Stearns & Wheler, LLC
ENVIRONMENTAL ENGINEERS & SCIENTISTS

Report

Conceptual Design Report General Instrument Corporation Sherburne, New York

March 1997

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CONCEPTUAL DESIGN REPORT
GENERAL INSTRUMENT CORPORATION
SHERBURNE, NEW YORK

Prepared for

GENERAL INSTRUMENT CORPORATION

Prepared by

STEARNS & WHELER, LLC
Environmental Engineers and Scientists
One Remington Park Drive
Cazenovia, NY 13035

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CONCEPTUAL DESIGN REPORT
GENERAL INSTRUMENT CORPORATION
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SECTION 1 - INTRODUCTION

This document is a conceptual design report for the installation of a permeable reaction wall system for the remediation of an assumed 300-foot wide dissolved chlorinated organics plume. These organics have been transported with the groundwater from the former General Instrument Corporation (GIC) site in Sherburne, NY, to the area known as West Field. The reactive zone will consist of granular iron which will promote reductive dechlorination of the chlorinated organics.

1.1 PURPOSE OF CONCEPTUAL DESIGN REPORT

The purpose of this conceptual design report is to present feasible alternatives, prepare comparable construction cost estimates, and document the engineering basis for the design of the recommended permeable reaction wall/funnel-and-gate system. This report also describes the materials and methods to construct the treatment system, and presents a construction cost estimate for the installation of the treatment system.

1.2 SITE DESCRIPTION

GIC owned and operated a manufacturing facility on TACO (now Kenyon Press Road) Street in Sherburne, NY from 1968 until 1983. The facility was owned and operated by others from 1947 until 1968. Site environmental impacts were discovered during the plant closure, which led to the site's being listed as a Class 2 site on the *New York State Registry of Inactive Hazardous Waste Sites*. A Remedial Investigation/Feasibility Study (RI/FS) and Record of Decision (ROD) have been completed for the site.

A. **Former TACO Property**. The former TACO facility was used to plate antennas and manufacture electronics parts. The 5.5-acre site borders agricultural fields on the west, residential and light commercial property on the east and south, and a petroleum bulk storage facility (bulk plant) on the north. Access to the site is from the east (Route 12) via what is now Kenyon Press

Road, formerly TACO Street. Figure 1-1 illustrates the location of the site in the Village of Sherburne. Figure 1-2 illustrates the orientation of the buildings at the site.

The facility consists of a 75,000 square foot main building, previously used for manufacturing, warehousing, and administration; a 4,900 square foot plating building, formerly used for applying metal plating material and for degreasing; a 1,600 square foot garage used as a maintenance shop; and a 2,800 square foot wooden shed used to store machinery and material. The area directly east of the plating building is a paved parking lot.

B. **West Field**. Adjacent to the western side of the former GIC site is agricultural property, known as West Field. Separating the former TACO property and the agricultural property are active railroad tracks. The West Field is used for growing crops (corn and oats), which are used as feed for dairy cattle. Access to the property is by the farm access roads from East State Street, near the Chenango River.

1.3 REMEDIAL DESIGN/FEASIBILITY STUDY/RECORD OF DECISION SUMMARY

The following is a brief summary of the site RI/FS.

A. **Source of Contamination**. During the RI, the soil under and in the vicinity of the former plating building was identified as a source of chlorinated hydrocarbons which resulted from the industrial activity which occurred during the plant operation. Some of the contaminants probably entered the saturated soil through the building's floor drain system, which was used to collect rinse water from the cleaning of aluminum antennas and associated parts. Concentrations of contaminants in soil beyond the perimeter of the building can be attributed to separate spills and releases of chemicals in that area, and also to vapor migration. Once contaminants are introduced into the saturated soil, the dissolved phase transport contributes to the movement of the contaminants within the groundwater, thereby constituting the dissolved groundwater plume. The contaminant plume (January 1995) extends into the West Field toward the Chenango River, as shown in Figure 1-3.

B. **Contaminants of Concern.** The chlorinated organic contaminants of concern in the West Field plume are trichloroethylene (TCE) and both isomeric forms of 1,2-dichloroethylene (1,2-DCE).

Vinyl chloride has been detected, but in general, at lower concentrations than TCE and 1,2-DCE. 1,1,1-trichloroethane (TCA) was also detected but also at much lower concentrations than that found for TCE and 1,2-DCE.

C. **Feasibility Study Summary**. The feasibility study evaluated treatment for three specific areas/media of the facility:

1. Soil in the vicinity of the plating building.
2. Soil north of the wooden shed adjacent to the northern property boundary.
3. Off-site groundwater.

Potential remedial alternatives were evaluated:

1. No action.

2. Excavation of contaminated soil "hot spots" and capping, and on-site groundwater pump-and-treat system.

3. Excavation of contaminated soils with off-site treatment and on-site groundwater pump-and-treat system.

4. Soil vapor extraction with bioventing soils and off-site groundwater pump and treat.

5. Soil vapor extraction with bioventing soils and off-site in-situ groundwater treatment.

The recommended remedy of the FS and included in the ROD was Alternative No. 5, which included in-situ soil vapor extraction to treat soils, free product recovery for the area north of the main building, and an in-situ permeable reaction wall to address groundwater contamination in the West Field area. This report details the in-situ permeable reaction wall portion of the remedy.

1.4 PERMEABLE REACTION WALL FIELD TRIAL RESULTS

A pilot study in-situ permeable reaction wall was installed in May 1995 to determine the applicability of this technology at the site. Results indicate that the reaction wall has successfully removed over 99 percent of the dissolved chlorinated organics entering the wall.

As detailed in the ROD, a full-scale permeable reaction wall would be installed if the pilot-scale reaction wall was deemed successful. Based on the pilot-scale results, implementation of the full-scale system will proceed to treat the dissolved chlorinated organic plume in the West Field area.

SECTION 2 - NATURE AND EXTENT OF CONTAMINATION

2.1 GENERAL

The following section will detail field work completed in 1996 and 1997, to define the lateral (north and south) extent and concentrations of the dissolved chlorinated organic plume. Further, investigation of the depth of the underlying clay layer will be discussed. This field data will be compared to the data used during the design and installation of the pilot-scale system. Finally, additional data needs will be addressed.

2.2 1996 AND 1997 FIELD INVESTIGATION SUMMARY

In July and August of 1996, a groundwater velocity verification test was completed in an effort to confirm groundwater flow rates that occurred in the pilot-scale permeable reaction wall/funnel-and-gate system. The test was followed by groundwater velocity measurements with a "downhole velocity meter." The purpose of these measurements was to further verify groundwater residence time in the treatment portion of the pilot-scale system.

A better definition of the depth to the underlying clay layer and concentrations of dissolved chlorinated organics was needed to design the full-scale permeable reaction wall. In November 1996, field testing was completed at the site. Objectives of this work included obtaining information regarding the depth to the underlying clay layer, extent and concentrations of the dissolved chlorinated organic plume, determination of the characteristics of the subsurface materials, and an evaluation of the presence of petroleum hydrocarbons.

In January 1997, additional field work was carried out to further define the extent of the dissolved chlorinated organics and underlying clay layer depths to the north. The results of the additional field work will be presented in separate correspondence.

2.3 FIELD INVESTIGATION RESULTS

Envirometal Technologies, Inc. (ETI) conducted tests in August and September 1996 with the purpose of verifying groundwater flow velocities in the pilot scale treatment system. The results of these tests were compared to groundwater velocities calculated from the groundwater elevation measurements recorded monthly by PRC Environmental Management, Inc. (PRC) as part of the pilot test evaluation of the system.

In August, groundwater verification testing consisted of addition of a solution of sodium bromide to the three upgradient wells located in the treatment cell (wells MW-U1, MW-U2, and MW-U3). Samples were then collected at regular time intervals from the monitoring wells located in the iron (wells MW-FE1, MW- FE2, and MW-FE3) and the downgradient wells (wells MW-D1, MW-D2, and MW-D3), with the samples being analyzed for bromide concentrations. Only three samples collected from the downgradient wells were found to contain bromide concentrations above background concentrations. Based on the time these samples were collected, the groundwater velocity was predicted to be in the range of 1.2 to 1.6 feet/day. However, the error associated with these measurements can be assumed to be high, because so few samples were found to contain concentrations of bromide above the background concentration. The reason the testing was not more conclusive was assumed to be due to two reasons. First the introduction of the bromide solution into the wells probably created very narrow plumes. If the groundwater flow direction at the time of the testing was not exactly perpendicular to the treatment cell, it is possible that the downgradient wells were not located in an area of the treatment zone where the narrow plumes would be intercepted. The second reason is that dilution of the original volume of bromide by the water in the upgradient wells may have been greater than anticipated.

Because of the uncertainties associated with the flow verification testing using the bromide solution, a down hole velocity meter was used to measure groundwater velocity in the treatment cell in September 1996. This work indicated the flow rate in well MW-FE1 to be 0.7 feet/day in the north to northwest direction. However, the accuracy associated with the meter's prediction of flow direction is not expected to be high. Further measurements were influenced by nearby construction activity.

Groundwater velocities estimated from the groundwater elevation measurements recorded by PRC indicated the groundwater flow velocity ranged from 0.2 feet/day to 1.2 feet/day. There is some question about the validity of the measurements that predicted flow velocities at the lower end of the range (0.2 feet/day) because the hydraulic gradient associated with those measurements was less than 0.001. The wells were resurveyed in August and additional measurements of groundwater elevation were made during the August and September testing. Flow velocities based on elevations measured in August and September 1996 were estimated at 0.7 feet/day, confirming the measurement made with the down hole velocity meter. Because it is probable that the actual flow rate varies depending on the hydraulic gradient at the site, the flow rate during the 6-month test period probably varied somewhat on a month to month basis. Since there is more confidence in the measurements which predicted the higher flow velocities, it is likely that the groundwater flow velocity actually ranges from 0.7 feet/day to 1.3 feet/day, which corresponds to a residence time in the treatment cell between 28 and 51 hours.

The results of the November 1996 investigation work included:

1. Depth to the underlying clay layer ranges from 14.5 to 19 feet.
2. There was no indication of measurable free petroleum product evident in the borings.
3. Groundwater analytical results are presented in Table 2-1.
4. The chlorinated organics plume was approximately 300 feet wide.

The results of the January 1997 investigation work included:

1. Depth to underlying clay layer ranges from 14.5 to 30 feet (14.5 to 19 feet within the plume area).

2. Groundwater analytical results are presented in Table 2-2.

3. The actual width of the TCE plume may be wider than 300 feet. The January sampling results have been successful in defining the northern extent of the plume. However, the extent of the plume in the southern direction has not been clearly defined. It should be noted, however, that the concentration of total VOCs detected in the sample from the most southern sampling location are lower than the concentrations of total VOCs in the portion of the plume that is located downgradient from the proposed location of the full-scale in-situ treatment system. Therefore, it can be expected that the organics present in the groundwater located south of the original 300-foot width plume, if not treated, would attenuate before reaching the nearest receptor.

2.4 COMPARISON OF DESIGN TO FIELD INVESTIGATION RESULTS

The findings of the November investigation are generally consistent with prior understandings. The maximum total chlorinated levels were 5100 μg/l, obtained from P-8, which were higher than anticipated, but within the range for which the pilot-scale system was designed. However, the depth of 19.5 feet to underlying clay was much deeper than the 15-foot depth encountered during the pilot-scale test. The findings of the January investigation were generally consistent with prior understanding.

SECTION 3 - FULL-SCALE DESIGN CONSIDERATIONS

3.1 GENERAL

This section describes the basis for design of the full-scale permeable reaction wall. Design considerations include expected influent contaminant concentrations, measured laboratory testing half-lives, established effluent concentration goals equal to the New York State Department of Environmental Conservation groundwater standards, and measured site groundwater seepage velocities.

