Final
Remedial Design
2-PHASE® Extraction System
Emerson Power Transmission
Ithaca, New York

Prepared by:

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May 1995

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Remedial Design
2-PHASE Extraction System
Emerson Power Transmission
Ithaca, New York

Prepared for:

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1.0 INTRODUCTION

This Remedial Design delineates the various elements of the planned remediation for groundwater that has been impacted by the releases of chemicals at the Emerson Power Transmission (EPT) facility in Ithaca, New York. The Remedial Design has been prepared in accordance with the Order on Consent, Index #A7-0125-87-09. Remediation by Xerox 2-PHASE® extraction is the remedial alternative selected by the Feasibility Study (Radian, 1994), and incorporated as part of the Record of Decision issued by the New York State Department of Environmental Conservation (NYSDEC) for this site (December 1994).

The EPT plant occupies approximately 94 acres located adjacent to Highway 96B in Ithaca, New York. The property straddles the southern boundary between the city of Ithaca and the town of Ithaca in Tompkins County. EPT, formerly Morse Industrial Corporation, manufactures primarily steel roller chain, which is fabricated in a variety of sizes. EPT/Morse has operated at the site since 1906, and is the original owner of all facilities on the property. EPT/Morse has been a subsidiary of Emerson Electric Co. since January 1983. Prior to that, Morse was a subsidiary of Borg-Warner Corporation.

In 1987, trichloroethene (TCE) was detected in waste oil skimmed from a fire water reservoir. Subsequent sampling indicated a possible release to the subsurface. Radian Corporation conducted a Preliminary Environmental Assessment and a Remedial Investigation (RI) to assess the impact of subsurface contamination on possible receptors. An Interim Remedial Measures (IRM) System was installed at the EPT facility in 1991, and has been operating up to the present time, in response to a NYSDEC requirement to conduct a limited groundwater remedial program. The RI was followed by a Feasibility Study to evaluate and select the best long-term remedial option. Remedial actions were specified in the Record of Decision for both soils and groundwater.

This Remedial Design report presents the detailed design for extracting and treating contaminated groundwater at the facility. Section 2 describes the 2-PHASE extraction system. Section 3 describes the tasks required for system operation and maintenance. Section 4 describes the sampling and analysis methodologies to be used in evaluating the remediation. Section 5 provides a schedule for conducting this remedial program. Section 6 presents an abbreviated list of referenced documents. Appended to this report are plans and specifications for performing all remedial tasks.

2.0 2-PHASE EXTRACTION SYSTEM DESIGN

Based on the results outlined in the Feasibility Study Report (Radian, August 1994), implementation of a Xerox 2-PHASE extraction system was selected as the preferred remedial alternative for the cleanup of chlorinated volatile organic compounds (VOCs) in groundwater at the EPT facility. This section provides an overview of 2-PHASE extraction technology, as well as a detailed plan for implementing this technology at the site.

2.1 Overview

The Xerox 2-PHASE extraction system was developed to increase the efficiency of remediating subsurface VOC contamination in low permeability formations. The system extracts both groundwater and soil vapor from single or multiple extraction wells by applying a high vacuum (22 - 25 inches of mercury) through a central lift pipe that extends down the well to just above the water table. Soil vapor drawn into the well by the vacuum creates a high-velocity air stream at the bottom tip of the lift pipe, which entrains the contaminated groundwater and lifts it to the ground surface. The vapor and water phases are then separated at the surface for treatment. The major advantages of the system include:

- Groundwater is brought to the surface without expensive pumps, wiring, and controls;
- The water table is continually depressed, without the fluctuation caused by conventional systems attempting to pump from low permeability formations;
- The zone of influence is deeper and wider than conventional systems, exposing more area for vapor recovery;
- The high vacuum removes both the specific yield and specific retention water;
- The groundwater extraction rate of wells is increased from 5 to 20 times, depending on the permeability of the formation;
- The turbulence caused as the entrained groundwater moves up the lift pipe effectively transfers more than 90% of the contaminants from the

water to the vapor phase; the separated water phase then only requires polishing to remove residual volatiles before disposal; and

- The contaminated soil vapor, combined with the contamination transferred from the liquid phase, results in a more concentrated vapor phase, which can be more efficiently treated.

The advantages of 2-PHASE technology over conventional pump-and-treat technology for use in the low permeability formation underlying EPT were clearly demonstrated during the 2-PHASE pilot test conducted at the site. Based on evaluation of the pilot test results, Radian anticipates that installation and operation of the 2-PHASE system presented in this Remedial Design will: 1) significantly increase groundwater drawdown and produce a deeper and wider cone of depression at each extraction well than pump-and-treat, and 2) significantly increase the rate of VOC removal from both the groundwater and the vadose zone over that achieved by pump-and-treat.

2.2 System Design

The system to be installed at the EPT facility will be a Xerox 2-PHASE extraction system, consisting of the following:

- Five extraction wells (EW-1, EW-3, MW-2, MW-3-31, and EW-4) and associated piping.

- Skid-mounted extraction equipment, including:
  - An air/water inlet separator with a water extraction pump;
  - A 50-hp, two-stage, oil-sealed, liquid ring vacuum pump;
  - A discharge air/oil separator with a coalescing filter;
  - An air-cooled heat exchanger for seal oil;
  - A vapor air/air after cooler with condensate separator;
  - An air/oil reheater.

- A train of two liquid Granular Activated Carbon (GAC) filters in series to adsorb liquid phase organic compounds before discharge to the SPDES outfall.

- Appropriate instrumentation, including:
  - Vapor flow meter, to indicate vapor discharge in SCFM; and

- Totalizing water flow meter, to indicate total water removed from the wells.

The calculations and assumptions made to arrive at the above equipment configuration are presented in Appendix A. The well location rationale is described briefly below.

The highest VOC concentrations have historically been detected in the immediate vicinity of the fire reservoir. VOC-containing water has migrated from the reservoir to the shallow (upper) portion of the fractured bedrock (30 to 60 feet BGS). The majority of the mass of VOCs present is found in this zone. Although the fire reservoir has been cleaned, residual mass present in the immediate vicinity now serves as a continuing source of VOCs in groundwater.

The Feasibility Study and Record of Decision specify an expansion of the existing IRM extraction well network for the 2-PHASE system. As originally described in these documents, the extraction well network for the 2-PHASE system would consist of the three existing IRM extraction wells (EW-1, EW-2, EW-3) and the addition of two new extraction wells (one in the vicinity of MW-5 and one west of monitoring well MW-3-31). Based on reexamination of the existing extraction and monitoring well networks during the current design effort, an alternative extraction well network design has been assembled for the Remedial Design, as described below.

A new extraction well, EW-4, will be located just north of the reservoir; this location is within the source area, somewhat downgradient of the reservoir itself, and will capture downgradient source area flow. Choosing this location for the source area extraction well offers several advantages over locating it at MW-5, including 1) MW-5 is located in a roadway, presenting piping connection access problems, and 2) use of EW-4 will allow MW-5 wells to be used as passive monitoring points for clean-up assessment.

