Masters Project

AN EVALUATION OF SUCCESSFUL ENVIRONMENTAL SITE RESTORATION PROGRAMS

By

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ABSTRACT

Companies are often faced with making difficult decisions to address environmental contamination at their properties. There are multiple reasons why companies choose, or are forced, to address environmental contamination. These reasons range from a government mandated enforcement order, discovery of contamination during an acquisition or divestiture, or the redevelopment of a closed facility. Within each of these scenarios, there are multiple definitions of success. Success can be defined from minimizing cost, redeveloping properties for residential purposes, or avoiding litigation from third parties or the government. Companies often design their remediation programs after they have determined their definition of success.

As part of its expansion in the United States, Siemens Energy & Automation, Inc. (SEA) has grown mainly by buying existing manufacturing companies. The majority of these acquisitions were conducted in the late 1970's and 1980's before the establishment of formal environmental due diligence procedures. Thus, the environmental condition of these properties were unknown until different sets of circumstances brought them to light and forced SEA to deal with them appropriately.

This project will evaluate three case studies from SEA locations in Alabama, Ohio, and Illinois. The remediation of each of these locations was designed to achieve different goals. Remediation goals for each location were defined by SEA management with the assistance of legal counsel and environmental consultants. The case studies will present the background of each location, what the objectives were for each location, review the technologies used to address the environmental problem and evaluate if the solutions implemented were successful in achieving the stated objective.

A tool called the Remediation Program Evaluation (RPE) matrix will be used to assess each of the cases. The matrix has been designed to evaluate several elements that ultimately dictate the success of site remediation programs. This project offers the opportunity to respectively evaluate site remediation programs and determine the utility of the RPE for future use in site remediation planning. By utilizing the RPE in future cases, it will increase the likelihood that remediation projects will be successful in achieving their objectives.

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Section 1.0 – Introduction

Industrial development of the United States has led to numerous innovations that are enjoyed today. Advances in medicines, development of consumer goods, and mass production of vehicles have raised the standard of living in the U.S. and made it the strongest nation in the history of the world. As part of these advancements, chemicals were used to conduct certain processes. Examples include the cleaning of metal parts with solvents, insulation of electrical equipment with Polychlorinated Byphenols (PCB), and use of metals in solution to enhance protection of products in certain harsh environments. Chemical use, and creation of them, has gone on since the industrial revolution began in the mid-1800's. This chemical use has led to problems that for the most part, were unforeseen.

Prior to 1970, no true environmental laws existed that regulated to use and disposal of chemicals used in manufacturing processes. Spent chemicals were often dumped down sewers, deposited on factory sites, buried on factory sites, sold to third parties for use, and used liberally on properties for things such as dust and weed control. In 1976, the Resource Conservation & Recovery Act (RCRA) was created to regulated broad categories of spent chemicals as waste. It required tracking of waste through a standard document called the uniform hazardous waste manifest, required inspections of waste storage locations, and mandated special facilities to be established to treat, store, and dispose of hazardous wastes. Further legislation was passed by the federal government in the early 1980's in response to the contamination discovered at Love Canal in New York State. This act, the Comprehensive Environmental Response and Compensation Act (CERCLA) established strict liability to parties who disposed of wastes at a given location. These could be old abandoned landfills, manufacturing sites, or any other area where contamination was discovered. Individual states then followed the federal governments lead by developing state specific programs that are usually more stringent than federal law.

Companies are often faced with making difficult decisions to address environmental contamination at their properties. There are multiple reasons why companies choose, or are forced, to address environmental contamination. These reasons range from a government mandated enforcement order, discovery of contamination during an acquisition or divestiture, or the redevelopment of a facility that is closed. Within each of these scenarios, there are multiple definitions of success. Success can be defined by from minimizing cost, redeveloping properties for residential purposes, or avoiding litigation from third parties or the government. Companies often design their remediation programs after they have determined what their definition of success is.