3.2 INFLUENT CONCENTRATIONS

The design influent concentrations of contaminants for the pilot-scale treatment system (September 1993) and the maximum concentrations observed in the November 1996 sampling event are as follows:

ANALYTE	PILOT SYSTEM DESIGN CONCENTRATIONS (PPB)	NOVEMBER 1996 CONCENTRATIONS (PPB)
TCA	96	7
PCE	90	100
TCE	529	2600
cDCE	5650	3600
VC	220 200+60b = 280	870 + 62b = 932

b - assumes ±1 percent of (TCE+cDCE) will appear as VC.

3.3 EFFLUENT CONCENTRATIONS

The full-scale permeable reaction wall will be designed such that groundwater leaving the system (effluent groundwater) will be at or below groundwater standards. The groundwater standards for TCA, PCE, TCE, and cDCE are 5 μg/l. The groundwater standard for VC is 2 μg/l.

3.4 REQUIRED RESIDENCE TIME

Required residence time is the amount of time the contaminants need to be in the iron reactant zone in order for degradation to lower the initial concentrations to below groundwater standards. Standard half-life reaction times were used from bench-scale testing performed at the University of Waterloo with groundwater from the GIC Sherburne site completed in 1994. The half-life reaction times for TCA, PCE, TCE, cDCE, and VC are 3.0 hours, 0.5 hours, 0.2 hours, 3.0 hours, and 2.1 hours, respectively. It appears that temperature does not have a significant effect on reaction rate (Matheson & Tratnyek, in publication), so this is a valid assumption. These half-life times will be used to determine the time necessary for the concentrations to degrade to less than the groundwater standards. Using the initial concentrations described in Section 3.2 and effluent concentrations described in Section 3.3, required residence times to treat the November influent concentrations (highest concentrations) are as follows:

ANALYTE	INITIAL NOVEMBER 1996 CONCENTRATIONS ~~(1996)~~	HALF-LIFE (HOURS)	RESIDENCE TIME (HOURS)
TCA	7 ppb	3	1.5
PCE	100	0.5	2.2
TCE	2600	0.2	1.8
cDCE	3600	3.9	36.6
VC	870 + 62b = 932	2.1	18.6

Total required residence time is the sum of the individual residence times for each compound, assuming sequential degradation of each compound. Therefore, the total residence time for volatile organic compounds (VOC) degradation in the reactive treatment zone is 1.5+2.2+1.8+36.6+18.6 = 60.7 hours, or 2.6 days. The models for the design were based on a three-day residence time, which allows for a factor of safety of 0.7 days, or 23 percent. This is consistent with predictions made by ETI based on groundwater sampling results of the field test.

3.5 REQUIRED THICKNESS OF IRON REACTION ZONE

A residence time of three days is the same residence time used in the evaluation of the pilot-scale treatment system, which successfully treated the influent VOC contaminants. The success of the pilot study indicated that the retention times resulting from the system geometry were sufficient to degrade influent concentrations to groundwater standards. ETI has performed additional modeling to evaluate the required dimensions of the system for two- and three-gate treatment systems. The two-gate system results in an increase in groundwater velocity through the gate sections of six times background, resulting in a required iron thickness of 6.4 feet. The three-gate system results in a groundwater flow rate increase of five over background, with a resulting required iron thickness of 5.4 feet.

The required thickness of reactive iron for a continuous permeable reaction trench configuration is calculated from the residence time and site-specific groundwater seepage velocity. To be conservative, the maximum seepage velocity of 85 feet per year (0.23 feet per day) from the remedial investigation (measured at Monitoring Well MW-17) will be used. For a residence time of three days with a seepage rate of 0.23 feet per day, the iron zone thickness of 0.7 feet would be required. For constructability and to be conservative, a total iron zone thickness of 1 foot will be evaluated for a continuous permeable reaction wall configuration. A 1-foot thickness results in a safety factor of 1 day, or 30 percent.

3.6 PREDICTED LIFE OF THE REACTIVE IRON

The design life of the system is 20 years. The life of the system is directly dependent on the predicted life of the reactive iron. The measured porosity of the iron is 0.4 to 0.45. Based on results of laboratory evaluations, an estimate has been made that the porosity losses could amount to as much as 7.5 percent of the original porosity per year. The porosity loss is theorized to occur due to precipitation of calcium, magnesium, and iron salts due to the pH increases resulting from the dechlorination reaction. However, investigations ongoing at the Canadian Air Forces Borden site have shown that there has not been any decrease in porosity in the iron used in a funnel-and-gate system constructed at the Borden site. Therefore, an assumption has been made for the funnel-and-gate system that iron porosity will decrease such that the gate will only require replacement once every 10 years. The continuous permeable reaction wall has more iron per unit area of flow; therefore, it is assumed that the iron porosity will be acceptable for the full 20-year design life.

SECTION 4 - CONSTRUCTION OPTIONS

4.1 GENERAL

Based on a review of the available construction techniques for a permeable reaction wall, there are nine scenarios that have been considered as alternatives. There are two separate methods, a continuous permeable reaction wall (one technique) or a funnel-and-gate system (eight techniques). The following is a list of the alternatives that were evaluated.

1. Continuous permeable reaction wall
2. Two-gate permeable reaction wall (slurry wall funnels)
3. Two-gate permeable reaction wall (waterloo sheet piling funnels)
4. Two-gate permeable reaction wall (vinyl sheet piling funnels)
5. Two-gate permeable reaction wall (geomembrane wall funnels)
6. Three-gate permeable reaction wall (slurry wall funnels)
7. Three-gate permeable reaction wall (waterloo sheet piling funnels)
8. Three-gate permeable reaction wall (vinyl sheet piling funnels)
9. Three-gate permeable reaction wall (geomembrane wall funnels)

For each construction technique, basic design considerations were evaluated to determine a comparative construction cost estimate. The basic design considerations were based on the previous modeling performed by ETI, the pilot study completed on the site, and typical construction methods.

Figure 4-1 presents the continuous wall system. Figure 4-2 presents the two-gate funnel-and-gate system. Figure 4-3 presents the three-gate funnel-and-gate system. Figure 4-4 presents a generalized geologic cross-section with the approximate locations of the continuous wall, two-gate funnel-and-gate, and three-gate funnel-and-gate systems.

4.2 CONTINUOUS WALL SYSTEM

A continuous wall system would be constructed by excavating a trench and subsequently backfilling with iron reactant. The system would be excavated approximately 1 foot into the less permeable clayey silt soil for a total depth of 21 feet. The continuous wall system would be equivalent to the width of the plume, which is 300 feet. The thickness of the wall has been determined to be 1 foot based on the calculations performed to determine the residence time necessary for the contaminant levels. The calculations have been discussed previously in this report.

The method of construction that has been evaluated is the use of a specialized deep trencher that can excavate a 1- foot wide trench 21 feet deep and backfill the trench all in one pass of the equipment. The trencher supports the sidewalls during backfilling with a boot and requires no dewatering. The boot has two sidewalls that maintain the open trench while backfilling is occurring. The backfill is completed with a loader placing the iron reactant in a hopper that is attached to the boot of the machine. The excavated soil is brought to the surface by the chain and is moved to either side by augers or conveyors. The excavated soil is placed into disposal containers.

To decrease the amount of hazardous soil requiring disposal, the top 3 feet of soil will be removed prior to the trenching. This material will be stockpiled adjacent to the area to be used as backfill over the wall. The iron wall will be placed to within 3 feet of the original ground surface to allow the continued use of the field by the property owner.

The wall will be filled with reactive iron material consisting of finely ground iron which has been put through a furnace to remove impurities such as oils which result from the grinding process. The particles range from 0.09 to 0.0059 inches in size. The iron has a unit weight of approximately 170 pounds per cubic foot (pcf) in a loose state to 200 pcf in a compacted state. The measured porosity of the iron material is 0.4 to 0.45. The layer of gravel separating the aquifer material from the iron on both the upgradient and downgradient sides of the previously described gate is not necessary. The aquifer will regulate the flow through the wall along the full length of the wall. In the final design, a second pass of the iron wall system in the vicinity of high concentrations will be considered.

following

The amount of excavated soil that is considered to be hazardous has been evaluated at the 1-foot width and considered to be any soil excavated by the trencher. The quantity is 1 foot wide by 18 feet deep (21 feet - top 3 feet) and 300 feet long equaling approximately 220 cubic yards with a fluff factor of 15 percent. The assumption was made that the unit weight of the excavated soil will be 135 pounds per cubic foot, which is equal to 1.8 tons per cubic yard. The resulting total disposal weight would be approximately 420 tons.

For the continuous wall, we would recommend two monitoring wells to be placed downgradient of the wall and one upgradient of the wall to monitor the effectiveness of the system. A separate monitoring well to be located to the south of the system would monitor the groundwater that was not captured by the system. The monitoring wells should be placed within 10 feet of the wall at three separate locations. Additional monitoring could be completed with pressure transducer piezometers to measure the pore pressure and determine the water height at that location. These locations could be at the north and south end of the system, with other locations upgradient and downgradient.

Based on experience of contractors performing similar projects, this construction could be completed within one to two weeks. The actual trenching may take as little as three days, with the remainder of time being site work, mobilization, decontamination, and demobilization time.

4.3 FUNNEL AND GATE

The funnel-and-gate system for in-situ treatment of contaminated groundwater consists of low permeability cutoff walls ("funnels") constructed with gaps ("gates") between the subsurface walls. The gaps consist of high permeability material which act as in-situ reactors that are able to decontaminate the groundwater. The cutoff walls modify the groundwater flow pattern such that the flow is primarily through the gate sections. The cutoff walls should be sufficiently impermeable with respect to the natural aquifer materials and the material in the gate. The funnel-and-gate system will be oriented perpendicular to the direction of groundwater flow in what is believed to be the center of the plume.

The gate will be filled with reactive iron material consisting of finely ground iron which has been put through a furnace to remove impurities such as oils which result from the grinding process. The particles range from 0.09 to 0.0059 inches in size. The iron has a unit weight of approximately 170 pcf in a loose state to 200 pcf in a compacted state. The measured porosity of the iron material is 0.4 to 0.45. There will be layers of gravel at least 1 foot thick separating the aquifer material from the iron on both the upgradient and downgradient sides. The purpose of the gravel is to reduce the effects of any high conductivity zones present in the aquifer upgradient of the gate by spreading this flow vertically.

The construction of the funnel-and-gate system is estimated to take two to six weeks, depending on the technique. The slurry and sheet piling will take approximately four to six weeks to construct, including the gates. The geomembrane wall would take approximately one week to complete, with the gate systems taking approximately one week to complete.

A. **Geometry of the System.** The funnel-and-gate system was modeled by ETI to determine the width and thickness of the system for this specific project. For a three-gate system with a 6:1 ratio, the total length would be 440 feet with three 20-foot gates. The anticipated configuration of the three-gate system would be 110 feet of funnel, 20 feet of gate, 80 feet of funnel, 20 feet of gate, 80 feet of funnel, 20 feet of gate, and 110 feet of funnel. For a two-gate system with a 10:1 ratio, the total length would be 555 feet with two 25-foot gates. The anticipated configuration of the two-gate system would be 190 feet of funnel, 25 feet of gate, 125 feet of funnel, 25 feet of gate, and 190 feet of funnel. These dimensions were evaluated to capture a 300-foot plume of chlorinated organic compounds. The thickness of the gates has been determined to be 7.5 feet for the three-gate system and 8.5 feet for the two-gate system. The thickness of iron will be 5.5 feet for the three-gate system and 6.5 feet for the two-gate system based on a residence time of three days for the in-situ seepage velocity of the aquifer of 85 feet per year. There will be at least 1 foot of gravel on either side of the iron.

The depth to the clay layer ranges from 14.5 to 19 feet; therefore, the funnel system will extend to depths greater than 19 feet. A depth of 20 feet to the top of the clay layer was evaluated for this conceptual design. The funnel is planned to go at least 4 feet into the clay layer for slurry wall construction, 1 foot for sheet pile construction, and 1 foot for the geomembrane wall construction.

