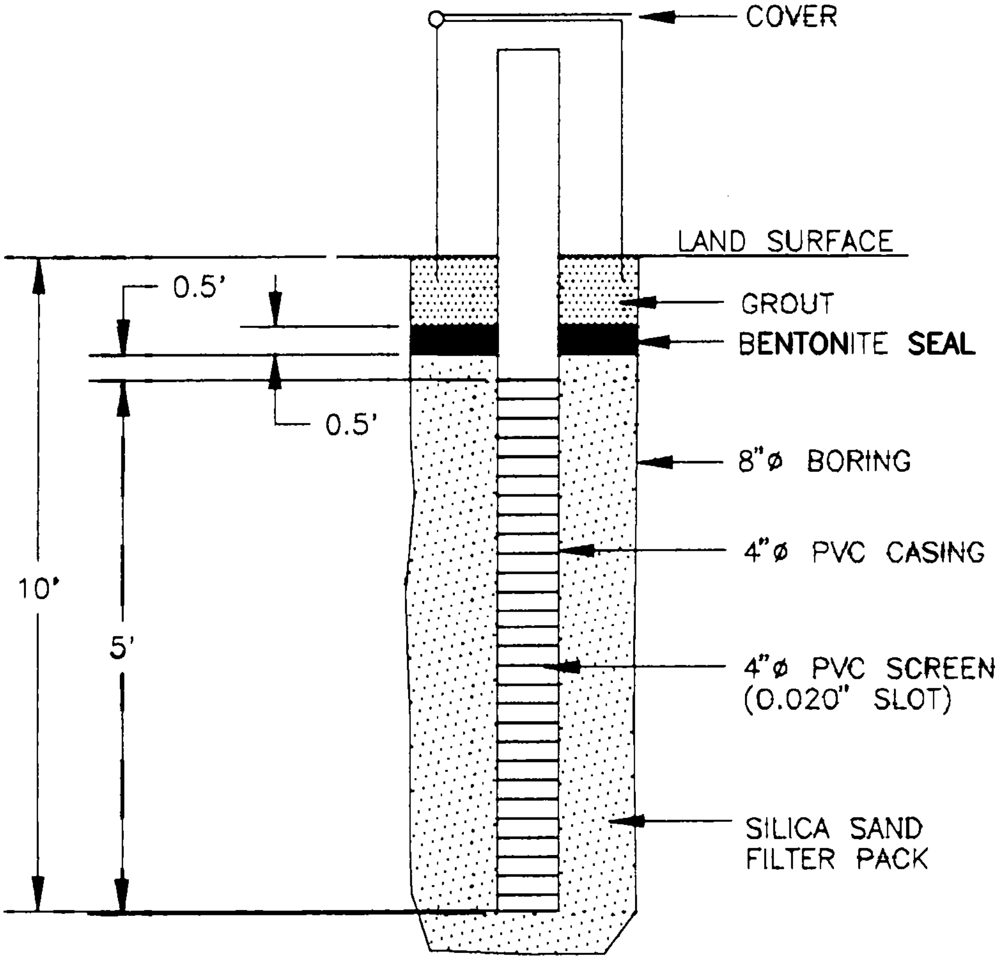
DRAWN FJF/TAD
DATE 9/16/98
PROJECT MANAGER M. SANFORD
DEPARTMENT MANAGER F. LENZO
LEAD DESIGN PROF. M. HANSEN
CHECKED M. SANFORD

ANAEROBIC CHEMICAL AND
BIOLOGICAL TRANSFORMATION
PATHWAYS FOR CHLORINATED
SOLVENTS
D.C. ROLLFORMS/INGERSOLL-RAND SITE
JAMESTOWN, NEW YORK