As part of its expansion in the United States, Siemens Energy & Automation, Inc. (SEA) has grown mainly by buying existing manufacturing companies. The majority of these acquisitions were conducted in the late 1970's and 1980's before the establishment of formal environmental due diligence procedures. Thus, the environmental condition of the properties were unknown until different sets of circumstances brought them to light and forced SEA to deal with them appropriately. This project will evaluate three case studies from SEA locations in Alabama, Ohio, and Illinois. The remediation of each of these locations was designed to achieve different goals. Remediation goals for each location were defined by SEA management with the assistance of legal counsel and environmental consultants. The case studies will present the background of each location, what the objectives were for each location, review the technologies used to address the environmental problem and evaluate if the solutions implemented were successful in achieving the stated objective.

This will be accomplished by use of a qualitative toll called the Remediation Program Evaluation (RPE) matrix. Use of the RPE in this project is to retroactively evaluate the three case studies presented in this report and determine if the initial objectives were achieved. Also, the RPE will help evaluate what elements of a successful remediation effort were either missing or undervalued. Ultimately, the goal of evaluating these cases with the RPE is to establish a sound evaluation method that can be used in the future when developing remediation programs to address contamination at any site across the U.S.

Section 2.0 – Objectives

There are several objectives that this project is designed to evaluate. These objectives are:

- Evaluate the success of each individual case based on the objectives initially defined by SEA as key to the successful remediation of each site.
- Determine if the correct objectives were chosen based on the outcomes of the remediation program.
- Evaluate each case with a RPE matrix to show if, and how, successful each objective truly was.
- Determine the viability of the RPE matrix as a viable tool for future planning purposes as a result of observations from the three cases evaluated.

Section 3.0 – Materials and Methods

The majority of the case information will come from existing technical environmental reports that SEA has obtained through the investigation and remediation of three cases presented. Supplemental information will be provided in this section to describe the various remediation alternatives available to address environmentally contaminated sites. Each site will then be evaluated using the RPE matrix to assess not only the initial objectives defined for each site, but the others that may apply. The goal in using the RPE matrix is to clearly identify whether or not the remedy selected to address each site was truly successful and discuss the utility of using the RPE for future site remediation planning. There are varying degrees of success in addressing environmentally contaminated properties, which will be captured within the RPE.

The evaluation should show the following:

- Were the key objectives met for each case?
- Was completion of the key objectives truly successful?
- Were the right objectives chosen in the first place?
- If an objective was not met, was it truly within SEA's control?
- Will use of the RPE on future sites be valuable?

3.1 – Background on Remediation Alternatives

The intent of this section is to briefly discuss various remediation technologies that can be implemented to address environmental contamination in soil and groundwater. Since the advent of environmental clean-up regulation in the late 1970's, remediation technologies have become more sophisticated in nature. Below are summaries of the various remediation technologies that SEA evaluated to address contamination at the three case sites discussed within this document.

Excavation of Contaminated Soils

The excavation approach is relatively self explanatory. Soils are investigated for recognized contamination levels through analytical sampling methods. Soils are sampled until either the state or federal regulatory standard is found or to non-detect. Comprehensive sampling programs are important because they allow for a complete understanding of a contaminated area so that costs can be estimated. Quantities of soil to be excavated are estimated. Soils are then removed and sent for treatment or disposal. Excavation programs are labor intensive, meaning that large equipment is used to excavated, stockpile, load, and transport soil for disposal. In most cases, soils are sent to off-site landfills or incinerators for disposal.

Groundwater Pump & Treatment

In groundwater pump and treat programs, a series of groundwater pumping wells are installed within a groundwater plume. The intent is to capture, extract, and control the migration of the contaminants in groundwater. Extracted groundwater is then treated and injected back into the groundwater table or is discharged to a local sanitary sewer system. This approach was one of the first remedies utilized to address groundwater contamination at sites. Although its use still exists today, other technologies have been discovered that are more effective from a time, cost, and effectiveness standpoint that have reduced its use as an optimal solution.