The gate system sheet piling will extend further into the clay due to dewatering considerations during excavation within sheet pile walls. For the sheet pile walls, the gate system would extend 7 feet into the clay layer. Initially, sheet piling will be used to form the four sides of a "rectangular box" which will be excavated by the contractor and filled with reactive iron and gravel. The excavation will be to an approximate depth of 21 feet to go at least 1 foot into the clay layer. The exposed sheet piling will need to be braced to maintain stability. The individual sections of the sheet pile walls, including rolled corners and T-sections, will be set in place prior to commencement of driving. This is required to ensure the last corner fits properly. Procedures for installation of the sheet piling include monitoring that joints remain free from debris.

Once the sheet piling has been installed, the contractor will excavate the native material from inside the rectangular form. The native material will be removed down to approximately 1 foot into the silty clay layer. The non-hazardous material (top 3 feet) will be staged at the side of the excavation for use as backfill. The hazardous excavated material will be staged on a polyethylene sheeting and covered with a double layer of the sheeting. These unsaturated soils will be staged separately from the material excavated from below the groundwater table. Saturated materials will be staged at the site prior to transportation to a disposal facility. It is expected that the contractor will provide equipment for dewatering operations to allow efficient removal of native material from below the groundwater table. All groundwater recovered during dewatering operations is expected to be contaminated and will be stored in temporary on-site tanks or drums to allow for treatment and characterization prior to disposal. Stearns & Wheler is exploring options for on-site treatment of dewatering and decontamination liquids.

The enclosure will be filled in sections with the use of temporary sheeting inside the gate system. The material will be filled to approximately 1 foot above the normal groundwater level (3 feet below the ground surface). A filtration/separation geotextile is planned to be placed at the bottom of the excavation and at the top of the iron/gravel backfill to help in keeping the fines from clogging the backfill. Unsaturated, native material will be used to complete filling the trench to match the site grade. Once the media is in place, the temporary sheeting will be removed and the sheet piles perpendicular to the groundwater flow will be removed. Sheet piling that is removed may be utilized for the construction of a different gate or for the funnel walls.

B. **Materials for Funnel Cut-off Walls**. Materials for the cut-off walls are planned to be one of the following: sealable steel sheet piling, vinyl sheet piling, slurry wall, or geomembrane wall. The permeability of the funnel system should be less than 10^{-7} centimeters per second (cm/s).

The steel sheet piling wall would be constructed of sealable joint sheet piling. Installation and grouting quality assurance/quality control (QA/QC) would be provided by a licensed Waterloo barrier sealing contractor. Joints in the cutoff walls and in the piling that form the sides of the gate will be sealed to provide the necessary permeability. The steel sheet piling would be placed by vibrating the sheet piles into place. The permeability of the system has been tested to be less than 10^{-8} cm/s.

The vinyl sheet piling wall would be similar to the steel sheet piling wall except that the impermeable joints would be constructed with a sealant. The vinyl sheet piling is less expensive than the steel sheet piling. The impermeable nature of the wall depends on the ability to seal the joints. As an alternative to the Waterloo method of sealant, the use of an hydrophilic waterstop could be considered for a possible cost savings. The vinyl sheet piling would be placed by vibrating the sheet piles into place. The permeability of the system has not been tested; however, previous data performed on cold-rolled steel sheet piling with sealed joints has been documented to be less than 10^{-6} cm/s. Based on the data, the interlocks of the vinyl sheet pile would be similar to the steel sheet pile with the same interlocks.

Interceptor geomembrane walls would consist of the use of interlocking 80 mil high density polyethylene panels that are placed vertically within a trench as a cut-off wall. The panels are connected with interlocks that have an hydrophilic sealant. The panels can be placed with a trencher that will make a trench, place the geomembrane wall, and backfill the wall. The permeability of the system has been tested to be less than 10^{-8} cm/s.

A slurry wall would be a trench excavated with a bentonite slurry used to maintain the open trench during the process of excavating and backfilling with a low permeability soil. The excavation of the slurry wall would result in soil that would need to be disposed as a hazardous waste. The permeability of a slurry wall can be designed to be less than the modeled hydraulic conductivity of 10^{-6} cm/s.

C. **Quantity/Amount of Waste Material Disposal Options**. Of the four different methods of funnel construction, the only methods that may result in waste material would be the slurry wall and the geomembrane wall. The amount of waste generated for the funnel cut-off walls is estimated to be 2,000 to 2,200 tons based on a slurry wall width of 3 feet and 1,300 to 1,400 tons for the geomembrane wall. The amount of waste generated for the gate systems would be approximately 640 tons. There are more than two disposal options; however, the two options that have been evaluated are GIC-approved disposal locations for hazardous materials. Other locations may be available with prior approval from GIC. Stearns & Wheler is also exploring on-site treatment options, which would be the preferred waste handling method.

D. **Location and Number of Monitoring Wells**. For the funnel-and-gate systems, we would recommend monitoring wells to be placed downgradient of the gates to monitor the effectiveness of the system. At one of the gates, we would recommend that a monitoring well be placed upgradient to serve as a basis for the system influent concentrations. A separate monitoring well to be located to the south of the system would monitor the groundwater that was not captured by the system. The monitoring wells should be placed within 30 feet of the gate. The two-gate system would have three monitoring wells, one upgradient and two downgradient. The three-gate system would have four monitoring wells, one upgradient and three downgradient. Additional monitoring could be completed with pressure transducer piezometers to measure the pore pressure and determine the water height at that location. These locations could be at the north and south end of the system with other locations upgradient and downgradient.

4.4 BASIS OF CONSTRUCTION COST ESTIMATES

This section details the basis and assumptions used in the estimation of construction costs for each of the permeable reaction wall alternatives. Some activities are inherent to all of the alternatives, and others are specific to the alternative.

Based on data collected during the RI/FS, the plume of chlorinated organics was assumed to be 300 feet wide at the planned location of the full-scale, in-situ treatment system. Data collected during the most recent subsurface investigation indicates the plume may be wider than 370 feet. However, to be consistent, all construction cost estimates were based on the system being required to treat a total plume width of 300 feet.

A. **Activities Inherent to all Construction Alternatives**. One of the first activities in preparation for construction of the permeable reaction wall is the site preparation. Site preparation includes clearing of any trees, equipment, or materials in the area where the permeable wall is to be constructed; and improvements to the access road to allow equipment to have better access to the site. The access road improvements include placement of gravel in specific sections or along the entire length of the access roadway. Mobilization and demobilization of equipment, materials, and supplies to and from the site is also inherent to each of the construction alternatives. Decontamination and soil dewatering pads have been included for decontamination of site equipment and for the dewatering of excavated soils, respectively. In order to monitor treatment efficiencies of the constructed permeable reaction wall, monitoring wells will be installed, four with the continuous reaction wall, and two gate systems, and five for the three-gate systems. Piezometers will also be installed upgradient and downgradient of the gates to monitor the permeability of the iron over time. Finally, the pilot-scale permeable reaction wall will be decommissioned during the construction of the full-scale system. Decommissioning will include the removal of the sheet piling associated with the pilot-scale system.

Contaminated soil and water will be generated with the construction of each of the alternatives. Soil will be generated from the excavation of the gates in each of the funnel-and-gate system alternatives. Additional contaminated soil would be generated during the slurry wall, geomembrane wall, and continuous permeable reaction wall alternatives. The continuous reaction wall would generate the least amount of soil at approximately 420 tons. The two-gate slurry wall funnel-and-gate system would generate the most amount of soil at approximately 2,200 tons. Finally, more water is generated during the installation of the permeable reaction wall alternatives with three gates than the two-gate option.

Finally, each of the construction cost estimates have an indirect cost section that includes estimated contingency, engineering/administration, and construction management costs. The contingency was calculated at 20 percent of the construction cost without the disposal or indirect costs. The engineering/administration was based on the existing budgets. The construction management costs were based on an estimate of construction time for each alternative.

B. **Specific Assumptions to Each Alternative.**

1. Alternative No. 1, the continuous permeable reaction wall, includes the installation of a 300 foot long by 1 foot wide by 21 feet deep continuous trench of iron. The wall would be keyed 1 foot into the underlying clay, which has been conservatively assumed to be at a depth of 20 feet. The wall would bisect the chlorinated groundwater plume, which has been estimated to be approximately 300 feet in length.

The continuous trench will be installed using a specialized machine that can continuously trench to depths of 25 feet and backfill the same trench with iron in one pass. There are at least three contractors with the specialized equipment. The continuous reaction wall has less groundwater flow across each square foot of iron wall; therefore, the design life of this alternative is assumed to be 20 years.

2. Alternative Nos. 2 and 6 involve the use of slurry walls to construct the funnel walls in the funnel-and-gate system. The slurry walls will be 3 feet wide, to a depth of 24 feet (4 feet into the underlying silty clay layer) and will either be 555 feet long with the two-gate system (Alternative No. 2), or 380 feet long with the three-gate system (Alternative No. 3). One third

of the soil excavated in the construction of the slurry trench will be reused in the slurry backfill mix. An assumption that the precipitants from the iron will decrease the flow through the gates, resulting in a design life of 10 years for the iron gate, requires that the complete gate be regenerated after a period of 10 years. For a 20-year design life of the system, the cost of the gate regeneration must be considered in the comparison between the alternatives. Waterloo sealable steel sheet piling system will be installed in the gate configurations for the iron placement. The steel sheet piling gate will be installed to a total depth of 27 feet, or 7 feet into the underlying cay.

Regeneration could be accomplished by drilling into the iron gates and auger mixing the iron to dislodge any buildup of precipitates. This mixing will increase the porosity of the iron, thereby increasing the flow through the iron gate.

3. Alternative Nos. 3, 4, 5, 7, 8, and 9 each include the funnel-and-gate configurations, with the funnel walls consisting of vinyl sheet piling, steel sheet piling, or interceptor geomembrane walls. The lengths of the funnels will range from 380 feet for the two-gate configurations to 505 feet for the three-gate configurations. Sheet piling and the interceptor geomembrane walls in the funnel sections will be installed to a depth 21 feet (1 foot into the underlying clay). Steel sheet piling will be installed for the gate sections to a total depth of 27 feet (7 feet into the underlying clay). An assumption that the precipitants from the iron will decrease the flow through the gates, resulting in a design life of 10 years for the iron gate, requires that the complete gate be regenerated after a period of 10 years. For a 20-year design life of the system, the cost of the gate regeneration must be considered in the comparison between the alternatives. Waterloo sealable steel sheet piling system will be installed in the gate configurations for the iron placement.

4.5 CONSTRUCTION COST ESTIMATE SUMMARY

Table 4-3 details the construction cost estimate summary for the nine permeable reaction wall alternatives. Key activities including site preparation, construction of the permeable reaction wall, materials, disposal and indirect cost are included. A more detailed construction cost estimate sheet for each alternative is included in Appendix A.

SECTION 5 - SELECTION OF PREFERRED ALTERNATIVE

5.1 GENERAL

Based on this conceptual design alternative feasibility study, the recommended permeable reaction wall construction technique is the continuous permeable reaction wall. This alternative is recommended for the following reasons;

1. Lowest construction cost estimate.

2. Simplest construction methods.

3. Lowest construction time frame.

4. Smallest footprint, thereby has the least effect on the property owner.

5. Apparent 20-year design life for the system components, as compared to the other alternatives with gate design lives of 10 years.

6. Least amount of construction changes would be required if the contaminant plume was found to be longer in length than expected.

The construction of this alternative would involve a specialized machine to excavate a trench and backfill with iron in one pass. This simple construction requires less time on site for specialized equipment (one week as opposed to four to six weeks for the rest of the alternatives). At least three companies have large trenchers, allowing for competitive bidding of this alternative's construction. The remainder of the site work can be completed either by the trenching contractor or by a local earthwork contractor. The saturated excavated soil and decontamination pad will be the only producers of contaminated water. The trenching operation would produce the least amount of contaminated soil. Finally, this alternative does not require the dependence on sealing of sheet piling for the cutoff of the groundwater flow.

The continuous wall has the smallest footprint of all the alternatives. The continuous wall will be the same width of the contaminant plume, which has been evaluated at approximately 300 feet. The other alternatives would affect 140 to 255 feet of additional property. The footprint of the alternative may be important with respect to future use by the property owner.