The 2-PHASE vapor extraction pilot test indicated that both EW-1 and EW-3, when operated alone, influenced drawdown at EW-2; i.e., EW-2 would be within the radius of influence of EW-1 and EW-3. It was therefore decided to utilize EW-1 and EW-3 as extraction wells, and use EW-2 to monitor remedial progress.

Drawdown observed during the pilot test suggested that the extraction wells' radius of influence is propagated primarily along horizontal water-bearing zones occurring along bedding planes. The vertical connection between these water-bearing zones is limited; it was found that extraction on EW-1 and EW-3 did not affect the shallow wells (MW-2, MW-3-13, P-1, P-2). Therefore, it was decided to use two shallow wells, MW-2 and MW-3-31, as extraction wells, in order to optimize vertical coverage of the contaminated zone. MW-3-31 will be advanced an additional 7 feet, so that the open interval will match that of MW-2. As shown in Radian Drawing P-1, the open intervals of MW-3-31 and MW-2 will overlap the open intervals of EW-1, EW-3, and EW-4, so that the entire contaminated zone (30 - 60 ft BGS) will be drawn upon.

2.3 Construction Process

The construction process will consist of decommissioning portions of the existing pump-and-treat IRM; modifying the existing IRM building to house the new system; and equipment installation, testing and start-up. These are discussed below.

2.3.1 Decommissioning the IRM

Many components of the IRM will remain in place, including the building itself, the treated water discharge pipe to the SPDES outfall, the air compressor, and the air dryer. The extraction well water discharge line, which runs between the wells and the building, will be abandoned in-place, as will the compressed air line that powers the pumps. Abandoning these in place will prove more efficient should reconversion back to a pump-and-treat approach be desired in the future. The pneumatic pumps will be removed from the wells, decontaminated, and stored in plastic for possible later reuse. The decontamination water will be added to the water storage tank currently located inside the IRM building. The water storage tank will be power-washed by a subcontractor, who will collect all sediment/solids from the interior of the tank into appropriate containers, characterize these materials, and arrange for their appropriate disposal. The tank itself will be disposed of as used industrial equipment. The pump controllers will be removed and prepared for storage. The interconnecting piping between the tanks and the carbon canisters will be rinsed free of contamination and disposed of as construction debris. The water transfer pumps will be rinsed and prepared for storage, for possible later reuse.

2.3.2 Building Modifications

Building rehabilitation will consist of patching cracks in the concrete floor, and coating the floor surface with a wear-resistant coating. A water sump will be installed in the floor. The 2-PHASE system will run automatically and unattended; if leakage occurs, water will fill the sump and a level indicator in the sump will shut down the skid, preventing further water loss to the building.

Electrical modifications will consist of providing a 480V, 3-phase service to power the skid (50 horsepower motor). Building modifications will consist of installing vent louvers and fans in the building, to accommodate the heat generated by the skid during operation.

2.3.3 Equipment Installation, Testing, and Start-Up

Installation

Each extraction well will have a lift pipe (straw) attached to its sealed well cap. Necessary gauges and valves for well operation will be installed. These will include a well bore vacuum gauge; a wellhead vacuum gauge; an aspiration air valve; and a vacuum line shut-off valve (for well isolation). A new 2-PHASE vapor extraction header will be installed between the extraction wells and the treatment building, using existing pipe racks; this will be an aboveground line of Schedule 80 PVC, and will be heat-traced and insulated. Each of the extraction wells will then be tied into this header.

The 2-PHASE skid will be installed as a complete assembly, and will be leveled, shimmed, and anchored. The extraction header will be connected to the skid. Vapor discharge pipes, with vapor flow measurement equipment, will penetrate the roof of the treatment building for discharge. The water discharge will be piped to the carbon canisters; the increased VOC stripping achieved by the 2-PHASE system makes only two canisters necessary, compared with the three required for the IRM. Power (480V, 3-phase) will be supplied to the main control panel of the 2-PHASE skid. The current IRM building lighting and heating systems will remain in place.

The Xerox 2-PHASE system to be installed is highly automated, and is designed with a number of interlocks which automatically shut down the system if a fault is detected. Operator intervention is required to clear the fault and restart the equipment. Quick detection and correction of fault conditions, and subsequent restart of operations, are therefore essential to efficient system operation. To minimize downtime, the system will be equipped with an autodialer, which will be programmed to notify appropriate personnel if the system shuts down. The unit is capable of sequentially dialing four telephone numbers, to ensure that contact is made. A remote telemetry system will also be included in the design. The telemetry system will monitor critical operational parameters through various sensors installed within the system, and will store data for remote access via telephone modem and personal computer. In addition to aiding in early detection of faults which could lead to eventual shut down, the telemetry system allows for routine analysis of system data and the optimization of system performance.

Testing

Testing activities will include pressure-checking the interconnecting well piping for leaks prior to installation of the heat tracing and insulation. In addition, the skid will be temporarily started to check the rotation of all electrical motors.

Start-Up

Following completion of the tests described above, the skid will be started, and a vacuum applied to each well in turn, to dewater the well and characterize vapor and water flow. When each of the wells has been dewatered and checked, all will be placed on-line together, and normal system operation will begin.

2.4 Site Security and Safety

Radian will develop and will require all sub-contractors working at the site to develop individual Site Safety and Health Plans to manage risks posed by physical, chemical, and biological hazards at the site. These plans will comply with the hazardous waste operations/emergency response requirements in 29 CFR 1910.120.

Existing fencing surrounding the EPT facility prevents access to the property by the general public. Warning signs will also be posted at each access point. The treatment building is kept locked at all times, with access restricted to approved EPT or Radian personnel. Equipment at the extraction well wellhead will be stored in locked enclosures. EPT employees will be asked to avoid the area, due to the presence of heavy equipment and the potential hazards created.

2.5 Quality Control

The construction contractor will designate a quality control representative who will be responsible for filing daily progress reports with Radian regarding the status of the work. The Radian on-site representative will be in frequent contact with the Radian Project Manager to provide regular progress updates and communicate any potential problems or other issues of concern. Radian will document all site activities.

2.6 Coordination with Other Site Activities

Installation of the 2-PHASE system is expected to occur in late summer or fall of 1995. Although most of the work associated with the 2-PHASE installation will take place inside the treatment building, the installation of the piping connecting the extraction wells with the treatment building will cross the area where excavation of petroleum-containing soil is planned. While it is expected that all soil excavation activities will be completed prior to any 2-PHASE installation work, Radian will coordinate the work in this area to ensure that there is no conflict between these two activities.

2.7 Air Emissions and Water Discharge

The New York State Department of Environmental Conservation (NYSDEC) has been contacted to provide a preliminary determination on air emission treatment regulation and sampling. Preliminary indications are that air treatment will not be required (phone conversation between Mr. Jeff Edwards (NYSDEC) and Mr. John Yackiw (Radian Corporation), April 27, 1995. If required by NYSDEC, daily OVA sampling at the vapor discharge will be performed during the first week of operation for compliance monitoring.