Air Sparging – Soil Vapor Extraction (AS/SVE)

The AS/SVE system begins by injecting air is into groundwater through a series of sparging points. The air itself is heated through use of an air compressor and turns liquid phase contaminants in groundwater into vapor. The vapors then rise to the ground surface and are collected through a series of vapor extraction points usually placed above the groundwater table. The collected vapors are then treated through granulated active carbon vessels. The clean air is then discharged into the atmosphere. AS/SVE is considered a longer term remedy. It usually takes anywhere between three to eight years for it to be truly effective. It works best in groundwater zones that are comprised of sand and gravel because the introduction of air and removal of vapors is easier in these particles that are much less cohesive. The initial capital cost is relatively low. The only equipment needed is an air compressor and a blower unit which operates the vapor extraction portion of the system.

Figures 1 & 2 – SVE vacuum blower unit and southern piping connection system at SEA Ohio site.

<u>In-Situ Thermal Desorption (ISTD)</u>

ISTD is a process that utilizes electricity to generate heat to remediate both soils and groundwater. ISTD utilizes multiple series of heater wells distributed across a contaminated area. These heater wells are then augmented with vapor extraction points to collect vapors that are mobilized. Soils and groundwater are heated first by raising the temperature of water moisture in the subsurface. As this occurs, steam fronts are generated that mobilize contaminants to the surface. The vapor extraction wells collect this steam, treat it through granular activated carbon vessels, and discharge the treated air to the atmosphere. ISTD is extremely quick and effective. Most projects last no longer than 2 years. In many cases, there is no detectable contamination left after ISTD is completed. The process is relatively expensive. It requires significant electricity usage and control equipment to treat contaminants collected.

Figures 3 & 4 – Photos of ITSD system installed at SEA Ohio Site

Soil Shredding

Soil Shredding is a process in which soils are excavated, treated, and then put back into place once remediation targets are reached. Soil shredding is very similar to excavation programs to the extent that soil sampling is needed to define excavation boundaries and similar equipment is needed to remove soil from the ground. Once soils are excavated, they are placed in a unit similar to a pug mill. The soils are then "shredded" or ground up to break it down into small particles. At this point, substances such as quick lyme are added to react with and "treat" contaminants that are in the soils. After treatment, the soils are stockpiled and sampled to ensure treatment standards have been met, and then they are placed back into the original excavation areas. Soil shredding is a relatively labor intensive process requiring operators for excavation, backfilling, sampling, and treatment steps of the process. Shredding can be very successful providing that levels of contamination are estimated accurately up front. Knowing the precise amount of contaminant concentrations is important so that the correct amount of lime can be added to properly treat contamination. Shredding is a quick but expensive remedy due to the high amount of labor required to carry out the process.

Figure 5 – Typical pug mill used for soil shredding (Source: US Microbics, Inc.)

<u>Chemical Injection</u>

Chemical injection programs are effective in treating contaminants in either soils or groundwater. Types of chemicals used are sodium and potassium permanganate, molasses, and ozone. The types of groundwater aquifers dictate what chemical is used to obtain the best results. The goal of the program itself is to inject the appropriate chemical into the subsurface and cause it to react with solvent contaminants. These chemicals then act as accelerants for carbon sources in the ground. As they react with solvents they are then consumed naturally which results in solvents being broken down into ethane's which are natural in the environment and not harmful. As in most cases, a comprehensive investigation program is needed up front to identify areas that require treatment. Chemical injection programs require additional information such as pH, soil densities, moisture content, and iron content. These factors are critical in determining an appropriate reactant chemical that would be a suitable remedy for a site. Based on the level of contamination present, pH, and soil densities the amount of chemical required to treat areas are calculated. The same parameters determine the spacing of injection points to provide adequate coverage in the volume of soil or groundwater that requires treatment. After the chemical is injected, results are monitored through both sampling of soils or groundwater depending on which media has been targeted. Additional injections may be necessary depending on results.