This alternative is also preferred in that the expected design life of the iron is 20 years as opposed to 10 years for the remaining permeable reaction wall alternatives. With the funnel-and-gate alternative, all of the captured groundwater is passed through either two (50 feet total) or three (60 feet total) gates. The ratio of the cross-sectional area of the iron to the amount of groundwater flow through the area for the gate system is greater than the continuous wall system. Laboratory testing results indicate that precipitates could reduce the porosity of iron over time. Therefore, the gate system has a greater chance of becoming clogged. This greater clogging ability has resulted in the assumption of the gate regeneration every 10 years during the 20-year design life of the funnel-and-gate systems. The continuous reaction wall provides contact between the groundwater and the reactive iron along the entire length and depth of the wall. With more cross-sectional area of iron per unit flow of groundwater, the possibility of precipitates clogging the iron decreases. Thus, the assumption has been made that regeneration of the iron may not be required during the 20-year design life of the system.

Finally, if the contaminant plume is found to be larger than expected, extension of the continuous permeable reaction wall alternative would result in the least amount of changes as compared to the other permeable reaction wall alternatives. Extension of the continuous reaction wall could be accomplished in a minimal amount of time with the trencher and with additional iron being ordered. The other alternatives would require additional modeling up front to determine the impact on the system geometry. Then, during construction, it could require weeks for the extra sheet piling to be ordered, shipped, installed, and sealed.

Of the nine permeable reaction wall alternatives, the preferred alternatives after the continuous wall system would be funnel systems with either the steel sheet piles, vinyl sheet piles, or geomembrane funnel walls. The least preferred alternative for this site would be the slurry wall funnel-and-gate alternative.

This report has been prepared as a conceptual design and feasibility study. The final design will depend on further contaminant plume information that is being collected concurrently with this study. In the event that any changes in the nature, design, or location of the system are planned, the conclusions, cost estimates, and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of this report modified or verified in writing. This study is not intended to be sufficient to estimate quantities or plan procedures for an accurate construction bid. The construction cost estimates are made on the basis of our experience and limited contractor communications; other factors beyond our control (material costs, competitive bidding and marketing conditions) could affect the contractors' bids for project construction costs.

SECTION 6 - REFERENCES

Starr, Robert C., "Field Hydraulic Test of a Rectangular Enclosure Comprised of Bethlehem Steel PZ22 Sheet Piling," Waterloo Centre for Groundwater Research, Waterloo, Ontario, Canada, 1992.

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Remedial Investigation for the General Instrument Corporation in Sherburne, New York, Stearns & Wheler, January 1993.

Feasibility Study for the General Instrument Corporation in Sherburne, New York, Stearns & Wheler, November 1993.

TABLES

TABLE 2-1 GROUNDWATER ANALYTICAL RESULTS
GENERAL INSTRUMENT CORPORATION
SHERBURNE, NY
NOVEMBER 1996

	Standard	**Sample Location**											
Analyte (ug/l)	**(ug/l)**	**N-1**	**S-1**	**S-2**	**S-3**	**S-4**	**S-5**	**S-6**	**S-7**	**MW-20**	**MW-21**	**P-3**	**P-8**
Acetone	50G	<10	<200	<100	<40	<10	<10	<10	<10	<10	<40	<20	<200
Benzene	0.7	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
Bromodichloromethane	50G	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
Bromoform	50G	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
Bromomethane	5	<10	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
2- butanone (MEK)	50G	<5	<200	<100	<40	<10	<10	<10	<10	<10	<40	<20	<200
Carbon disulfide	50*	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
Carbon tetrachloride	5	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
Chlorobenzene	5	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
Chloroethane	5	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
Chloroform	**7**	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
Chloromethane	50	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
Dibrmochloromethane	50G	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
1,1-dichloroethane	5	**7.5**	<100	<50	<20	<5	<5	<5	<5	9.7	<20	<10	<100
1,2-dichloroethane	5	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
1,1-dichloroethene	5	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
1,2-dichloroethene (total)	5	**140**	**3600**	**250**	**48**	**25**	**17**	**17**	**9.2**	**20**	**250**	**250**	**2500**
1,2-dichloropropane	5	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
cis-1,3-dichloropropene	5	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
trans-1,3-dichloropropene	5	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
Ethylbenzene	5	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
2-hexanone	50G	<10	<200	<100	<40	<10	<10	<10	<10	<10	<40	<20	<200
Methylene chloride	5	<10	<200	<100	<40	<10	<10	<10	<10	<10	<40	<20	<200
4-methyl-2-pentanone (MIBK)	50*	<10	<200	<100	<40	<10	<10	<10	<10	<10	<40	<20	<200
Styrene	5	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
1,1,2,2-tetrachlorethane	5	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
Tetrachloroethene	5	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
Toluene	5	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
1,1,1-trichloroethane	5	**7**	<100	<50	<20	<5	<5	<5	<5	**9.9**	<20	<10	<100
1,1,2-trichlorethane	5	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
Trichloroethene	5	**16**	**140**	**500**	<20	**44**	**8.5**	**8**	<5	**28**	**480**	**140**	**2600**
Vinyl chloride	2	<5	**870**	**62**	<20	<5	<5	<5	<5	<5	<20	**36**	<100
o-xylene	5	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
m-xylene	5	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100
p-xylene	5	<5	<100	<50	<20	<5	<5	<5	<5	<5	<20	<10	<100

All values in this table are based upon NYSDEC standards as of October 1993
G: NYSDEC guidance value
* Treated as an unspecified organic contaminant
Shaded areas indicate exceedances of standards

TABLE 2-2 GROUNDWATER ANALYTICAL RESULTS
GENERAL INSTRUMENT CORPORATION
SHERBURNE, NY
JANUARY 1997

	Standard	Boring ID								
Analyte	**(ug/l)**	**N-2**	**N-3**	**N-4**	**N-5**	**N-6**	**N-7**	**S-9**	**S-10**	**S-11**
Acetone	**50G**	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzene	**0.7**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromodichloromethane	**50G**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromoform	**50G**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromomethane	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
2-Butanone (MEK)	**50G**	<10	<10	<10	<10	<10	<10	<10	<10	<10
Carbon disulfide	**50***	<5	<5	<5	<5	<5	<5	<5	<5	<5
Carbon tetrachloride	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chlorobenzene	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chloroethane	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chloroform	**7**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chloromethane	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dichlorobromomethane	**50G**	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1-Dichloroethane	**5**	**6.6**	<5	<5	<5	<5	<5	<5	<5	<5
1,2-Dichloroethane	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1-Dichloroethene	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,2-Dichloroethane (total)	**5**	<5	<5	<5	<5	<5	<5	**130**	**92**	**51**
1,2-Dichloropropane	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
cis-1,3-Dichloropropene	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
trans-1,3-Dichloropropene	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Ethylbenzene	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
2-Hexanone	**50G**	<10	<10	<10	<10	<10	<10	<10	<10	<10
Methylene chloride	**5**	<10	<10	<10	<10	<10	<10	<10	<10	<10
4-Methyl-2-pentanone (MIBK)	**50***	<10	<10	<10	<10	<10	<10	<10	<10	<10
Styrene	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1,2,2-Tetrachloroethane	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Tetrachloroethene	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Toluene	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1,1-Trichloroethane	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1,2-Trichloroethane	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Trichloroethene	**5**	**14**	<5	<5	<5	<5	<5	**48**	**39**	**36**
Vinyl chloride	**2**	<5	<5	<5	<5	<5	<5	<5	<5	<5
o-Xylene	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
m-Xylene	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5
p-Xylene	**5**	<5	<5	<5	<5	<5	<5	<5	<5	<5

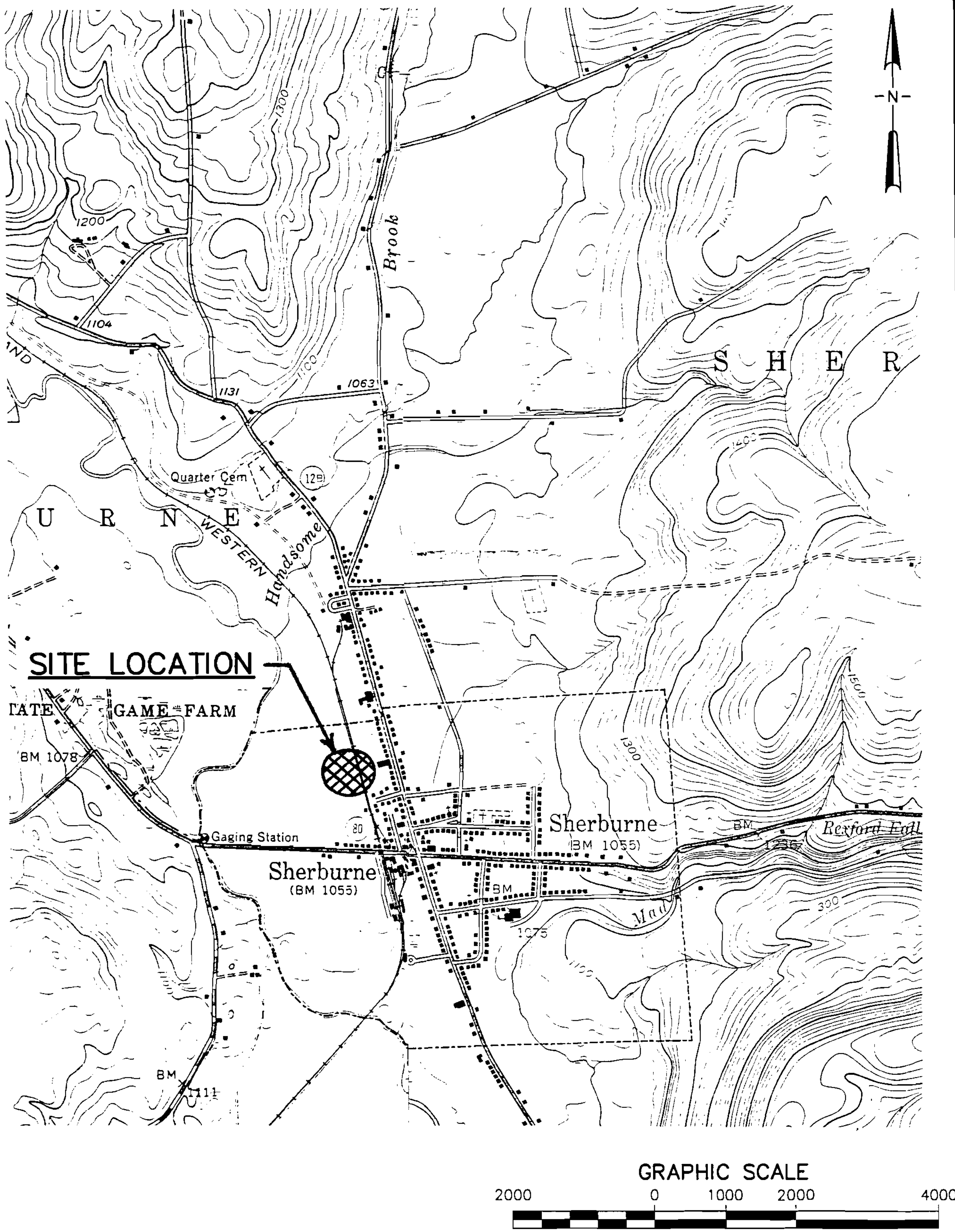
G: NYSDEC Guidance Value
All values in this table are based upon NYSDEC standards as of October 1993
* Treated as an unspecified organic contaminant
Shaded areas indicate exceedances of standards

TABLE 4-1 PERMEABLE REACTION WALL CONSTRUCTION COST ESTIMATE SUMMARY FOR 300 FOOT PLUME
GENERAL INSTRUMENT CORPORATION
SHERBURNE, NY

		2-Gate				3-Gate			
Activity/Equipment/Material	Continuous Wall	Slurry Wall	Steel Sheet Piling	Vinyl Sheet Piling	Geomembrane	Slurry Wall	Steel Sheet Piling	Vinyl Sheet Piling	Geomembrane
Site Preparation	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
Construction of Permeable Wall	$260,000	$300,000	$410,000	$350,000	$350,000	$280,000	$380,000	$320,000	$310,000
Materials	$240,000	$300,000	$400,000	$360,000	$280,000	$310,000	$380,000	$350,000	$310,000
Disposal									
Hazardous Landfill NY	$110,000	$590,000	$170,000	$170,000	$380,000	$540,000	$170,000	$170,000	$350,000
Incinerator, AR	$590,000	$3,100,000	$900,000	$900,000	$2,000,000	$2,800,000	$900,000	$900,000	$1,800,000
Disposal of Liquids	$10,000	$80,000	$70,000	$70,000	$70,000	$100,000	$100,000	$100,000	$95,000
Indirect Costs									
Contingency	$130,000	$260,000	$210,000	$200,000	$220,000	$260,000	$218,000	$178,000	$220,000
Engineering/Administrative	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000
Construction Management	$110,000	$140,000	$160,000	$150,000	$120,000	$140,000	$160,000	$150,000	$120,000
Total for Disposal at Landfill, NY	$1,000,000	$1,800,000	$1,500,000	$1,400,000	$1,500,000	$1,800,000	$1,400,000	$1,300,000	$1,500,000
Total for Disposal at Incinerator,A	$1,500,000	$4,100,000	$2,200,000	$2,100,000	$3,200,000	$4,000,000	$2,300,000	$2,100,000	$3,000,000
Operations and Maintenance Costs	$0	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000
Quarterly Monitoring for 20 years	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000

Notes
1. Total width of plume is assumed to be 300 feet for comparison purposes (actual width of the plume may be greater)
2. Depth to underlying clay is 20 feet
3. Pilot scale system will not be reused in the full scale system.
4. Design life of system is 20 years.
5. Design life of iron for continuous wall system is 20 years.
6. Design life of iron for funnel and gate systems are 10 years.
7. Quarterly monitoring is estimated to be $20,000 per year for 20 years.