PROJECT NUMBER AY00002190002
DRAWING NUMBER 5



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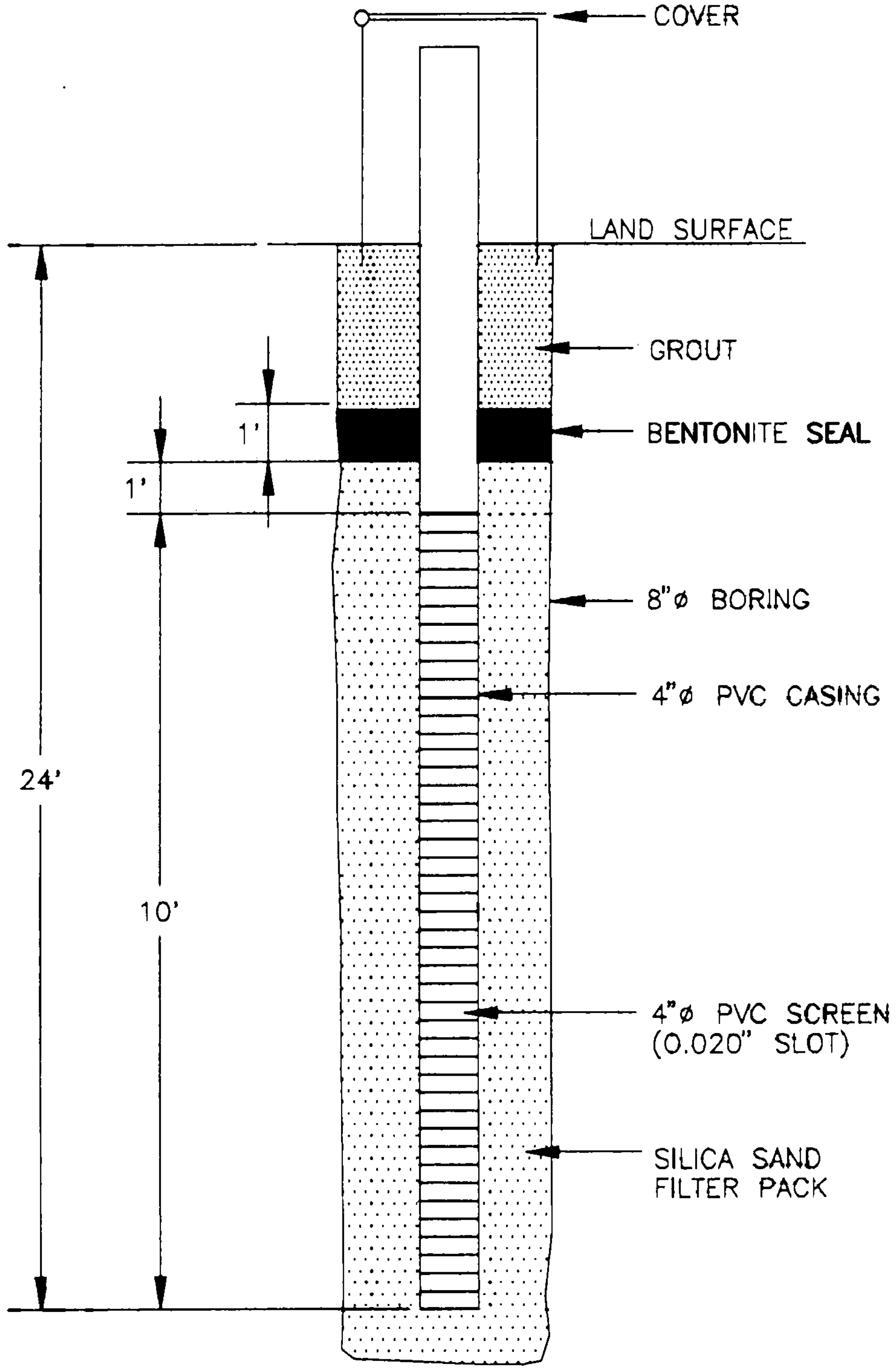
FAX: 518/452-4398

DRAWN FJF/TAD	DATE 9/18/98	PROJECT MANAGER M. SANFORD	DEPARTMENT MANAGER F. LENZO
CONSTRUCTION DETAILS FOR INJECTION WELL IW-1, TILL D.C. ROLLFORMS/INGERSOLL-RAND SITE JAMESTOWN, NEW YORK		LEAD DESIGN PROF. M. HANSEN	CHECKED M. SANFORD
		PROJECT NUMBER AY00002190002	DRAWING NUMBER 6



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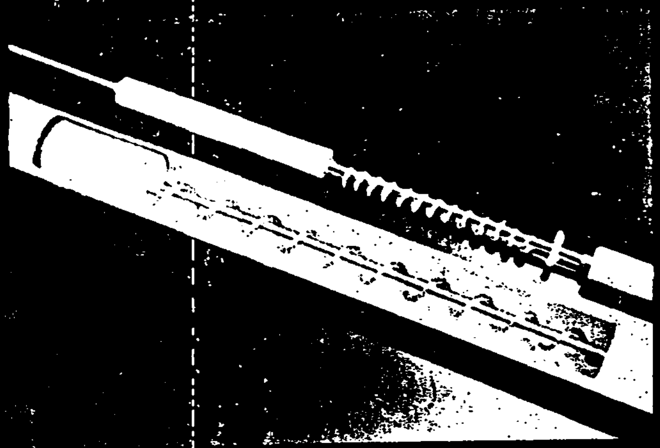
DRAWN FJF/TAD	DATE 9/16/98	PROJECT MANAGER M. SANFORD	DEPARTMENT MANAGER F. LENZO
CONSTRUCTION DETAILS FOR INJECTION WELL IW-2, TILL D.C. ROLLFORMS/INGERSOLL-RAND SITE JAMESTOWN, NEW YORK		LEAD DESIGN PROF. M. HANSEN	CHECKED M. SANFORD
		PROJECT NUMBER AY00002190002	DRAWING NUMBER 7