Modification of the existing SPDES permit is not expected to be necessary, based on correspondence during negotiation of possible SPDES modification related to installation of the IRM system (letter from Mr. Mario M. Nirchi, P.E. of NYSDEC, to Ms. Maryelena Pardo of Shaw, Pittman, Potts, and Trowbridge, December 17, 1990). The 2-PHASE system is expected to discharge approximately 1,282 gallons/day, representing an increase of only 3.5% over the current facility discharge of 37,000 gal/day. A preliminary indication on this subject has been requested from NYSDEC.

3.0 SYSTEM OPERATION AND MAINTENANCE

The necessity for visits to the site by an operator will be minimized by the highly automated nature of the equipment. Skid maintenance will be per the manufacturer's operations and maintenance manual. In addition, certain process parameters related to system performance will be recorded each time the operator is on site. An example of the type of form to be used is shown in Figure 3-1. These data will be reviewed to assess system performance. Operators will be on site as needed during system start-up, and typically twice a week thereafter, for as long as the system is in operation.

Emerson Power Transmission, Ithaca, New York
2-PHASE Vacuum Extraction System, Operating Data

Date:		Operator:		
Skid Parameters		Well Parameters		
Vapor Flow:		Well	Wellhead Vacuum (in Hg)	Well Bore Vacuum (in Hg)
Total Vapor:		EW-1		
Total Water:		EW-2		
Operating Hours:		EW-4		
System Vacuum:		MW-2		
		MW-3-31		

General Comments: ______________________________

Any oil leaks observed? ______________________________

Any water leaks observed? ______________________________

Building temperature: ______________________________

Action items/parts required: ______________________________

Figure 3-1. Example Checklist

4.0 SAMPLING AND ANALYSIS PLAN

To evaluate remedial progress, samples will be collected on a regular basis from the monitoring wells, the extraction wells, and from several points along the groundwater treatment train, for analysis for TCE and related organic compounds by EPA Method 8010. This section describes the location and frequency of this sampling. Sampling procedures will be in accordance with the document entitled, "Emerson Power Transmission, Interim Remedial Measures, Sampling and Analytical Plan," Radian Corporation, July 19, 1991.

4.1 Sample Locations

The locations of the monitoring wells and extraction wells are shown on Radian Drawing P-1. Sample locations along the treatment train are shown on Radian Drawing I-1.

Samples will be collected from the extraction wells by temporarily shutting the well off to allow for water recharge, and then using a dedicated bailer to obtain a groundwater sample. Precarbon treatment samples will be collected from a 0.5-inch valve (TS-0). A 0.5-inch valve will be located between the first and second carbon unit (TS-1) and in the effluent line from the second carbon unit (TS-2).

4.2 Sampling Frequency

A summary of sampling frequency is presented in Table 4-1. On a one-time basis during the start-up period (i.e. during the first month of operation), samples will be collected from each of the extraction and monitoring wells, and from the sampling locations along the treatment train. In addition, water levels will be measured from each of the extraction and monitoring wells. Following start-up, long-term

Table 4-1

System Monitoring and Water Sampling

Location	Start-Up[a]	Long-Term[b]	EPA Method 8010 Analysis	Water Level Measurement
Extraction Wells				
EW-1	X	S (Q)[c]	√	√
EW-3	X	S (Q)[c]	√	√
EW-4 (new well)	X	S (Q)[c]	√	√
MW-2	X	S (Q)[c]	√	√
MW-3-31	X	S (Q)[c]	√	√
Treatment Train				
TS-0	X	M	√	
TS-1	X	M	√	
TS-2	X	M	√	
Monitoring Wells				
EW-2	X	S (Q)[c]	√	√
MW-1	X	S (Q)[c]	√	√
MW-3-13	X	S (Q)[c]	√	√
MW-3-100	X	S (Q)[c]	√	√
MW-3-150	X	S (Q)[c]	√	√
MW-5-100	X	S (Q)[c]	√	√
P-1	X	S (Q)[c]		√
P-2	X	S (Q)[c]		√

a "Start-up" is defined as the first month of operation.
b "Long-term" is defined as subsequent to the first month of operation.
c Wells marked S(Q) will be sampled semi-annually for compliance monitoring, with off-quarter samples being used for performance assessment purposes only. For example, during Q1 and Q3, semi-annual samples would be collected for compliance monitoring, and during Q2 and Q4 the off-quarter samples would be collected.
X One-time sampling
M Monthly sampling
S Semi-annual sampling
Q Quarterly sampling

compliance samples will be collected monthly from the sampling locations along the treatment train, and on a semi-annual basis from the extraction and monitoring wells; water levels will also be recorded semi-annually.

In addition to the semi-annual compliance sampling described above, samples will be collected and water levels recorded on the off quarters, for system performance assessment purposes only. These sample collection events will be performed using the same procedures as the semi-annual sampling but, since their purpose is to assist in evaluating remedial performance, departures from the semi-annual protocol (i.e., hold time exceedances, etc.) will not invalidate the samples from being used for this purpose.

If NYSDEC requires it, daily OVA sampling at the vapor discharge will be performed during the first week of operation for compliance monitoring. In addition, it is recommended that a single sample be taken from the vapor exhaust on a bi-weekly basis, to help assess system performance. It is recommended that performance sampling be performed using the Microseeps® technology. This approach utilizes a syringe and vial collection process, with analysis by Method AM4.02, which is a modified version of EPA Method TO-14. Method AM4.02 analyzes volatile organic compounds in soil gas samples, using a gas chromatograph in conjunction with an automated headspace sampler. A wide bore capillary column is used in conjunction with an output splitter connected to an electron capture detector and a flame ionization detector.

5.0 PRELIMINARY SCHEDULE

The anticipated project schedule is summarized below. The compliance monitoring sampling schedule is described in Section 4.0.

Project Milestone	Elapsed Time From Project Approval
Order skid	1 week
Assemble complete bid package	2 weeks
Drill new extraction well (EW-4)	3 weeks (duration, 2 days)
Receive and review construction bids (all site work except new extraction well)	4 weeks
Award bid	6 weeks
Start work	7 weeks
Delivery of skid. Shut down pump-and-treat and begin decommissioning of IRM. Begin building rehab.	14 weeks
Installation complete. Begin testing and start-up.	16 weeks
Begin operation.	20 weeks
Semi-annual reporting to NYSDEC (water discharge volume and analytical results for discharge water, to demonstrate compliance).	6 months, and every 6 months thereafter.

6.0 REFERENCES

1. Radian Engineering, Inc., Feasibility Study Report, Emerson Power Transmission (EPT), Ithaca, New York. August 1994.

2. Radian Corporation, Final Report, Remedial Investigation Stage 1 and 2, Emerson Power Transmission (EPT), Ithaca, New York. February 1990.

3. New York State Department of Environmental Conservation, Morse Industrial Corporation, Record of Decision. December 1994.

Appendix A
DESIGN CALCULATIONS

RADIAN CORPORATION

CALCULATION SHEET

CALC. NO. ______

SIGNATURE John Yackiw DATE 3/31/95 CHECKED ______ DATE ______

PROJECT Emerson/Ithaca 2-Phase JOB NO. ______

SUBJECT Process Design SHEET 1 OF ______ SHEETS

1.) Design Assumptions:

1.) 4 existing wells, EW-1, EW-3, MW-2 & MW3-31 will be connected to system.

2.) 1 new extraction well, upgradient of existing wells (towards fire reservoir) will be connected.