FIGURES



REFERENCE USGS QUADRANGLE MAPS SHERBURNE, N.Y. N4237.5–W7522.5/7.5 EARLVILLE, N.Y N4237.5–W7530/7.5	Stearns & Wheler, LLC ENVIRONMENTAL ENGINEERS & SCIENTISTS CAZENOVIA, NEW YORK DATE:2/97 JOB No.:41587ZA	GENERAL INSTRUMENT CORPORATION SHERBURNE, NEW YORK CONCEPTUAL DESIGN REPORT FIGURE 1–1 SITE LOCATION PLAN

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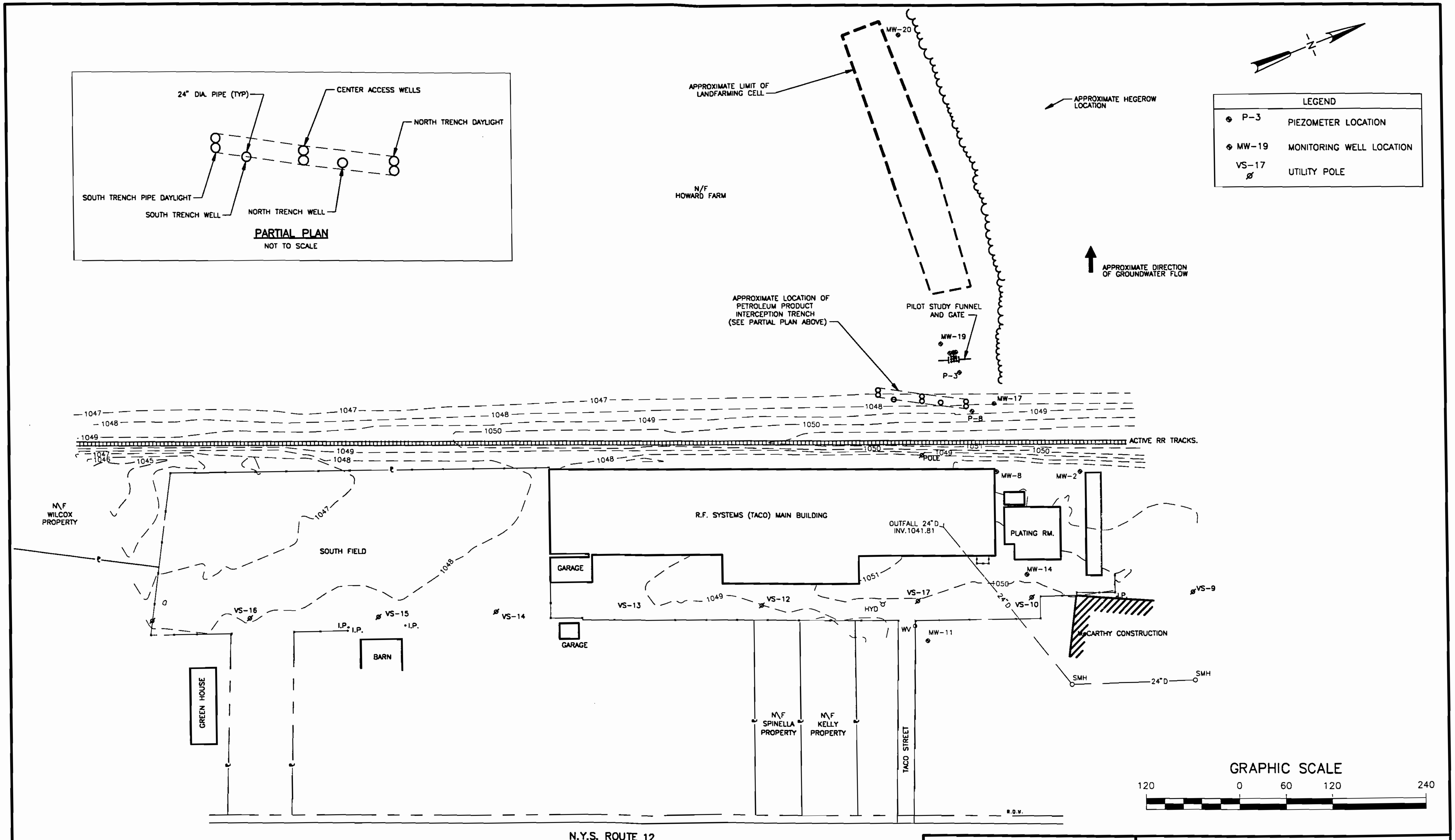

Stearns & Wheler, LLC
ENVIRONMENTAL ENGINEERS & SCIENTISTS
CAZENOVIA, NEW YORK

DATE:2/97 JOB No.:41587ZA

GENERAL INSTRUMENT CORPORATION
SHERBURNE, NEW YORK
CONCEPTUAL DESIGN REPORT

FIGURE 1-2
SITE PLAN

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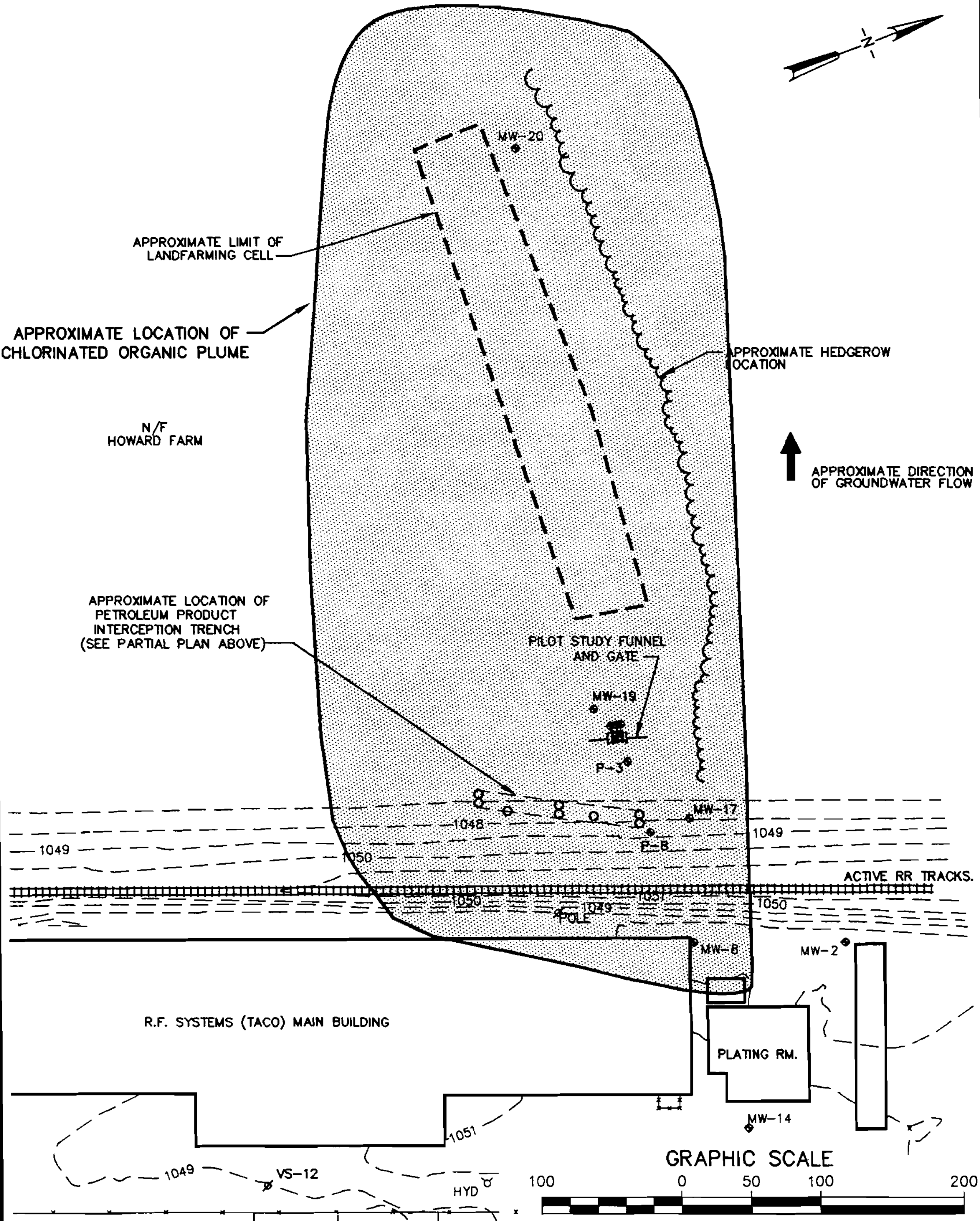

