Battelle Bioremediation and Sustainable Environmental Technologies Conference
June 27 – 30, 2011 Reno, Nevada

Managing legacy contaminants at a former oil refinery site in Wellsville, New York

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ABSTRACT

Many facilities exist in North America dedicated to the processing (refining) of petroleum hydrocarbons. For the "first generation" of these refining facilities (roughly defined by the authors as circa 1900 – 1970); little, if any environmental controls were imposed on the petroleum refining process. As a result, product releases to soil and groundwater commonly occurred.

Remediation of these sites has played a prominent role in the literature related to both A) in-situ bioremediation, and B) treatment wetlands. While in-situ attenuation of hydrocarbon-based compounds occurs naturally (with a positive effect on site closure), the net loading of hydrocarbons into the surficial aquifer can have unintended consequences which can influence future remediation outcomes.

In the case of the project site in Wellsville, New York, an oil refinery was operated by Sinclair from circa 1901 though 1958. Although refining operations ceased over 50 years ago, legacy contaminants persist at the site. In the case study site (western New York state), a constructed wetland treatment system was chosen to minimize life-cycle costs associated with long-term site closure. This system consisted of the following components:

- A cascade aerator (4 units in parallel) to oxidize iron to the Fe^{+3} state.
- A sedimentation pond to settle and remove ferric hydroxide precipitates
- A series of surface flow wetlands (3 in parallel) to further remove iron and also to remove residual organic compounds (notably aniline and nitrobenzene).
- A series of vertical flow wetlands (5 in parallel) with a reactive limestone media to add alkalinity to the water and buffer the effluent pH.

This system was commissioned in December, 2008. To date, the system has removed 98% of the influent iron, 99% of the influent aniline, and 94% of the influent nitrobenzene.

FACILITY DESCRIPTION

The Wellsville treatment facility consists of four major unit processes that are designed to reduce metals, organic compounds, and buffer the pH of the recovered groundwater. The unit processes can be summarized as:

- A cascade aeration system (4 corrugated metal pipes in parallel) to oxidize iron to the Fe^{+3} state.
- A sedimentation pond (0.16 ha) to settle and remove ferric hydroxide precipitates
- A series of surface flow wetlands (3 in parallel) to further remove iron and also to remove residual organic compounds (notably aniline and nitrobenzene). The surface flow wetland cells have a combined area of 0.7 hectares.
- A series of vertical flow wetlands (5 in parallel) with a reactive limestone media to add alkalinity to the water and buffer the effluent pH. The vertical flow wetland cells have a combined area of 0.07 hectares.

The system is designed to operate at a nominal flow rate of 840 m^3/day, but actual flow rates have exceeded this by 20%. A schematic of the facility is show in Figure 1:

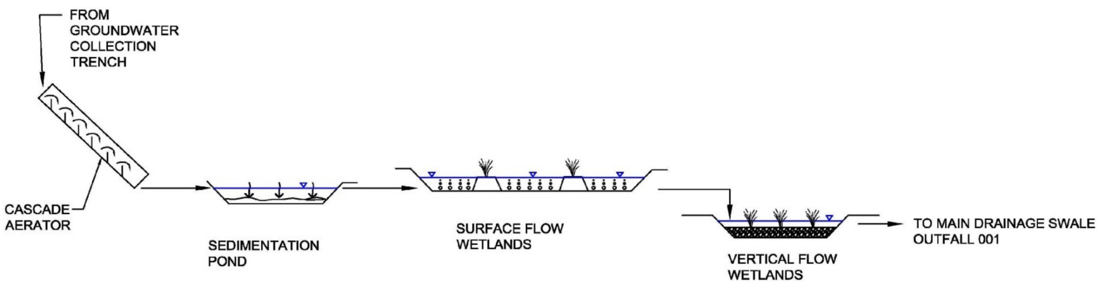

Figure 1 – Wellsville, New York Treatment Wetland Process Schematic

Due to the cold-climate application of the treatment wetlands (Figure 2), there has been some variation in treatment performance; mainly attributable to start-up effects.

Figure 2 – Wellsville New York Treatment Wetland Operating Under Winter Conditions

One major modification was made to the facility in March 2009, when an aeration system was installed in the deep zones of the surface flow wetlands, mainly to enhance aerobic degradation of semi-volatile compounds (notably aniline and nitrobenzene).

RESULTS AND DISCUSSION

Although extensive monitoring of the system has been done, primary constituents of concern include iron, pH, aniline and nitrobenzene. (Figures 3 through 6).