2.) From the 2-Phase Extraction Pilot Test Report, Vapor Flow, per well, averaged 19-23 ACFM. However, this flow was mainly (15 ACFM) due to aspiration air. The "straw" was too large, and aspiration air was required to keep the water flowing. Actual flow from the formation was approximately 3-7 ACFM/well.

Therefore: assume some aspiration air, but only about ½ the quantity used during the pilot test.

Vapor Flow/Well: $5 + \frac{1}{2} 16 = 13$ ACFM/well ≈ 13 SCFM/well

For 5 wells: 65 SCFM

Water Flow: From the 2-Phase Extraction Pilot Test Report;

EW-1 : 13.3 gal/hr
EW-3 : 8.0 gal/hr

RADIAN CORPORATION

CALCULATION SHEET

CALC. NO. ______

SIGNATURE John Yackiw DATE 4/3/95 CHECKED ______ DATE ______

PROJECT Emerson / Ithaca 2-Phase JOB NO. ______

SUBJECT Process Design SHEET 2 OF ______ SHEETS

2.) Con. : Water Production

Assume the other three wells will produce an average: $\frac{13.3+8.0}{2}$ of the two wells tested

$$3 \cdot \frac{13.3+8.0}{2} = 31.95 \text{ gal/hr}$$

Total: $13.3 + 8.0 + 31.95 = 53.25$ gal/hr

$\Rightarrow .89$ gpm

3. Emission Calculations:

EW-3: 84.0 hrs ≈ 672 gallons

TCE: .57# ⇒ 101,638 ug/l } if all contamination
DCE: .08# ⇒ 14,265 ug/l } comes from water

December 1993 Analytical Results:

TCE: 40,000 ug/l
DCE: 7,000 ug/l

∴ TCE : 40,000/101638 = 39.4% from water
DCE : 7,000/14,265 = 49.1% from water

EW-1: 71.4 hrs ≈ 950 gallons

TCE: .21# ⇒ 26,488 ug/l } if all contamination
DCE: .06# ⇒ 7,568 ug/l } comes from water

RADIAN CORPORATION

CALCULATION SHEET

CALC. NO. ____

SIGNATURE John Yackiw DATE 4/3/95 CHECKED ____ DATE ____

PROJECT Emerson/Ithaca 2-Phase JOB NO. ____

SUBJECT Process Design SHEET 3 OF ____ SHEETS

3.) Con. : EW-1

December 1993 Analytical Results

TCE: 19,000 ug/l
DCE: 7,300 ug/l

∴ TCE: 19,000/26,488 = 71.7% from water
DCE: 7,300/7,568 = 96.5% from water

For MW-2:

use average of EW-1 & EW-3 partitioning factors

November 1994 Analytical Results

TCE: 18,000 ug/l / (71.7+39.4)/2 = 32,403 ug/l
DCE: 8,500 ug/l / (96.5+49.1)/2 = 11,676 ug/l

For MW-3-31:

use EW-3 partitioning factor

TCE: 160,000 ug/l / 39.4% = 406,091 ug/l
DCE: 5,000 ug/l / 49.1% = 10,183 ug/l

For the new well, assume MW-3-31 concentrations

∴

	EW-1	EW-3	MW-2	MW-3-31	New
TCE	26488	101,638	32,403	406,091	406,091
DCE	7568	14,265	11,676	10,183	10,183
Flowrate	13.3 gal/hr	8 gal/hr	10.65 gal/hr	10.65 gal/hr	10.65 gal/hr

RADIAN CORPORATION

CALCULATION SHEET

CALC. NO. ____

SIGNATURE: John Yackiw DATE: 4/3/95 CHECKED: ____ DATE: ____

PROJECT: Emerson / Ithaca 2-Phase JOB NO. ____

SUBJECT: Process Design SHEET: 4 OF ____ SHEETS

3. Con.

EW-1 : 26,488 μg/l · $\frac{3.785\,l}{1\,gal}$ · $\frac{1\,lb}{4.536 \times 10^8\,\mu g}$ · 13.3 gal/hr = 2.94×10^{-3} #/hr
7,568 μg/l · 13.3 gal/hr = $.840 \times 10^{-3}$ #/hr

EW-3 : 101,638 · $\frac{3.785\,l}{1\,gal}$ · $\frac{1\,Lb}{4.536 \times 10^8\,\mu g}$ · 8 gal/hr = 6.786×10^{-3} #/hr
14,265 · 8 gal/hr = $.952 \times 10^{-3}$ #/hr

MW-2 : 32,403 · $\frac{3.785\,l}{1\,gal}$ · $\frac{1\,Lb}{4.536 \times 10^8\,\mu g}$ · 10.65 gal/hr = 2.88×10^{-3} #/hr
11,676 · 10.65 gal/hr = 1.04×10^{-3} #/hr

MW-3-31 :
406,091 · $\frac{3.785\,l}{gal}$ · $\frac{1\,Lb}{4.536 \times 10^8\,\mu g}$ · 10.65 gal/hr = 36.09×10^{-3} #/hr
10,183 · 10.65 gal/hr = $.905 \times 10^{-3}$ #/hr

New Well ⇒ Same as MW-3-31 ⇒ 36.09×10^{-3} #/hr
$.905 \times 10^{-3}$ #/hr

Total: (Assumes all to vapor)

TCE : .085 #/hr (61.20 #/month)
DCE : .0046 #/hr (3.31 #/month)

(Note: These values should rapidly drop off after project start.)

RADIAN CORPORATION

CALCULATION SHEET

CALC. NO. ______

SIGNATURE John Yackiw DATE 4/7/95 CHECKED ______ DATE ______

PROJECT Emerson/Ithaca 2-Phase JOB NO. ______

SUBJECT Process Design SHEET 5 OF ______ SHEETS

4) Vapor Phase Treatment Requirements:

Flow: 65 SCFM, continuous
Temperature: 100 - 120 °F
Pressure: 1-2 psig
Relative Humidity: 30 to 50 %
Contaminant Loading: TCE: .085 #/hr
DCE: .0046 #/hr

5.) Liquid Phase Treatment Requirements:

Flow: 4-6 gpm intermittant
Temperature: 40-80 °F
Pressure: 2-4 psig
Contaminant Loading: TCE: 72,200 ug/l *
DCE: 5,700 ug/l *

* Absolute worst case, assumes no stripping action. Concentrations are from Nov. 1994 sampling event, averages of wells to be connected. New well assumed to have same concentration as MW3-31.

Appendix B
PLANS

Please refer to the plans included with this submittal.

Appendix C
SPECIFICATIONS

PROJECT SPECIFICATIONS

1.0 GENERAL

(1) The Contractor will be responsible for obtaining any city and/or County construction and building permits that are required.

(2) Contractors will be responsible for complying with all applicable safety rules prescribed by Radian, OSHA and other Federal, State and local agencies.

3) Contractors shall provide and maintain safe tools and equipment, for the performance of their work, which comply with Federal and State requirements.

4) Contractors shall furnish approved hard hats for their employees and other safety apparel such as eye protection, ear protection, foot guards and safety belt, as required, for safe performance of their particular work assignment.