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ENVIRONMENTAL ENGINEERS & SCIENTISTS
CAZENOVIA, NEW YORK

DATE:2/97 JOB No.:41587ZA

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CONCEPTUAL DESIGN REPORT

FIGURE 1-3
JANUARY 1995 CONTAINMENT PLUME

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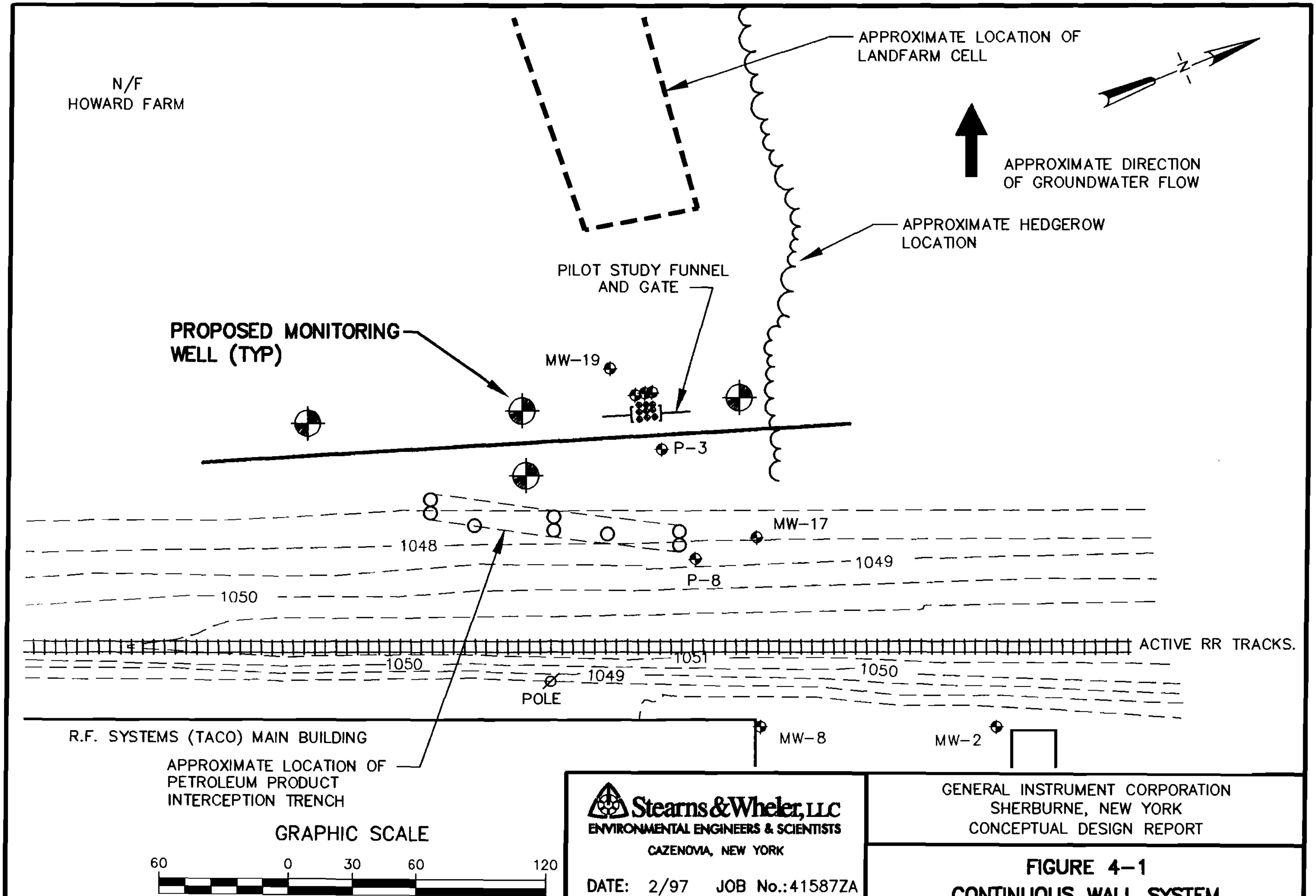

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FIGURE 4-1
CONTINUOUS WALL SYSTEM

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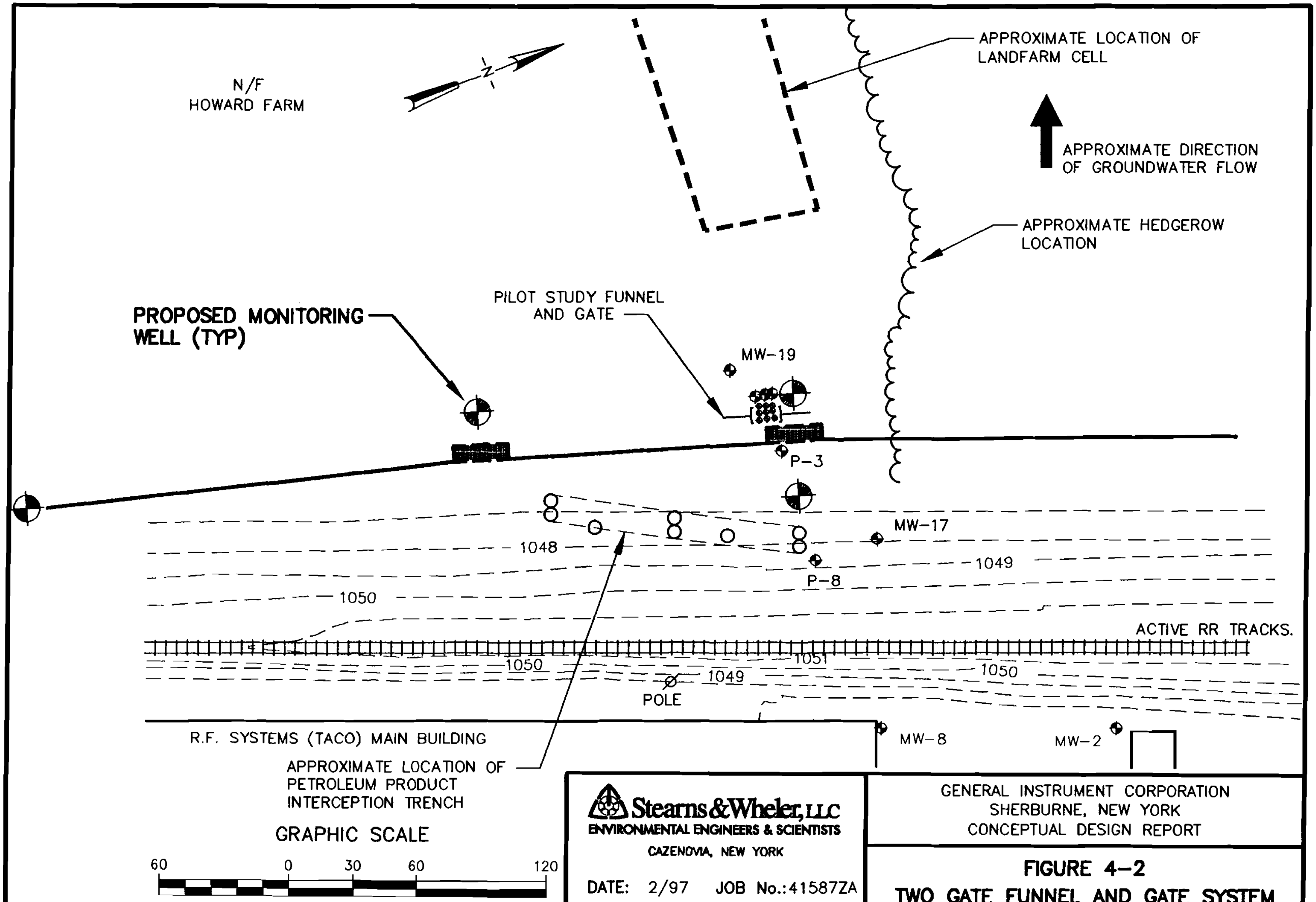

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CONCEPTUAL DESIGN REPORT

FIGURE 4-2
TWO GATE FUNNEL AND GATE SYSTEM

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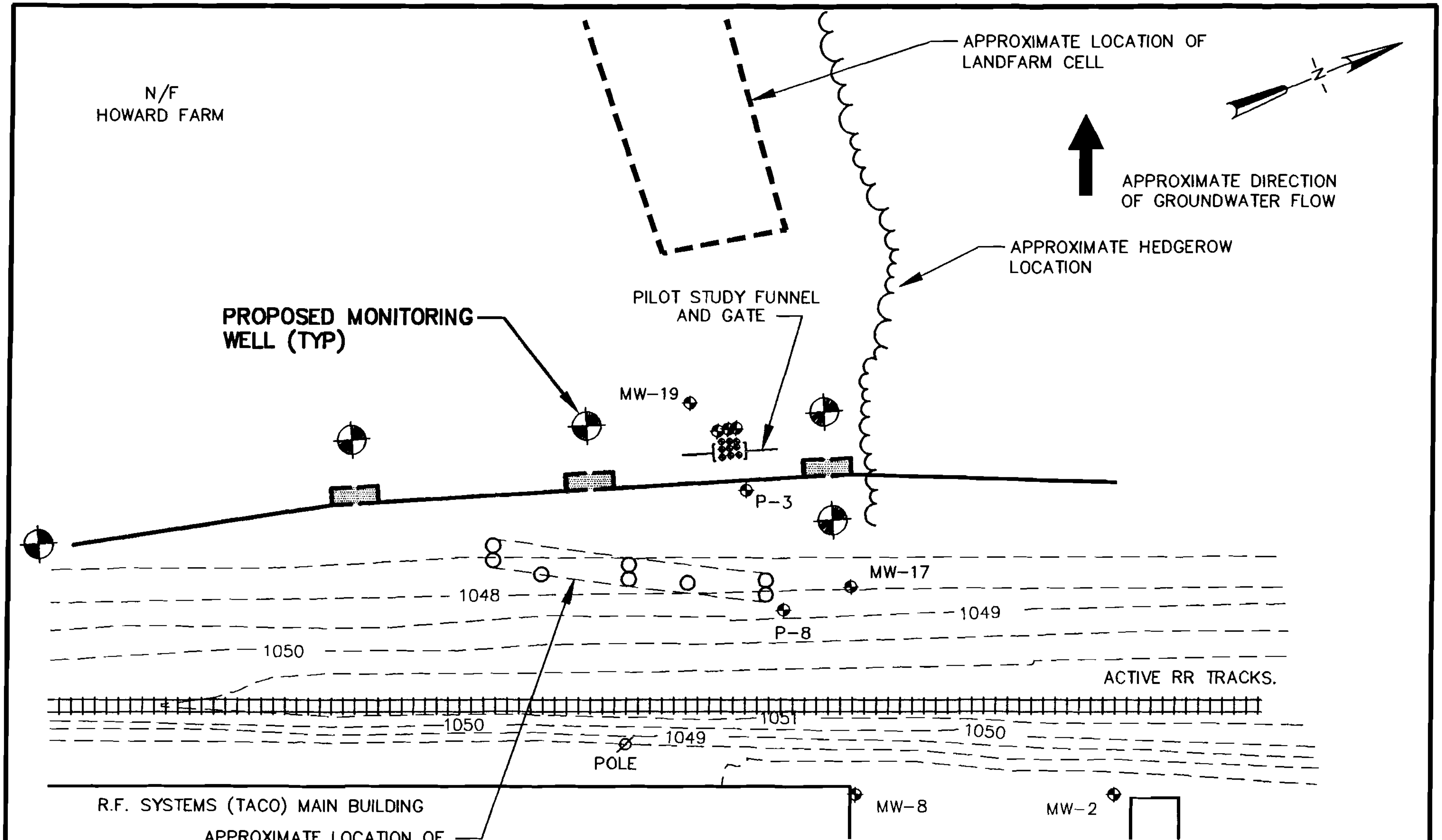

