Green Remediation Using Renewable Energy and Automation

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ABSTRACT

The project reduced contaminants associated with gasoline at a retail fuel station while implementing green practices to reduce the overall, negative environmental impact. Groundwater gasoline range organic concentrations at the site were 500 mg/L prior to system startup. Advanced technologies and automation were implemented to minimize the energy requirements, allow for flexibility in flow rates, minimize the operations and maintenance requirements, and maximize system run time. An electric catalytic oxidizer with exhaust heat recovery was used and energy consumption was tracked to analyze efficiency. Variable frequency drives on the blower and discharge water pump were utilized for more efficient variable speed operation. Solar powered groundwater sampling events were conducted using battery operated equipment charged in a photovoltaic equipped site trailer. Automated data acquisition with remote upload capability was utilized to minimize site visit fuel consumption and labor.

Keywords: green remediation, automation, multi-phase extraction, solar powered trailer, variable frequency drive

1 BACKGROUND

A release of gasoline was documented at the site in 1998 as part of an underground storage tank (UST) upgrade. Despite multiple previous attempts at remediating the site, elevated concentrations of hydrocarbon constituents above the local clean up criteria for soil and groundwater existed in June, 2008. At that time, a corective action plan (CAP) was submitted to the local regulatory agency proposing the system described herein.

The EPA specifically recognizes six core elements of green remediation with soil vapor extraction (SVE) Systems: Energy, Air, Water, Land & Ecosystems, and Materials & Waste [1]. These elements were incorporated in development of a comprehensive and proactive CAP for remediating the site, while maintaining a low level of environmental impact.

2 TECHNOLOGY SELECTION

After completion of a small scale pilot test and remedial alternatives analysis, multi-phase extraction (MPX) was selected as the primary active remediation technology. MPX was not the cheapest technology or the easiest to implement, but it had the highest anticipated effectiveness out of all of the alternatives. Increased effectiveness was anticipated to result in lower over environmental impact of the remedial technology by reducing the duration of active remediation.

Air sparging was identified as a potential contingency technology and ultimately monitored natural attenuation (MNA) will complete the remedial process.

3 SYSTEM DESIGN

Remediation system design commenced once the CAP was approved by the local regulatory agency. Several constraints were managed during the design process including those listed in Table 1.

Constraint	Description
Ongoing Site Operations	The retail gas station was to remain open through the duration of the proejct.
Residential Proximity	Local codes required no more than 55 decibals audible at the property line.
Traffic	Trench paths and extraction wells were to be located to minimize operational impact.
Limited Floor Space	A 5’X7’ restroom and the rooftop were available for equipment siting.
Power Availability	Site power was limited to 240 volt, single phase.
Emissions	Vapor treatment required to meet local regulatory standards.
Water Discharge	Water required to meet City and County pretreatment standards and discharge limits.

Table 1: Select Design Constraints for MPX System

Equipment was selected with a focus on performance automation and energy efficiency during the anticipated variable operation modes and settings. The mechanical components of the system include three extraction wells, one vapor liquid separator (VLS), a VLS pump and water treatment system, an automated vapor control valve (VCV), a vacuum pump, and an electric catalytic thermal oxidizer (CATOX). A control and communication system was installed for process control and data acquisition. The