(5) Each Contractor has the responsibility for instructing it employees in safe practices for the operation of tools and equipment, and for the maintenance of a safe working environment.

(6) Existing underground installation are indicated on the drawings only to the extent such information was discovered by Radian in preparing drawings. There is no guarantee as to the accuracy or completeness of such information, and all responsibility for the accuracy and completeness thereof is expressly disclaimed.

(7) Prior to any subsurface work, the Contractor will be responsible for locating and marking all underground utilities in the vicinity of the site, including gas, water, sewer, and marking all underground utilities in the vicinity of the site, including gas, water, sewer, and electrical, by contacting all local utilities and by prospecting. Location of utility facilities shown on drawings are approximate. Caution should be exercised and utilities should be exposed by hand or by means acceptable to the utility owner. Any utilities damaged by the Contractor shall be repaired to the original condition by the Contractor.

(8) All construction waste, refuse and excess materials shall be removed from the site by the Contractor and, upon completion of the work, the site will be left in a clean and orderly state.

(9) Contractor shall be responsible for providing adequate barracades, fencing, warning flashers and all site control necessary for work in progress.

(10) All discrepancies in the plans, specifications, or utility interferences shall immediately be brought to the attention of the Engineer for clarification.

2.0 WELL BOXES AND PLUMBING

(1) Four extraction wells are existing, and one new well will be installed: EW-1, EW-3, MW-3-31, MW-2, and EW-4. Stainless steel enclosures with hinged covers will be provided and installed on each well by the Contractor. Contractor shall install plumbing fixtures, gauges, valves, etc. at well heads of all five wells.

(2) Installation of valves and fittings shall be strictly in accordance with the manufacturer's specifications. Particular care shall be taken not to over stress threaded connections at the sleeves. In making solvent welded connections, the solvent shall not be spilled on valves or allowed to run from joints.

(3) All piping will be PVC 1120, Sch 80, normal impact unless otherwise noted on the drawings. All pipe joints shall be solvent weld socket joints and installed in strict accordance with manufacturers recommendations.

(4) Joints for plastic pipe shall be solvent welded except flanged or threaded where required. All PVC joints shall be assembled in accordance with ASTM-2855. In making solvent welded connections, clean dirt and moisture from piping and fittings, bevel pipe ends and apply solvent cement of the proper grade.

(5) All PVC fittings shall be socket type for socket welded joints as designated in ASTM D-2467 or D-2466, except where threaded as shown on the drawing, and as designated in ASTM D-2464, or flanged as shown on the drawings and shall be compatible with the pipe where installed. Flanges shall be furnished with 1/8 inch thick full faced gaskets. Flange bolts and nuts shall be cadmium plated steel.

(6) All piping shall have sufficient number of unions to allow convenient removal of piping and shall be as approved by Radian.

(7) Inside the process building, the piping layout and installation shall be made in the most advantageous manner possible with respect to maximizing headroom, minimizing tripping hazards, providing adequate valve and gauge access, opening and equipment clearance, and clearance for other work. Particular attention shall be given to piping in the vicinity of

equipment requiring periodic removal such as filters, carbon drums, etc. Maintain maximum access to equipment for maintenance.

(8) The Contractor shall test the assembled piping system by applying and maintaining a vacuum of 20 inches of mercury (approximately 10 psi) for two hours with less than 1 inch of mercury loss over that time period. The testing must be witnessed by a Radian representative.

3.0 EXTRACTION SKID

(1) The Contractor will be responsible for providing equipment to unload and set the vacuum extraction skid in the process building. The skid is approximately 7 feet square and 8 feet tall. Radian will coordinate with the Contractor regarding the delivery schedule for the skid.

(2) The skid shall be shimmed and leveled to 1/4 inch tolerance and grouted in place using a Portland Cement grout pad. Grout shall be no less than 1/2 inch thick and shall be composed of one part cement, two parts sand, and sufficient water to permit placing and packing.

(3) The skid shall be bolted in place to the existing concrete slab using 5/8 inch diameter anchor bolts with a minimum of 4 inches embedment and minimum of 3 bolts per side. The bolt locations are to be coordinated with the skid supplier.

4.0 PROCESS BUILDING

(1) Existing exterior wall shall be reinforced around the new louvers.

(2) Following installation of piping, exhaust fans, louvers, emission stacks, etc. in the process building, all joints, cracks, and openings must be sealed with a weatherproof sealant such as Dow-Corning 790 Building Sealant or GE Silpruf Weatherproofing sealant.

(3) All interior exposed piping shall be labeled in accordance with ANSI A13.1, Scheme for the Identificaion of Piping Systems. The markers shall be vinyl cloth with all temperature adhesive suitable for the PVC pipe finish surface. The label shall read "contaminated water" in black letters on a yellow color field. Size of legend letters and length of marker shall be as specified in ANSI A13.1 for the size of the pipe being labeled. Marker spacing shall be no more than 20 feet on center.

5.0 CONCRETE

(1) Cement used in concrete work should be Type I Portland. Concrete shall have an ultimate compressive strength of 3000 PSI in 28 days. Design fc=2000 PSI in 28 days unless otherwise specified. Maximum slump shall be 3 inches. Air entrainment shall be added to the concrete in the amount of 6% by volume.

6.0 MECHANICAL

1) All well head and well box piping shall follow specifications as drawn and noted.

(2) All outside piping shall follow specifications as drawn and noted.

(3) All process building piping shall follow specifications as drawn and noted.

7.0 ELECTRICAL

(1) All work shall be done in accordance with the National Electric Code (NFPA-70, 1993) and all pertinent state, local and utility requirements. All equipment shall meet the requirements of the Underwriters Laboratory (UL) for the purpose which it is used.

(2) The Contractor shall verify the exactly location of the equipment, raceway, and wiring prior to installation. New conduits may not be shown on the plan drawings, but shall be provided in accordance with the one line diagram and panel schedule. The designation is shown on the one line diagram. Each circuit shown on the panelboard schedule shall be provided with a minimum 3/4 inch conduit with 2#12 AWG, #12 GND conductors from the panelboard to the load.

(3) All signal cable shields shall be grounded at the control panel. The shield end at the instrument shall be taped to insulate it from ground.

(4) All cables shall have a unique number and labeled with a permanent labeling system. All label numbers shall be added to the as-built drawings.

(5) Testing: All power conductors shall be measured for its insulation resistance to ground after the conductors have been pulled and before the conductors have been terminated. Conductors with an insulation resistance less than (2) megohms shall be replaced. No splices

are permitted.

(6) All conduits shall be galvanized rigid steel, unless otherwise noted. All conduits shall be run exposed and supported off the routing surface.

(7) All wiring and equipment shall meet the specifications as drawn and noted.

8.0 SUBMITTALS

(1) The Contractor shall submit work plans, installation plans and product information on all materials included in the work.

(2) The Contractor shall allow a 7-day review period in the construction schedule for submittal review. All submittals should be sent to the reviewer in one package.