Stearns&Wheler, LLC
ENVIRONMENTAL ENGINEERS & SCIENTISTS
CAZENOVIA, NEW YORK

DATE: 2/97 JOB No.: 41587ZA

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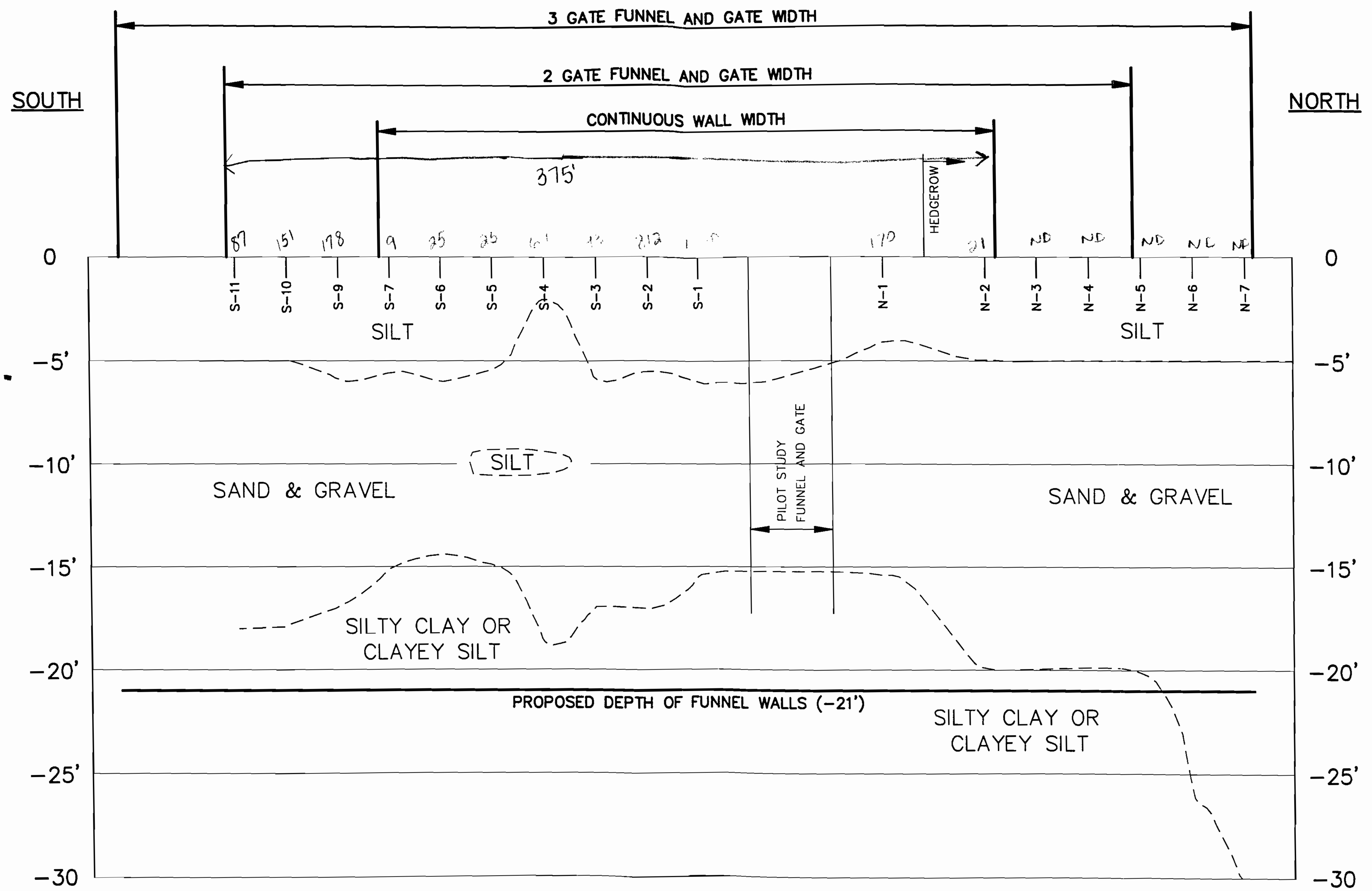
SHERBURNE, NEW YORK
CONCEPTUAL DESIGN REPORT

FIGURE 4-3
THREE GATE FUNNEL AND GATE SYSTEM



NOTES:

1. SOIL STRATUM LINES ARE BASED UPON A STRAIGHT LINE INTERPRETATION BETWEEN BORINGS AND MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS.
2. SOIL CLASSIFICATIONS ARE GENERALIZED DESCRIPTIONS OF THE SOIL DEPOSITS.

SCALE: 1" = 50' HORIZONTAL
1" = 5' VERTICAL

7.5" → 375' [illegible]

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FIGURE 4-4
GENERALIZED CROSS-SECTION

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APPENDIX A

PERMEABLE REACTION WALL CONSTRUCTION COST ESTIMATE SUMMARIES FOR 300-FOOT PLUME

PERMEABLE REACTION WALL COST ESTIMATE SUMMARY FOR A 300 FOOT PLUME
ALTERNATIVE #1 - CONTINUOUS PERMEABLE REACTION WALL
GENERAL INSTRUMENT CORPORATION
SHERBURNE, NY

Activity/Equipment/Material	No. of Units	Unit	Unit Cost	Total Cost	375'
Site Preparation					
Site preparation, access improvements	1	Lump Sum	$50,000	$50,000	
Construction of Permeable Wall					
Mobilization/Demobilization	1	Lump Sum	$70,000	$70,000	
Install Trench 300→375 ft	300 375	Linear Foot	$500	$150,000	187,500
Install Reactive Iron 1.25×	300	Linear Foot	$30	$9,000	11,250
Monitoring Wells	4	Each	$1,500	$6,000	
Piezometers	1	Lump Sum	$10,000	$10,000	
Decommisioning of Pilot Scale system	1	Lump Sum	$12,000	$12,000	
Materials					
Reactive Iron	600 750	Tons	$400	$240,000	300,000
		Subtotal		$550,000	
Disposal					
Disposal of Soils					650,0[illegible]
Hazardous Landfill NY	420 525	Tons	$270	$110,000	137,500
Incinerator, AR	420	Tons	$1,400	$590,000	73[illegible]
Disposal of Liquids	1	Lump Sum	$10,000	$10,000	
Subtotal	Disposal at Landfill, NY			$670,000	800,000
	Disposal at Incinerator,AR			$1,200,000	1,400,000
Indirect Costs					
Contingency				$130,000	
Engineering/Administrative				$75,000	
Construction Management				$110,000	
Total Cost Landfill Option				$1,000,000	1,120,000
Total Cost Incinerator Option				$1,500,000	1,720,000

Notes
1. Total Length of wall assumed to be 300 feet for puposes of comparison.
2. Actual width of the plume may be greater, which would increase the wall length
3. Thickness of reaction wall - 1.0 foot; if 2.0 foot thickness is needed for a portion of the wall, the costs of the system will be higher.
4. Depth to underlying clay is 20 feet
5. Permeable wall a total of 21 feet deep, 1 foot into clay
6. Pilot scale system will not be reused in the full scale system.
7. Design life of this option is 20 years.
8. Disposal of Liquid minimum cost for amounts less than 3,000 gallons

PERMEABLE REACTION WALL COST ESTIMATE SUMMARY FOR A 300 FOOT PLUME
ALTERNATIVE #2 - TWO GATE PERMEABLE REACTION WALL(SLURRY WALL)
GENERAL INSTRUMENT CORPORATION
SHERBURNE, NY

Activity/Equipment/Material	No. of Units	Unit	Unit Cost	Total Cost
Site Preparation				
Site preparation, access improvements	1	Lump Sum	$50,000	$50,000
Construction of Permeable Wall				
Mobilization/Demobilization	1	Lump Sum	$90,000	$90,000
Install Slurry Wall	12,200	Square Feet	$9	$110,000
Sheet Piling Installation	3,700	Square Feet	$15	$56,000
QA/QC Program	1	Lump Sum	$5,000	$5,000
Grouting	1	Lump Sum	$10,000	$10,000
Monitoring Wells	4	Each	$1,500	$6,000
Piezometers	1	Lump Sum	$10,000	$10,000
Decommisioning of Pilot Scale system	1	Lump Sum	$12,000	$12,000
Materials				
Reactive Iron	650	Tons	$400	$260,000
Waterloo Sheet Piling	3,700	Square Feet	$10	$40,000
		Subtotal		$650,000
Disposal				
Disposal of Soils				
Hazardous Landfill NY	2,200	Tons	$270	$590,000
Incinerator, AR	2,200	Tons	$1,400	$3,100,000
Disposal of Liquids	80,000	Gallons	$1	$80,000
Subtotal	Disposal at Landfill, NY			$1,300,000
	Disposal at Incinerator,AR			$3,800,000
Indirect Costs				
Contingency				$260,000
Engineering/Administrative				$75,000
Construction Management				$140,000
Total Cost Landfill Option				$1,800,000
Total Cost Incinerator Option				$4,100,000

Notes
1. Total length of wall 555 feet to capture the assumed 300 feet plume
2. Actual width of the plume may be greater, which would increase the wall length
3. Thickness of iron in gates - 6.5 feet
4. Depth to underlying clay is 20 feet
5. Slurry wall to be seated 4 feet into clay, total average depth of wall to be 24 feet.
6. Pilot scale system will not be reused in the full scale system.
7. One third of excavated soil will be reused in the slurry wall, 2/3 to be disposed of.
8. Design life of this option is 10 years.
9. Regeneration of iron after 10 years estimated at $200,000.

PERMEABLE REACTION WALL COST ESTIMATE SUMMARY FOR A 300 FOOT PLUME
ALTERNATIVE #3 - TWO GATE WALL(WATERLOO STEEL SHEET PILING)
GENERAL INSTRUMENT CORPORATION
SHERBURNE, NY

Activity/Equipment/Material	No. of Units	Unit	Unit Cost	Total Cost
Site Preparation				
Site preparation, access improvements	1	Lump Sum	$50,000	$50,000
Construction of Permeable Wall				
Mobilization/Demobilization	1	Lump Sum	$110,000	$110,000
Sheet Piling Installation	14,000	Square Feet	$15	$210,000
QA/QC Program	1	Lump Sum	$14,000	$14,000
Grouting	1	Lump Sum	$49,000	$49,000
Monitoring Wells	4	Each	$1,500	$6,000
Piezometers	1	Lump Sum	$10,000	$10,000
Decommisioning of Pilot Scale system	1	Lump Sum	$12,000	$12,000
Materials				
Reactive Iron	650	Ton	$400	$260,000
Waterloo Sheet Piling	14,000	Square Feet	$10	$140,000
		Subtotal		$860,000
Disposal				
Disposal of Soils				
Hazardous Landfill NY	640	Tons	$270	$170,000
Incinerator, AR	640	Tons	$1,400	$900,000
Disposal of Liquids	72,000	Gallons	$1	$70,000
Subtotal	Disposal at Landfill, NY			$1,030,000
	Disposal at Incinerator,AR			$1,800,000
Indirect Costs				
Contingency				$210,000
Engineering/Administrative				$75,000
Construction Management				$160,000
Total Cost Landfill Option				$1,500,000
Total Cost Incinerator Option				$2,200,000

Notes
1. Total length of wall 555 feet to capture the assumed 300 feet plume.
2. Actual width of the plume may be greater, which would increase the wall length
3. Thickness of iron in gates - 6.5 foot
4. Depth to underlying clay is 20 feet
5. Sheet Piling to be seated 1 feet into clay for funnel, total average depth of wall 21 feet.
6. Sheet piling to be seated 7 feet into clay for gates, total depth 27 feet.
7. Pilot scale system will not be reused in the full scale system.
8. Design life of iron gate is 10 years.
9. Regeneration of iron after 10 years estimated at $200,000.

PERMEABLE REACTION WALL COST ESTIMATE SUMMARY FOR A 300 FOOT PLUME
ALTERNATIVE #4 - TWO GATE PERMEABLE REACTION WALL(VINYL SHEET PILING)
GENERAL INSTRUMENT CORPORATION
SHERBURNE, NY

Activity/Equipment/Material	No. of Units	Unit	Unit Cost	Total Cost
Site Preparation				
Site preparation, access improvements	1	Lump Sum	$50,000	$50,000
Construction of Permeable Wall				
Mobilization/Demobilization	1	Lump Sum	$100,000	$100,000
Sheet Piling Install	14,000	Square Feet	$15	$210,000
QA/QC	1	Lump Sum	$5,000	$5,000
Grouting	1	Lump Sum	$10,000	$10,000
Monitoring Wells	4	Each	$1,500	$6,000
Piezometers	1	Lump Sum	$10,000	$10,000
Decommisioning of Pilot Scale system	1	Lump Sum	$12,000	$12,000
Materials				
Reactive Iron	650	Tons	$400	$260,000
Vinyl Sheet Piling	10,300	Square Feet	$4	$41,000
Adeka Sealant	1	Lump Sum	$18,000	$18,000
Steel Sheet Piling	3,700	Square Feet	$10	$37,000
		Subtotal		$760,000
Disposal				
Disposal of Soils				
Hazardous Landfill NY	640	Tons	$270	$170,000
Incinerator, AR	640	Tons	$1,400	$900,000
Disposal of Liquids	72,000	Gallons	$1	$70,000
Subtotal	Disposal at Landfill, NY			$1,000,000
	Disposal at Incinerator,AR			$1,700,000
Indirect Costs				
Contingency				$200,000
Engineering/Administrative				$75,000
Construction Management				$150,000
Total Cost Landfill Option				$1,400,000
Total Cost Incinerator Option				$2,100,000

Notes
1. Total Length of wall 555 feet to capture the assumed 300 feet plume.
2. Actual width of the plume may be greater, which would increase the wall length
3. Thickness of iron in gates - 6.5 foot
4. Depth to underlying clay is 20 feet
5. Sheet Piling to be seated 1 feet into clay for funnel, total average depth of wall 21 feet.
6. Sheet piling to be seated 7 feet into clay in gates, total depth 27 feet.
7. Pilot scale system will not be reused in the full scale system.
8. Design life of iron gate is 10 years.
9. Regeneration of iron after 10 years estimated at $200,000.