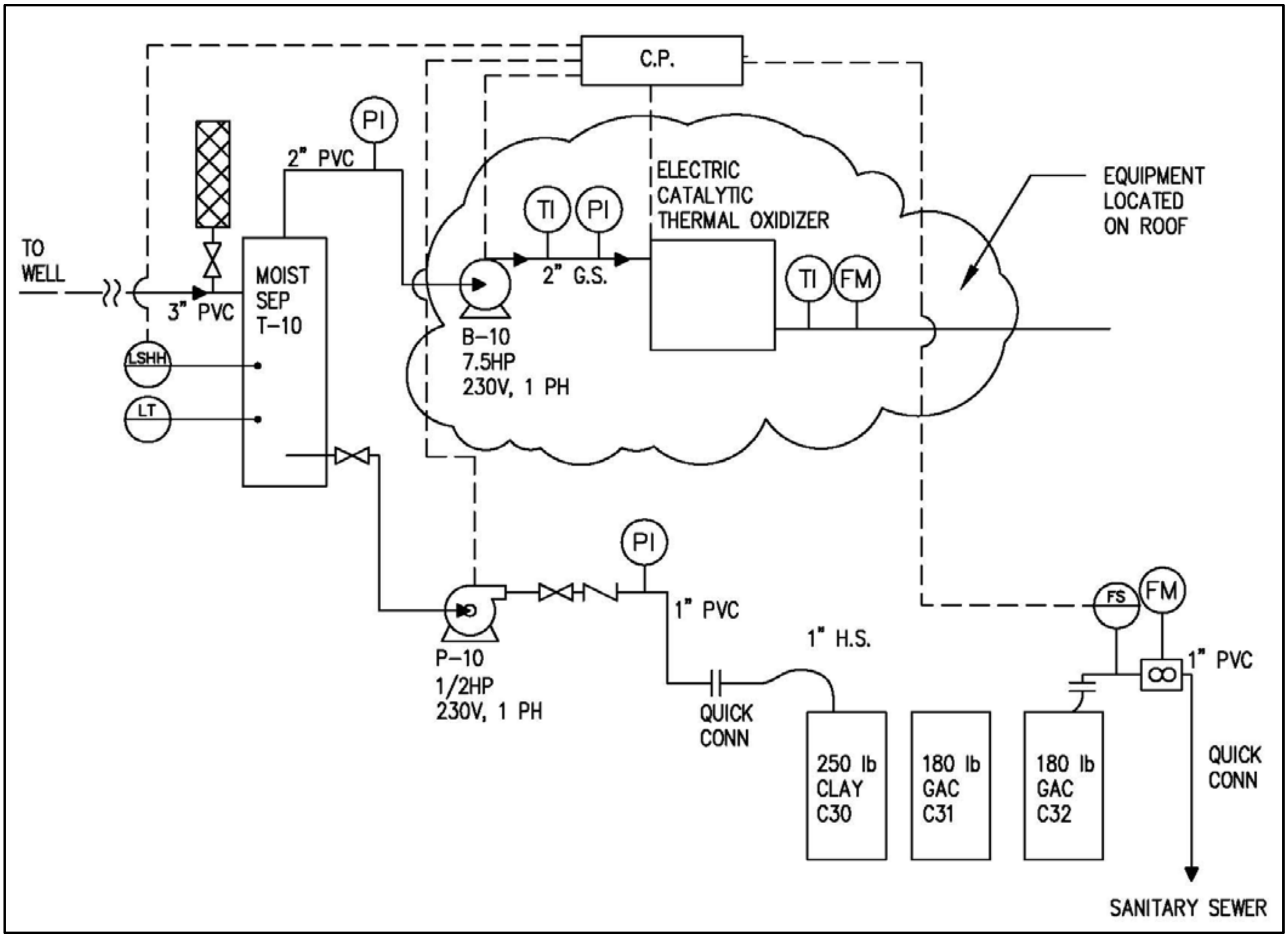

Figure 1: Process and Instrumentation Diagram

system component design is presented in the process and intrumentation diagram shown in Figure 1.

3.1 Vaccum Pump

The selected vacuum pump utilized to transport water and vapor from the extraction wells to the treatment system was a 7.5 horse power rotary claw. A variable frequency drive (VFD) pump controller was utilized to allow for energy efficient speed adjustments to the vacuum pump.

The manufacturer specified sound level rating for the vacuum pump is 80 decibels acoustic (dBA) and local regulations require sound levels at the property line to be less than 55 dBA. The EPA recognizes that adverse impacts on wildlife and the community can be reduced through use of a pump housing [1]. The vacuum pump was mounted in a sound enclosure and located on the roof of the building to comply with regulations and minimize the audible effect on the environment. During normal operation, the vacuum pump is not audible at the property line.

3.2 Electric Catalytic Thermal Oxidizer

The vapor treatment device selected was an electric CATOX as shown in Figure 2. The CATOX includes a 7.2 kW heater, onboard control system, and economizer heat exchanger for preheating of the incoming vapor. The CATOX controller operates the VCV which mixes the extracted vapor from the subsurface with ambient air to adjust hydrocarbon loading across the catalyst. By controlling the VCV, the CATOX continually maximizes the destruction rate of the system without operator input.

The automated control of hydrocarbon loading across the catalyst resulted in extended operating periods. Spikes in extracted vapor concentrations which have the potential to overheat the CATOX resulting in system shutdown were mitigated by the VCV. Low vapor or high moisture conditions that have the potential to extinguish the flame source in a propane fueled CATOX were not an issue with the selected electric CATOX. In the first 18 months of operation the system ran a total of 88.6% of the time inclusive of all downtime associated with maintanance and configuration modifications.

Figure 2: Electric Catalytic Oxidizer Installed On The Roof

3.3 Vapor Liquid Separator Pump

The VLS pump selected was a 0.75 horsepower centirfugal pump. The VLS pump is activated by a proportional integral derivative (PID) controller with input from a continuous level transmitter installed in a parallel site glass on the VLS. The PID controller adjusts pump speed using a VFD. During periods of high groundwater removal, the PID controller allows for continuous operation of the VLS pump which minimizes stop and start events. Reducing stop and start events minimizes the potential for a pump prime loss which would result in a VLS high level alarm shutdown.