Emerson Power Transmission
Equipment List

Equipment	Manufacturer	Procurement	Installation
Well EW-4	None (see drilling specification)	Radian	Drilling contractor
Well-head enclosures for EW-1, EW-2, EW-4, MW-2, MW-3-31	Hoffman or equal	Contractor	Contractor
Plumbing/fittings for EW-1, EW-2, EW-4, MW-2, MW-3-31	Various as shown in drawings	Contractor	Contractor
Well heads and "straws"	Various as shown in drawings	Contractor	Contractor
Process piping and fittings	Various as shown in drawings	Contractor	Contractor
Valves, gauges	Various as shown in drawings	Contractor	Contractor
Skid mounted 2-PHASE extraction blower	Wintek Inc. (see skid specification)	Radian	Contractor
Vapor flowmeter and computer	Endress & Hauser FCV 1810 and ZL 6351	Radian	Contractor
Pressure and temperature transmitter for vapor	Endress & Hauser	Radian	Contractor
Autodialer	Phonetics Model 1104	Radian	Contractor
Totalizing Water Meter	Badger or equal	Contractor	Contractor

DRILLING SPECIFICATIONS

One new well will be installed and one existing well will be advanced 7′ as described below. Both wells will require development by purging and surging. Preferred drilling method is air rotary. Equipment and tools shall be decontaminated prior to advancing each borehole and prior to departure from the site.

1.0 NEW WELL (see Figure 1)

(1) Placement: The well is to be located north of the fire reservoir and north of the fence.

(2) The fence is located along a retaining wall which extends approximately 7′ above the ground surface as the topography slopes down at an approximate 30° angle to the north. Surface finish to the south of the fence and retaining wall is flat and paved; access to this area is tight. The fence and a steam line are to be temporarily disconnected (by Facility personnel) and the drill rig backed up to overhang the retaining wall. Radian is to receive utility clearance from Facility personnel prior to breaking grade.

(3) Installation Methods: Drill through the overburden; siltstone bedrock will be encountered at approximately 5′ below grade. To isolate the overburden, the well shall be constructed of 3″ diameter steel casing grouted in a minimum 5″ diameter rock socket, extending 5′ (minimum) to 10′ into the top of bedrock approximately 10′ to 15′ below ground surface (BGS)). A 2-3/4″ diameter borehole shall then be advanced below the casing to serve as the open interval. This open interval shall advance to 40′ BGS.

(4) Rinse materials from decontamination, development water, and soil cuttings will be stored for disposal in 55-gallon, DOT 17H approved metal drums. All drums shall be marked by the drilling contractor with the project name, contents, source and date staged onsite at a location specified by Emerson.

(5) Total borehole depth/Open interval: 40′ BGS/approximately 15′-40′ BGS.

(6) Material specifications: 3″ diameter steel casing. Bentonite powder. Portland cement or equivalent.

(7) Protective casing with locking cap.

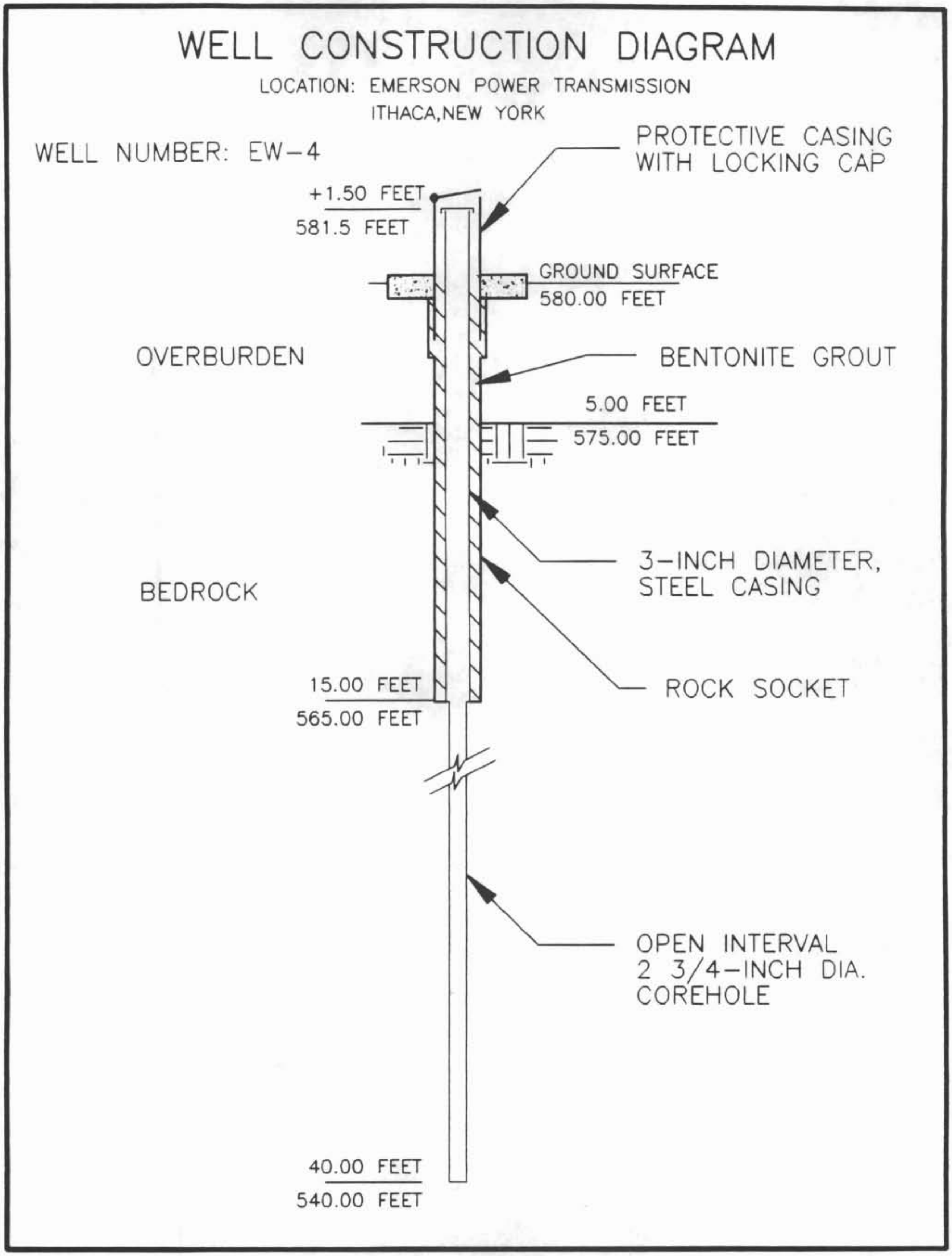

Figure 1. Well Construction Diagram, New Well

(8) Grout: Backfill borehole to surface grade with neat cement/bentonite grout (Mix 3 lbs. bentonite powder/7 gallons water/2-20 kg bags cement). Drive 3″ diameter steel casing, let the grout set, then drill the casing interior.

(9) Surface completion: Above ground. 3″ diameter steel casing, stick-up of approximately 1.5′. Locking, protective steel casing, 2′ stick-up.

2.0 EXISTING WELL (see Figure 2)

(1) The existing well MW-3-31 has a protective casing and locking cap with a 2.52′ stick-up. The well riser is 4″ diameter schedule 40, PVC grouted 5′ into bedrock (to 21′ BGS). A 3″ diameter open rock borehole extends to 31′ BGS. This open rock interval shall be advanced 7′, for a total well depth to 38′ BGS, with a 2-3/4″ or 3″ diameter bit.