Under most circumstances, chemical injection programs are relatively passive remedies. They rely on a catalyst, permanganate, to react with a contaminant (solvent) in the natural environment. The initial cost for the injection program is relatively low because there is no capital equipment needed with other technologies and there is no ongoing maintenance of systems. The cost increases if additional injections are needed. Since this type of approach is a passive remedy, it may take several years to achieve regulatory standards.

Figure 6 – Typical rig used for chemical injection programs (Source: Zebra Environmental)

<u>Dual Phase Vapor Extraction (DPVE)</u>

Dual Phase Vapor Extraction (DPVE) is very similar to AS/SVE. It's targeted mainly at solvent contamination in soils. DPVE utilizes a series of vapor extraction wells placed in areas of soil contamination. The wells are then operated by a blower until which creates a vacuum on the extraction points. The air collected is treated through granular activated carbon to remove contaminants and then discharged into the atmosphere. The carbon itself is then treated and can be reused. DPVE works very well in unconsolidated soils, sand and gravels. It can also work well in consolidated soils, clays and silts, but requires a tight spacing of extraction points to be effective. Capital costs for DPVE are relatively low. Extraction points are installed and connected through piping to the blower unit and carbon vessels. Electricity costs to operate the blower unit are relatively minimal. DPVE is more of a passive remedy. It typically takes a longer period of time to treat contaminants and can often require additional treatment with another remediation technology. DPVE works very well in areas of high contamination, but on areas with low starting concentrations of contaminants has a lower return.

Figure 7 – Typical DPVE wellfield layout (Source: Plexus Scientific)

3.2 – Alabama Case Study

3.2.1 – Site Background

The facility was constructed in 1952 and was used as a transformer maintenance and repair facility. The property is roughly 2.5 acres and the building and asphalt parking occupy roughly 100,000 sq.ft. of the site. SEA assumed ownership of the property in 1998. The Alabama location was part of a larger transaction that took place with Viacom, Inc. The facility conducted repairs, replaced interiors, and the retrofit filling and draining of PCB transformers. PCB oils were drained and transferred through a three inch steel underground line to a 5,000-gallon above-ground holding tank. New oils were then transferred from a 5,000-gallon new oil tank to the awaiting transformer. Other activities associated with the repair processes included: loading/offloading of transformers from railcars, cleaning and washing of transformers and parts, painting, machine shop fabrication, motor repair, etc. Soon after SEA acquired the property, it ceased the practice of repairing transformers containing PCBs. By December 1998, it ceased all transformer and motor repairs at this site.

In the fall of 2001, the City of Birmingham, Alabama conducted surveys of its sewer system. The city's goal of this survey was to identify abandoned or broken lines so that they could either be repaired or removed from their sewer system. The city was in the process of separating its sanitary and storm sewer systems in response to concerns raised by USEPA. The city located a broken line on SEA's property and requested permission to investigate it. SEA granted the city permission and in August 2001, the line was investigated by the city. During the investigation, a representative of the Alabama Department of Environmental Management (ADEM) collected a sample of the excavated soil. In November 2001, SEA was notified by ADEM that PCB was found in the soil sample and requested that SEA contact USEPA for guidance on clean-up of the contamination.

In December 2001, SEA performed a limited investigation of the area around the broken sewer line. The goal of the investigation was to gauge if PCB contamination was confined to this localized area. At a depth of three feet below surface, PCB sample data indicated that soils had been contaminated and contained PCB concentrations above regulatory limits. Additional sampling and analysis, conducted as part of the excavation, indicated that PCB contaminated soils exceeding regulatory limits existed to depths of at least 10 feet below surface. A total of 160 tons of contaminated material was removed. Due to the discovered depths of contaminated soil, a decision was made to cease the excavation and perform additional assessment work.