3.4 Control and Communication

A programmable logic controller (PLC) was selected for data acquisition and control. A remote terminal unit (RTU) and associated communications service was selected for remote access of system information. Using a secure web interface, data was available to the operations and management team including alarms and instantaneous CATOX temperature data. The RTU was set up to call the mobile phone of the equipment operator if there were any system alarms.

Automated alarm reporting and data collection reduced the frequency of mobilization to the project site. Site visits were required, on average, once per month.

4 SAMPLING

4.1 Solar Powered Groundwater Sampling

Quarterly groundwater sampling events were conducted utilizing battery operated equipment charged in a photovoltaic equipped site trailer shown in Figure 3.

Figure 3: Battery Operated Groundwater Sampling Equipment And Solar Powered Trailer In Background

The solar powered trailer includes two 130 watt polycrystalline silicon panels connected to a solar controller. The solar controller distributes power to two six volt, deep cycle goft cart batteries. The batteries feed through a power inverter which provides 300 watts of steady fequency, 120 volt power. The power is distributed to recepticles located on the interior of the trailer and allows for secure, overnight charging of the battery operated equipment.

Utilization of renewable energy as a power source for remediation activities results in a lower environmental impact to the site. Prior to implementation of the solar trailer, groundwater sampling equipment was powered by a vehicle battery. The vehicle was left idling bewteen sample collection periods to make certain the battery remained charged. Utilization of solar powered sampling equipment eliminated the emissions and fuel consumption associated with idling vehicles.

4.2 Digital Data Acquisition For Groundwater Parameters

Handheld personal computers (PCs) were utilized for digital acquisition of groundwater parameter data during quarterly sampling events. The data collected and stored in the handheld PCs was uploaded to a file server and utilized in reporting without the need for any printing prior to final report submittal.

Digital recording of field data reduced the use of paper otherwised used in written recordings, minimized the time associated with transcribing and analyzing the data, and the battery operated units were charged with the solar powered trailer.

5 RESULTS

Extracted soil vapor concentrations have reduced substantially within the first two years of operation and onsite groundwater concentrations are trending downward. Figure 4 presents the decline in mass extraction rate. MNA is a technique of utilizing natural processess to degrade contaminants in soil and groundwater. MNA will be implemented once groundwater concentrations have been reduced to acceptable levels. The negative environmental impacts on the five EPA core elements of green remediation will substantially reduce upon transition to MNA.

The results include a system that consumes a total of 5.2 kW. Site visits are required once per month on average due to remote data collection and automation. The system has been up and running for 88.6% of the time for the first 19 months of operation inclusive of all downtime associated with maintenance and configuration modifications.

A typical SVE system consumes 77,600 kWh per year [1], whereas, the installed system has consumed 39,806 kWh per year to date. The estimated direct cost savings associated with the green remediation effort are 22.7%.

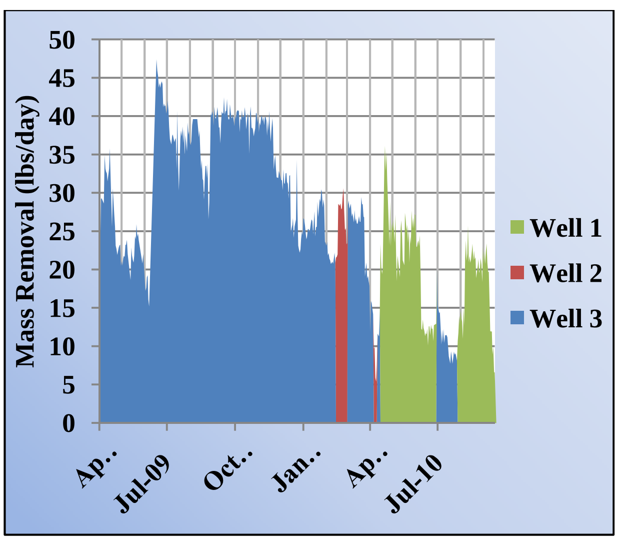

Figure 4: Extraction Well Mass Removal Rates

6 CONCLUSIONS

Incorporation of green remediation into MPX design and implementation may result in reducing the negative environmental impact through utilization of renewable energy and automation. The greatest quantifiable reduction of negative environmental impact of this project was associated with automation and its ability to limit transportation and labor associated with site visits.

Utilization of renewable energy in remediation projects can reduce negative environmental impact especially if existing practices include inefficient techniques. In areas where a power supply is difficult or costly to acquire, renewable energy in the form of solar power can be the best solution. In locations where engine exhaust is not acceptable, solar power is a viable solution.

REFERENCES

[1] United States Environmental Protection Agency, Office of Solid Waste and Emergency Response, "Green Remediation Best Management Practices: Soil Vapor Extraction & Air Sparging," EPA 542-F-10-007, 1-4, 2010.