APPENDIX A

APPENDIX A

PetroTrap™ Literature

Passive Skimmers to Meet the Needs of Every Site...



PetroTrap-E™

...and Every Budget

PetroTrap™

Call 1-800-ENVIRO 4

or your nearest PetroTrap™ distributor

PetroTrap-E™...

The PetroTrap-E™ units have been designed using the same quality manufacturing as the Original PetroTrap™. We have created these low cost alternatives for use on sites with minimal water table fluctuations. The 2" (0.7 Liter) and 4" (2.0 Liter) models feature a 12" buoy travel, a standard 90 day warranty and are competitively priced at $585.00 and $635.00 respectively.

PetroTrap™...

When water table fluctuations are significant and you need your unit to accommodate, look to the original PetroTrap™ for recovery. These units feature a 24" buoy travel and a lifetime warranty which includes replacement of parts for the lifetime of the system.

2" (0.7 Liter) and 4" (2.0 Liter) models are available for recovery of most-refined fuels. Please contact EPI with your site specifications or with questions on free product recovery.

Description:

Our unique passive **skimmer** system which incorporates the use of an active buoy assembly. This **buoy** assembly removes free product to a sheen.

PetroTrap™ units can **be** installed in minutes and are **ideal** on sites where free product recovery must **begin** *immediately*. The system employs the use of a collection canister, eliminating the need to run electricity or air lines to the well.

Installation is quick **and** easy–lower the unit into the **well** much the same **way** as a bailer, and suspend it using the lanyard/vent tube (standard 25' length). **The** unit begins recovering product as soon as **product** is available. Periodically, the canister is emptied manually **through** the drain valve at the bottom of the canister.

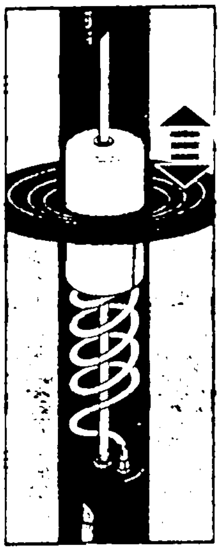
	4" PetroTrap™	2" PetroTrap™
Diameter	3.5"	1.75"
Length	61.0"	76.88"
Weight	18 Lbs.	6.25 Lbs.
Volume	2.0 Liters /.53 Gallons (Other Volumes Optional)	0.7 Liters /.20 Gallons (Other Volumes Optional)
Min. Depth of Water Required	29.0"	39.0"

	4" PetroTrap-E™	2" PetroTrap-E™
Diameter	3.5"	1.75"
Length	49.0"	64.88"
Weight	15 Lbs.	5.25 Lbs.
Volume	2.0 Liters /.53 Gallons (Other Volumes Optional)	0.7 Liters /.20 Gallons (Other Volumes Optional)
Min. Depth of Water Required	29.0"	39.0"

PetroTrap™ is manufactured by Enviro Products Inc. and is part of EPI's line of *"Pure & Simple"* remediation products.

Features:

- No power source required
- Installation takes only minutes
- Effective with petroleum fuels
- Ideal monitoring device to indicate migrating plumes
- Available for 2" and 4" wells



The **PetroTrap**™ filter recovers free product to a sheen

Materials of Construction:

- Stainless steel
- Brass
- Polyethylene
- PVC

Standard System Includes:

- PetroTrap™ skimmer assembly (2" or 4" Model)
- 25' suspension hose
- Choice of 2", 4", or 6" locking well cap

Options:

- Additional canister which will double the **PetroTrap's**™ capacity
- Varying lengths of suspension hose

Rentals Available!

For wells where a high yield of free product is expected, consider using a SkimRite, EPI's active skimmer system.

Enviro Products Means Service!

Call 1-800-ENVIRO 4

ENVIRO PRODUCTS
1431 Rensen Street • Suite A • Lansing, Michigan 48910
(517) 887-1222 • 1-800-ENVIRO 4 • Fax: (517) 887-8374