PERMEABLE REACTION WALL COST ESTIMATE SUMMARY FOR A 300 FOOT PLUME
ALTERNATIVE #5 - TWO GATE (INTERCEPTOR GEOMEMBRANE WALL)
GENERAL INSTRUMENT CORPORATION
SHERBURNE, NY

Activity/Equipment/Material	No. of Units	Unit	Unit Cost	Total Cost
Site Preparation				
Site preparation, access improvements	1	Lump Sum	$50,000	$50,000
Construction of Permeable Wall				
Mobilization/Demobilization	1	Lump Sum	$90,000	$90,000
Installation of Interceptor Wall	510	Linear Foot	$310	$160,000
Installation of Sheet Piling	3,700	Square Feet	$15	$56,000
QA/QC	1	Lump Sum	$5,000	$5,000
Grouting	1	Lump Sum	$10,000	$10,000
Monitoring Wells	4	Each	$1,500	$6,000
Piezometers	1	Lump Sum	$10,000	$10,000
Decommisioning of Pilot Scale system	1	Lump Sum	$12,000	$12,000
Materials				
Reactive Iron	600	Ton	$400	$240,000
Waterloo Sheet Piling	3,700	Square Feet	$10	$37,000
		Subtotal		$680,000
Disposal				
Disposal of Soils				
Hazardous Landfill NY	1,400	Tons	$270	$380,000
Incinerator, AR	1,400	Tons	$1,400	$2,000,000
Disposal of Liquids	70,000	Gallons	$1	$70,000
Subtotal	Disposal at Landfill, NY			$1,100,000
	Disposal at Incinerator,AR			$2,800,000
Indirect Costs				
Contingency				$220,000
Engineering/Administrative				$75,000
Construction Management				$120,000
Total Cost Landfill Option				$1,500,000
Total Cost Incinerator Option				$3,200,000

Notes
1. Total Length of wall 555 feet to capture the assumed 300 feet plume.
2. Actual width of the plume may be greater, which would increase the wall length
3. Thickness of iron in gates - 6.5 foot
4. Depth to underlying clay is 20 feet
5. Interceptor geomembraneto be seated 1 feet into clay for funnel, total average depth of wall 21 feet.
6. Sheet piling to be seated 7 feet into clay in gates total depth, 27 feet.
7. Pilot scale system will not be reused in the full scale system.
8. Design life of iron gate is 10 years.
9. Regeneration of iron after 10 years estimated at $200,000.

PERMEABLE REACTION WALL COST ESTIMATE SUMMARY FOR A 300 FOOT PLUME
ALTERNATIVE #6 - THREE GATE PERMEABLE REACTION WALL(SLURRY WALL)
GENERAL INSTRUMENT CORPORATION
SHERBURNE, NY

Activity/Equipment/Material	No. of Units	Unit	Unit Cost	Total Cost
Site Preparation				
Site preparation, access improvements	1	Lump Sum	$50,000	$50,000
Construction of Permeable Wall				
Mobilization/Demobilization	1	Lump Sum	$90,000	$90,000
Installation of Slurry Wall Funnels	9,120	Square Feet	$9	$82,000
Installation of Sheet Piling	4,380	Square Feet	$15	$66,000
QA/QC	1	Lump Sum	$5,000	$5,000
Grouting	1	Lump Sum	$10,000	$10,000
Monitoring Wells	5	Each	$1,500	$8,000
Piezometers	1	Lump Sum	$10,000	$10,000
Decommisioning of Pilot Scale system	1	Lump Sum	$12,000	$12,000
Materials				
Reactive Iron	660	Ton	$400	$264,000
Waterloo Sheet Piling	4,500	Square Feet	$10	$45,000
		Subtotal		$640,000
Disposal				
Disposal of Soils				
Hazardous Landfill NY	2,000	Tons	$270	$540,000
Incinerator, AR	2,000	Tons	$1,400	$2,800,000
Disposal of Liquids	100,000	Gallons	$1	$100,000
Subtotal	Disposal at Landfill, NY			$1,300,000
	Disposal at Incinerator,AR			$3,500,000
Indirect Costs				
Contingency				$260,000
Engineering/Administrative				$75,000
Construction Management				$140,000
Total Cost Landfill Option				$1,800,000
Total Cost Incinerator Option				$4,000,000

Notes
1. Total Length of wall 380 feet to capture the assumed 300 feet plume.
2. Actual width of the plume may be greater, which would increase the wall length
3. Thickness of iron in gates - 5.5 foot
4. Depth to underlying clay is 20 feet
5. Slurry wall to be seated 4 feet into clay for funnel, total average depth of wall to be 24 feet.
6. Pilot scale system will not be reused in the full scale system.
7. One third of excavated soil will be reused in the slurry wall, 2/3 to be disposed of.
8. Design life of iron gate is 10 years.
9. Regeneration of iron after 10 years estimated at $200,000.

PERMEABLE REACTION WALL COST ESTIMATE SUMMARY FOR A 300 FOOT PLUME
ALTERNATIVE #7 - THREE GATE WALL(WATERLOO STEEL SHEET PILING)
GENERAL INSTRUMENT CORPORATION
SHERBURNE, NY

Activity/Equipment/Material	No. of Units	Unit	Unit Cost	Total Cost
Site Preparation				
Site preparation, access improvements	1	Lump Sum	$50,000	$50,000
Construction of Permeable Wall				
Mobilization/Demobilization	1	Lump Sum	$110,000	$110,000
Sheet Piling Installation	12,000	Square Feet	$15	$180,000
QA/QC Program	1	Lump Sum	$14,000	$14,000
Grouting	1	Lump Sum	$49,000	$49,000
Monitoring Wells	5	Each	$1,500	$8,000
Piezometers	1	Lump Sum	$10,000	$10,000
Decommisioning of Pilot Scale system	1	Lump Sum	$12,000	$12,000
Materials				
Reactive Iron	660	Tons	$400	$264,000
Waterloo Sheet Piling	12,000	Square Feet	$10	$120,000
		Subtotal		$820,000
Disposal				
Disposal of Soils				
Hazardous Landfill NY	640	Tons	$270	$170,000
Incinerator, AR	640	Tons	$1,400	$900,000
Disposal of Liquids	100,000	Gallons	$1	$100,000
Subtotal	Disposal at Landfill, NY			$1,090,000
	Disposal at Incinerator,AR			$1,800,000
Indirect Costs				
Contingency				$218,000
Engineering/Administrative				$75,000
Construction Management				$160,000
Total Cost Landfill Option				$1,400,000
Total Cost Incinerator Option				$2,300,000

Notes
1. Total Length of wall 380 feet to capture the assumed 300 feet plume.
2. Actual width of the plume may be greater, which would increase the wall length
3. Thickness of iron in gates - 5.5 foot
4. Depth to underlying clay is 20 feet
5. Sheet Piling to be seated 1 feet into clay for funnel, total average depth of wall 21 feet.
6. Sheet piling to be seated 7 feet into clay in gates, total depth 27 feet.
7. Pilot scale system will not be reused in the full scale system.
8. Design life of iron gate is 10 years.
9. Regeneration of iron after 10 years estimated at $200,000.

PERMEABLE REACTION WALL COST ESTIMATE SUMMARY FOR A 300 FOOT PLUME
ALTERNATIVE #8 - THREE GATE PERMEABLE REACTION WALL(VINYL SHEET PILING)
GENERAL INSTRUMENT CORPORATION
SHERBURNE, NY

Activity/Equipment/Material	No. of Units	Unit	Unit Cost	Total Cost
Site Preparation				
Site preparation, access improvements	1	Lump Sum	$50,000	$50,000
Construction of Permeable Wall				
Mobilization/Demobilization	1	Lump Sum	$100,000	$100,000
Sheet Piling Install	11,500	Square Feet	$15	$170,000
QA/QC	1	Lump Sum	$5,000	$5,000
Grouting	1	Lump Sum	$10,000	$10,000
Monitoring Wells	5	Each	$1,500	$8,000
Piezometers	1	Lump Sum	$10,000	$10,000
Decommisioning of Pilot Scale system	1	Lump Sum	$12,000	$12,000
Materials				
Reactive Iron	660	Tons	$400	$264,000
Vinyl Sheet Piling	7,000	Square Feet	$4	$28,000
Adeka Sealant	1	Lump Sum	$14,000	$14,000
Waterloo Sheet Piling	4,500	Square Feet	$10	$45,000
		Subtotal		$720,000
Disposal				
Disposal of Soils				
Hazardous Landfill NY	640	Tons	$270	$170,000
Incinerator, AR	640	Tons	$1,400	$900,000
Disposal of Liquids	100,000	Gallons	$1	$100,000
Subtotal	Disposal at Landfill, NY			$890,000
	Disposal at Incinerator,AR			$1,700,000
Indirect Costs				
Contingency				$178,000
Engineering/Administrative				$75,000
Construction Management				$150,000
Total Cost Landfill Option				$1,300,000
Total Cost Incinerator Option				$2,100,000

Notes
1. Total Length of wall 380 feet to capture the assumed 300 feet plume.
2. Actual width of the plume may be greater, which would increase the wall length
3. Thickness of iron in gates - 5.5 feet
4. Depth to underlying clay is 20 feet
5. Sheet Piling to be seated 1 feet into clay for funnel, total average depth of wall 21 feet.
6. Sheet piling to be seated 7 feet into clay in gates, total depth 27 feet.
7. Pilot scale system will not be reused in the full scale system.
8. Design life of iron gate is 10 years.
9. Regeneration of iron after 10 years estimated at $200,000.

PERMEABLE REACTION WALL COST ESTIMATE SUMMARY FOR A 300 FOOT PLUME
ALTERNATIVE #9 - THREE GATE (INTERCEPTOR GEOMEMBRANE WALL)
GENERAL INSTRUMENT CORPORATION
SHERBURNE, NY

Activity/Equipment/Material	No. of Units	Unit	Unit Cost	Total Cost
Site Preparation				
Site preparation, access improvements	1	Lump Sum	$50,000	$50,000
Construction of Permeable Wall				
Mobilization/Demobilization	1	Lump Sum	$90,000	$80,000
Installation of Interceptor Wall	380	Linear Foot	$310	$120,000
Installation of Sheet Piling	4,500	Square Feet	$15	$68,000
QA/QC	1	Lump Sum	$5,000	$5,000
Grouting	1	Lump Sum	$10,000	$10,000
Monitoring Wells	5	Each	$1,500	$8,000
Piezometers	1	Lump Sum	$10,000	$10,000
Decommisioning of Pilot Scale system	1	Lump Sum	$12,000	$12,000
Materials				
Reactive Iron	660	Ton	$400	$264,000
Waterloo Sheet Piling	4,500	Square Feet	$10	$45,000
		Subtotal		$670,000
Disposal				
Disposal of Soils				
Hazardous Landfill NY	1,300	Tons	$270	$350,000
Incinerator, AR	1,300	Tons	$1,400	$1,800,000
Disposal of Liquids	95,000	Gallons	$1	$95,000
Subtotal	Disposal at Landfill, NY			$1,100,000
	Disposal at Incinerator,AR			$2,600,000
Indirect Costs				
Contingency				$220,000
Engineering/Administrative				$75,000
Construction Management				$120,000
Total Cost Landfill Option				$1,500,000
Total Cost Incinerator Option				$3,000,000

Notes
1. Total Length of wall 380 feet to capture the assumed 300 feet plume
2. Actual width of the plume may be greater, which would increase the wall length
3. Thickness of iron in gates - 5.5 foot
4. Depth to underlying clay is 20 feet
5. Interceptor geomembrane to be seated 1 foot into clay for funnel, total average depth of wall 21 feet.
6. Sheet piling to be seated 7 feet into clay in gates, total depth 27 feet.
7. Pilot scale system will not be reused in the full scale system.
8. Design life of iron gate is 10 years.
9. Regeneration of iron after 10 years estimated at $200,000.