(2) The protective casing and PVC casing must remain intact or be replaced with 2′ and 1.5′ stickups, respectively. Radian Corporation will have removed the controller box from the area to provide access to the well.

(3) Rinse materials from decontamination, development water, and soil cuttings will be stored for disposal in 55-gallon, DOT 17H approved metal drums. All drums shall be marked by the drilling contractor with the project name, contents, source and date staged onsite at a location specified by Emerson.

3.0 WELL DEVELOPMENT

(1) Both wells shall be developed by purging and surging. The wells will provide little recharge; therefore, purging shall occur by bailing.

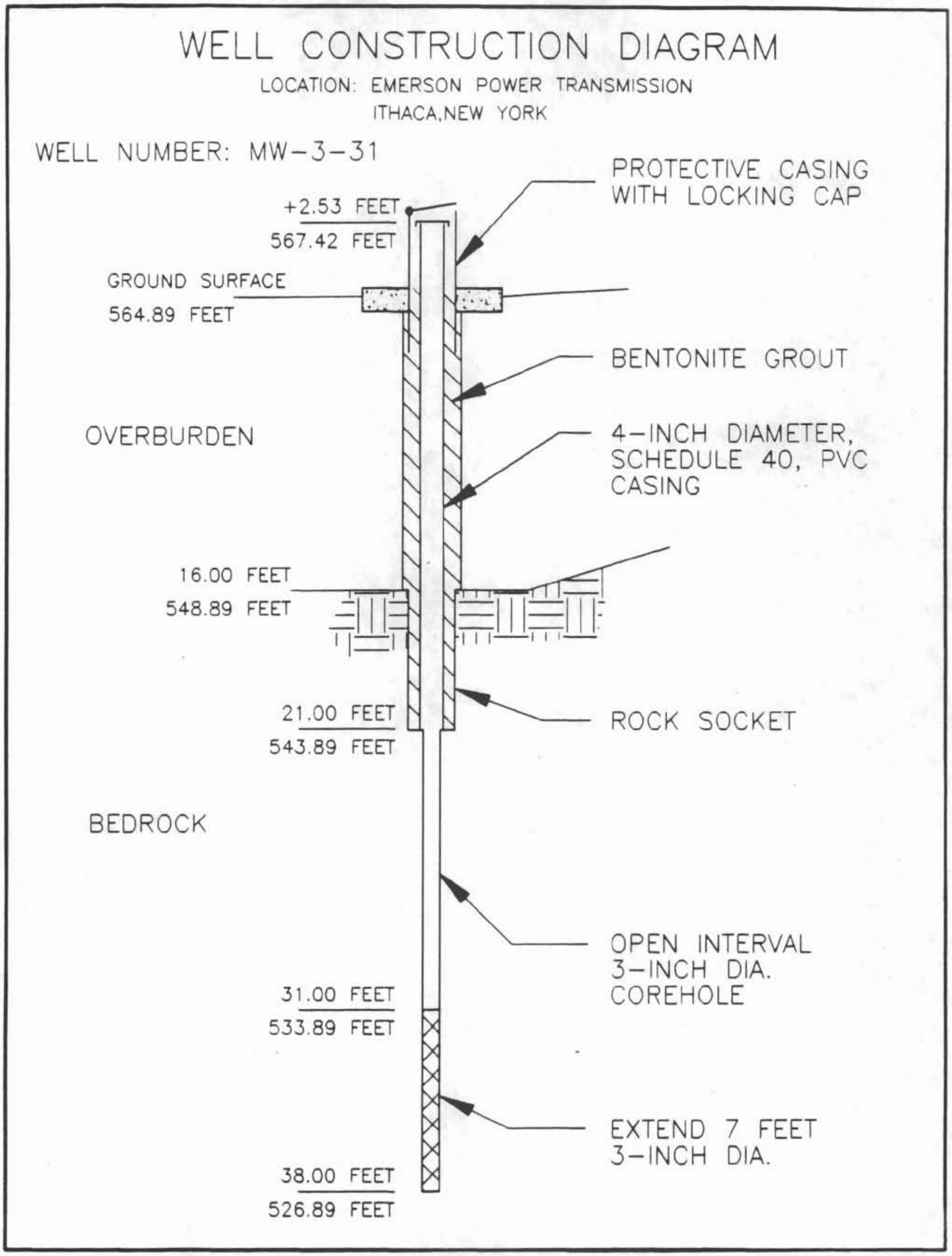

Figure 2. Well Construction Diagram, Existing Well

2-PHASE EXTRACTION SYSTEM SPECIFICATION

1.0 2-PHASE EXTRACTION SYSTEM OVERVIEW

(1) The 2-PHASE Extraction system will be used for subsurface remediation of Trichloroethylene and Dichloroethylene contaminated groundwater and soil. It, therefore, must be capable of simultaneously handling two phase (liquid and vapor) flow. The overall system will consist of four major components: phase separation system, vacuum pump system, seal-fluid system, and a vapor conditioning system. All operational pieces shall be mounted on a steel base frame assembly. The base frame shall be equipped with lifting lugs and fork lift pockets for transportation and field installation.

(2) The inlet separator in the phase separation system should be appropriately designed to provide total separation of the incoming vapor and groundwater streams. In addition, any solids present should be captured in the liquid phase and removed prior to the liquid stream being sent through the liquid treatment system.

(3) The vacuum pump system will consist of one liquid ring vacuum pump.

(4) The seal-fluid system will include a seal-fluid separator/reservoir tank, and an appropriate arrangement of circulating pumps and heat exchangers.

(5) The vapor conditioning section will be designed to provide the most economical utilization of hot and cold streams resulting in vapor temperatures and relative humidities in the desired range.

(6) The VES system will have a main control panel and GFI's where appropriate. All motors used will be of the totally enclosed, fan-cooled type (TEFC) with a service factor of 1.15.

(7) The equipment will be designed for continuous 24-hour full-load service. Good piping practices should be employed through every stage of the system. Flanged and welded fittings are desired, however threaded joints are acceptable provided that unions are placed to allow for easy access/dismantling of sections and major pieces of equipment. All components will be fully pre-piped, pre-wired, skid-mounted, and factory tested prior to delivery. All weldments shall be designed and performed in strict conformance with AWS standards. All lubrication points will be clearly marked and accessible while the equipment is operating.

2.0 PHASE SEPARATION SYSTEM

2.1 Inlet Separator

(1) The inlet separator will be used to separate the water and vapor streams. As the quality of the water is unknown at this point (i.e. may contain sediment, iron, etc), the separator must be equipped to handle particulates and be easily accessible for periodic draining and cleaning. The separator will be sized appropriately and constructed of corrosion-resistant materials. It will contain a demister element. The separator will be equipped with 4 level switches (high-alarm shutdown, pump on, pump off, low-alarm pump off) of appropriate design (capacitance probe is preferred) which will control the operation of the transfer pump. In addition, the separator will be equipped with a vacuum gauge with isolation valve, temperature gauge, and one instrumentation port (½" NPT). A liquid level sight glass mounted in a clear housing will also be included.