During January through March of 2002, a comprehensive site investigation program was implemented by SEA to determine the extent of PCB contamination at the site. Over 245 soil borings were taken at the site. Each soil boring was sampled at 2-foot intervals to a depth of 16 feet. In addition, four groundwater monitoring wells were installed to determine groundwater flow direction and gauge water quality. Interior surfaces of the building were sampled to determine if they were contaminated by PCB. The results of this program yielded that there was wide spread PCB contamination over the majority of the site.

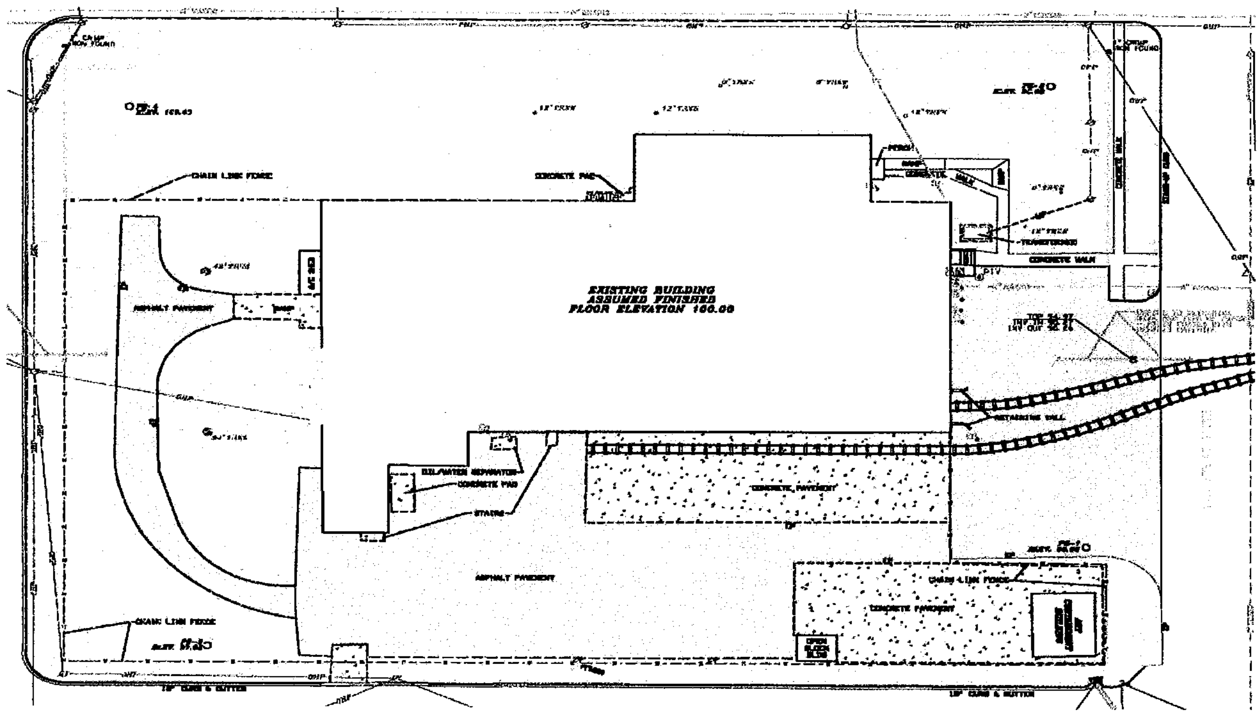

Figure 8 – Overhead plan of SEA's Alabama site

3.2.2 – Initial Site Objectives

SEA felt, given the concentrations found at the site, that immediate action was necessary to address threats to human health and the environment. This opinion was reinforced by conversations that SEA had with USEPA. SEA's objectives in addressing this site were:

- Proceed with a remedy that will quickly and effectively reduce the impacts of the site.
- Retain a qualified contractor & consultant experienced with PCB matters to assist with the remediation program.
- Conduct remediation program in most cost effective manner.
- Keep visibility at the site low during operations due to other PCB sites in the area, namely at Anniston, Alabama.
- Conduct remediation program in voluntary manner, rather than under the threat of enforcement from USEPA.
- Remediate soils to below 100 PPM and utilize engineering controls such as caps and encapsulation to control the remaining PCB at the site.

- Return the building to suitable use to it meets occupancy requirements under the PCB rule.

The 100 PPM threshold was the key regulatory standard evaluated as part of forming the objectives and selecting the remedy for this site. The PCB rule allows a site to be remediated to concentrations below a 100 PPM threshold providing that residual concentrations are managed by engineering controls. In this case, those controls consisted of asphalt and soil capping of areas, encapsulation of concrete, and cleaning of effected surfaces. The other alternative was to remediate the site to 1 PPM, which is considered clean under the PCB rule. The cost differences in these two approaches were considerable. Estimates for the 100 PPM option were $5.1M while the 1 PPM option was $12.2M. The 1 PPM option required nearly twice the amount of excavation and a total demolition of the existing building.

3.2.3 – Summary of Remedy Selected For Site

SEA evaluated two remedial alternatives to address the issues at the site. The first was direct excavation of the contaminated soils and disposal at an offsite location. The second was soil treatment via ISTD. The excavation process is relatively straight forward. Quantities are estimated that require removal and total project costs can be developed rather quickly. As described in more detail in Section 3.1, ISTD utilizes heat to mobilize contaminants in soils. Those contaminants are then collected, treated, and results in cleaning of soils. ISTD is also a relatively expensive process to implement. A quick and timely response was SEA's main goal at this site. SEA felt that ISTD was neither a fast enough remedy and was cost prohibitive.

SEA chose to excavate the impacted soils in and outside of the building and send those soils to an offsite location. The excavation remedy was selected because it could be completed in a very quick fashion, six months, and reduced the risks at the site. Although offsite liability was considered in this analysis, SEA felt that the long term risk was low. This was due to the fact that this soil was being disposed of at a location that SEA already had a significant amount of waste at. This location was a Toxic Substances Control Act (TSCA) approved landfill in Emelle, Alabama. This landfill is certified to handle waste materials that are specifically regulated under TSCA. There are only a few landfills in the country that can handle TSCA wastes. The excavation program began at the site in July 2002 and was completed, with the site fully restored, by February 2003.

3.3 – Ohio Case Study

3.3.1 – Site Background

The site was built in 1956 and serves as the manufacturing hub for a sister facility that is 20 miles north of the site. This business produces low voltage safety switch and circuit breaker apparatuses mainly for use in industrial applications. This site has produced components for safety switch and circuit breaker products since it was built. The components are manufactured in this location and shipped to the sister facility for final assembly. The relationship between these two locations has not changed through multiple owners of the business. Current manufacturing activities include plating, stamping, molding, welding, and metal deburring. The facility was acquired by SEA from another entity in 1983.

As part of the electroplating process, chlorinated solvents had been used for degreasing parts prior to plating inside the main building. Trichloroethene (TCE) was the primary degreasing solvent used at the facility during the 1950s, 1960s, and 1970s. In 1978, 1,1,1-trichloroethane (TCA) replaced TCE as a degreaser. Use of all chlorinated solvents at the property ceased in 1993. Prior to 1980, there were two wastewater treatment settling basins located south of the main building. The settling basins were used to de-water wastewater sludges generated from electroplating operations. Discharges to the wastewater treatment settling basins included metal-bearing waters from plant operations and chlorinated solvents from spills to the plant floor. The wastewater treatment basins were last used in 1980 and closed in 1981.

In 1990, SEA began a limited investigation on the south side of the building where the former wastewater basins existed. SEA desired to expand the existing facility to the south and was advised by legal counsel to investigate this area prior to any construction. The results of the investigation found soil contaminated with TCE & TCA as well as various metals generated from the electroplating process. TCE & TCA impacts appeared not to be bound to this area.