2.2 Liquid Transfer System

(1) One properly sized progressive cavity pump is required for transfer of contaminated liquid from the inlet separator to the water treatment system. The pump shall have a flow capacity of 5 gallons per minute (GPM) at the maximum rated vacuum capacity of the vacuum pump on the suction side of the transfer pumps. The operation of the pump will be automatically controlled by the level switches on the inlet separator. In addition, a selector switch at the main control panel will allow for manual control of the transfer pump with automatic pump shut-off occurring at the low alarm separator level condition in both hand and auto modes. The low-alarm inlet separator level condition will activate a red alarm condition light on the main control panel. However the vacuum system shall remain operational. In the event that a high-alarm inlet separator condition occurs; the entire system should shut down to prevent damage.

(2) Because of the possible presence of fine sediment, a large capacity filter system must be included for solids removal prior to reaching the water treatment system. Pressure switches, located after the transfer pump, but prior to the filter system will be provided, to shut down the transfer pump in the event of filter pluggage. In addition, pressure gauges with isolation valves and instrumentation ports (½" NPT) will be required to monitor pressures at the transfer pump outlet and across each filter in the filter system design.

(3) Isolation valves, positioned at the transfer pump inlet and outlet, will be provided to facilitate pump change outs. Check valves and Y-strainers must also be placed in appropriate locations (i.e. strainers on pump inlet, check valve on pump outlet, etc.).

3.0 VACUUM PUMP AND SEAL FLUID CIRCULATION SYSTEM

3.1 Vacuum Pump

(1) The proposed system design will include one appropriately sized liquid ring vacuum pump -- preferably of the oil-seal type, although, water-seal systems will be considered. The pump must be capable of handling an air flow of at least 500 ACFM at 17-25 inches HgVAC. The vacuum pump will be equipped with a high temperature limit switch and instrumentation port (½" NPT) at the pump outlet. The temperature switch will protect the pump by shutting it down in the event of high pump temperature. In addition to the above criteria, the pump must have a manual vacuum relief valve (complete with silencer), an inlet check valve, and a vacuum gauge.

(2) The drive motor (TEFC) will be coupled directly to the pump and OSHA approved guards will be supplied by the manufacturer. Provisions (jack bolts, etc.) for easy pump to motor alignment will be included in the design.

3.2 Seal Fluid Circulation System

(1) The selected seal fluid will be tolerant of contamination by water, Trichloroethylene, and Dichloroethylene. All components in the seal fluid circulation system will be compatible with these fluids.

(2) The vacuum pump will have a seal fluid circulation system. The system will include an oil separator/reservoir tank with a multi-stage mechanical and coalescing mist elimination system. The tank will be equipped with a pressure gauge, sight glass, two level switches (high and low), a removable top, a flanged hand-hole clean-out, and a conveniently located drain valve. The level switches will activate red alarm condition lights on the main control panel, and shut the vacuum pump down.

(3) A centrifugal pump will be used to circulate the seal fluid for the system, and will be sized to deliver the appropriate amount to the vacuum pump. A globe valve for flow rate adjustment, and a pressure gauge located at the circulation pump outlet is required, and liquid strainers and/or filters must be included in the design as needed.

(4) An air-liquid heat exchanger (HEX) rated for 110°F ambient operation is required and must be equipped with inlet and outlet temperature and pressure gauges and ½" NPT instrumentation ports. A heat exchanger bypass line, equipped with an adjustable temperature control valve will be provided, to maintain optimum seal fluid temperature. The HEX fan may be run off the vacuum pump or driven by an auxiliary motor, however the design must be compact.

4.0 VAPOR CONDITIONING SYSTEM

(1) The vapor leaving the system must be in the temperature range of 100°-120° F, have a relative humidity of between 30% and 50%, and be at a high enough pressure to overcome exhaust stack losses of .5 psi. Thus, an appropriate heat exchange/water removal system must be designed to reach these requirements. The system may be a combination of air to air heat exchangers and/or shell and tube heat exchangers utilizing the cool groundwater from the inlet separator. The designed system must also have temperature and pressure gauges installed in appropriate locations to allow for system performance evaluation, and all condensate must be routed back to the inlet separator.

5.0 CONTROL PANEL

(1) The main control panel, switches, and indicator lights will be NEMA 4 rated. Motor controls, equipment, and wiring shall be in accordance with NFPA 70. The main control panel will be mounted on the vacuum pump skid.

(2) The main control panel will include a full voltage magnetic starter for the vacuum pump with 3-phase overload protection and reset switches, a 460/110 volt transformer with fused primary and secondary, a 15 AMP 110V GFI outlet, and a main power disconnect. A Hand-Off-Auto (HOA) switch will be provided for the liquid transfer pump. A start button will be provided for the vacuum pump, and should send power to the liquid transfer pump HOA switch, and simultaneously start the vacuum and seal fluid circulation pumps. A stop button will be provided for the vacuum pump, that will simultaneously stop the vacuum and seal fluid circulation pumps. An oversized total stop button that will interrupt power to all components, except allow manual (hand) operation of the liquid transfer pump will also be provided.

(3) Green status lights, indicating motor operation, will be provided for the liquid transfer pump, the vacuum pump, and vapor conditioning equipment motors. Red alarm condition lights will be provided for each inter-lock fault, including motor overload. All status and alarm condition lights will be push to test type. No auto restarts will be allowed, therefore, an alarm condition reset button will also be required.

(4) Appropriate safety inter-locks, other than those described in the previous sections, must be designed into the system for safety and prevention of equipment damage. In addition, a minimum of two spare inter-lock relays, wired for total system shutdown, will be provided to interface with externally provided treatment equipment.

6.0 OPERATING PARAMETERS/AVAILABLE UTILITIES

Inlet Vapor Flowrate:	500 ACFM
Inlet Water Flowrate:	1 GPM
Temperature of Inlet Stream:	60°F
Particle Size of Sediment Filtration:	10 micron
Required Level of Vacuum:	25 inches Hg
Ambient Air Temperature:	110°F
Temperature of Final Vapor Stream:	110°F
Relative Humidity of Final Vapor Stream:	40%
Electrical Utilities:	460V, 3 Phase

7.0 PAINT

(1) All ferrous metal surfaces, excluding shafts, gears and bearing surfaces shall be prepared with a minimum of a power tool cleaning (SSPC-SP3). The surfaces shall then be shop-painted with a buyer approved system of primer and top coat. The color will also be approved by the buyer prior to application.

8.0 GENERAL CONDITIONS AND WARRANTY

(1) Shop drawings will be provided, for approval, prior to fabrication. The buyer shall be informed of factory testing at least one week prior to testing, and shall have the option of witnessing the tests. Installation instructions, including all equipment support and anchor requirements, will be provided one week prior to delivery of the system, and operation and maintenance manuals with a list of recommended spare parts must be provided upon delivery of the system.

(2) A minimum one year material and workmanship warranty must be provided for a bid to be considered. A warranty for seal fluid carryover in the vacuum pump exhaust stream must also be provided (10 ppm or less is desired with oil seal units).