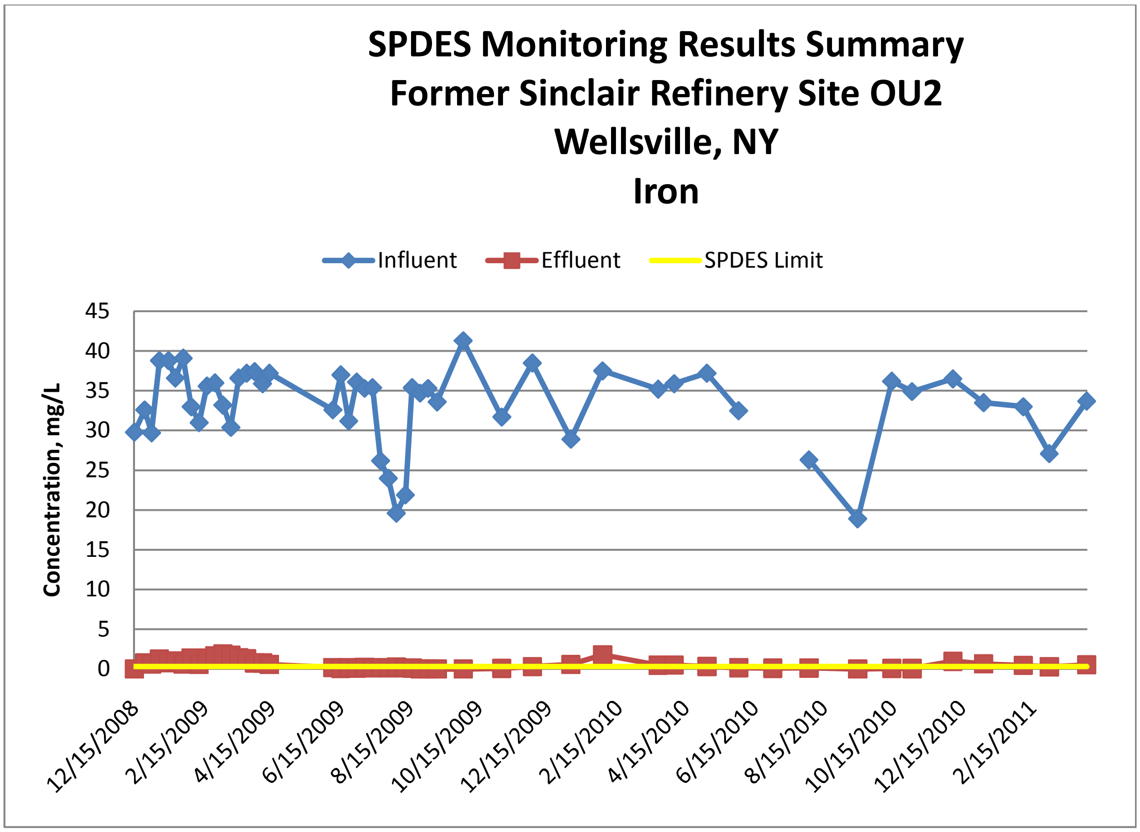

Figure 3 – Iron Removal at the Wellsville New York Treatment Wetland

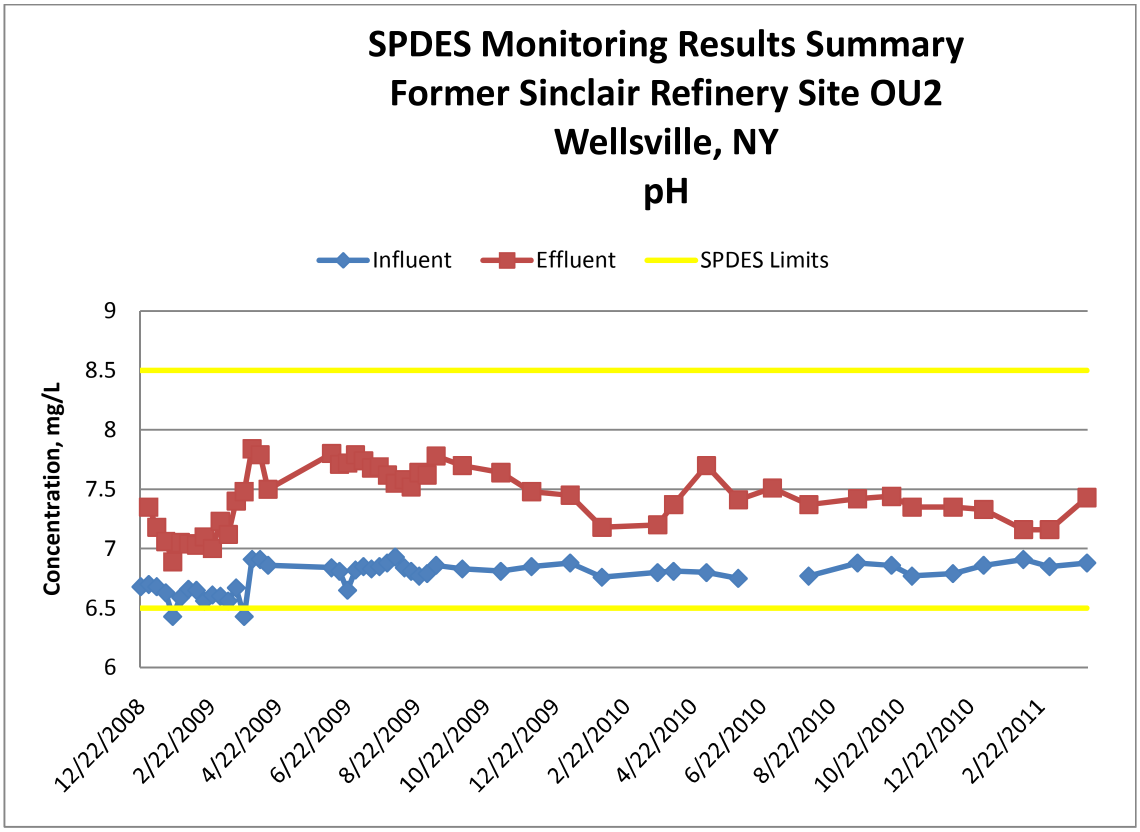

Figure4 – pH Buffering at the Wellsville New York Treatment Wetland

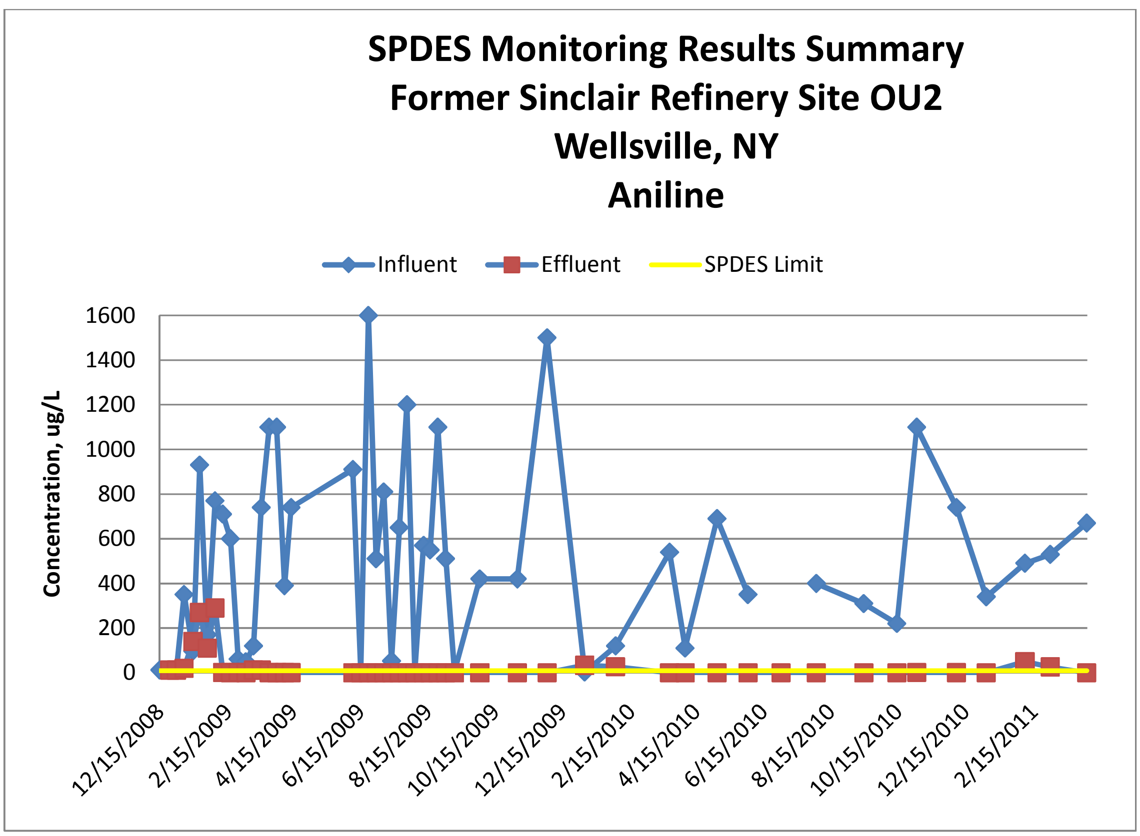

Figure 5 – Aniline Removal at the Wellsville New York Treatment Wetland

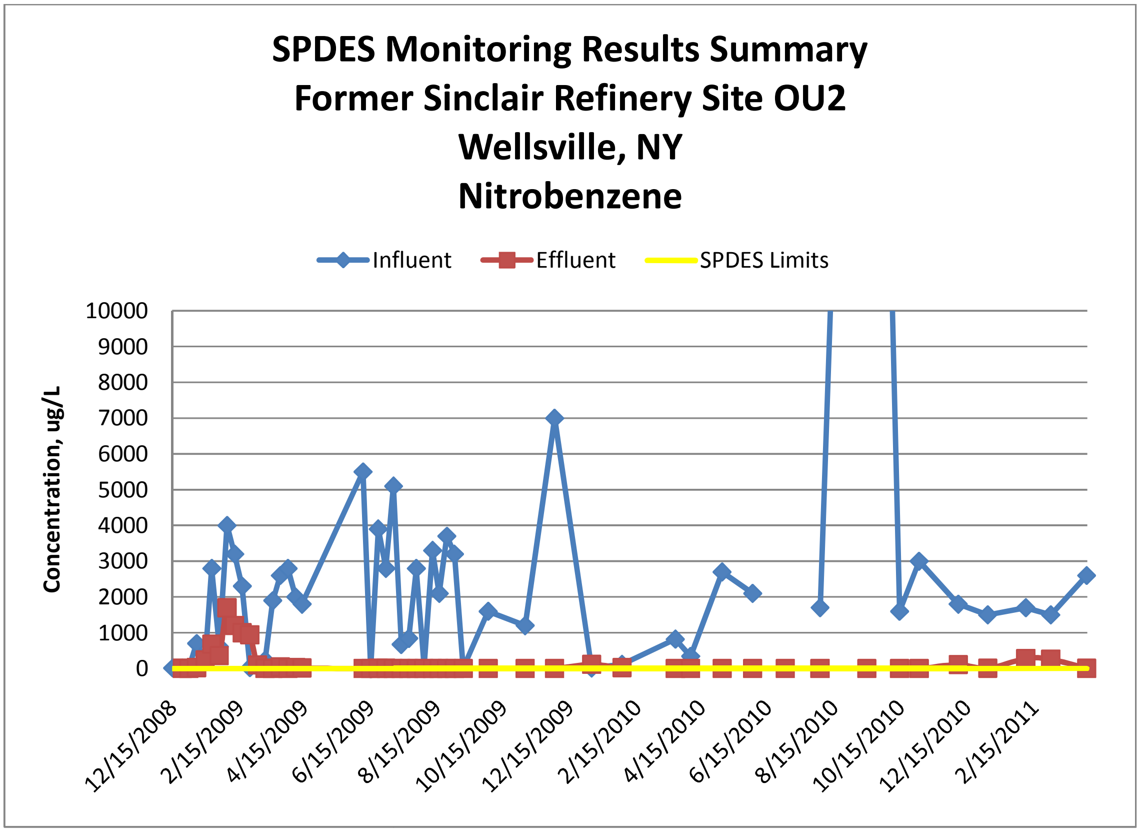

Figure 6 – Nitrobenzene Removal at the Wellsville New York Treatment Wetland

Removal rates for iron have averaged 98%; while removals for aniline and nitrobenzene have averaged 99% and 94%, respectively. Performance of the overall system suggest first-order removal coefficients of 135 m/yr for aniline and 122 m/yr for nitrobenzene, based on an assumed hydraulic characterization of the system as 5 tanks in series (TIS).

CONCLUSIONS

This case study illustrates the effective management of legacy contaminants at the former Sinclair refinery site in Wellsville, New York. The decision to trade between land vs. mechanical complexity (the wetland treatment area is about 10% of the overall site) has resulted in a highly stable treatment process that successfully meets regulatory expectations despite variations in influent concentrations.

ACKNOWLEDGEMENTS

This work is the result of the Atlantic Richfield Company (ARCO), now part of British Petroleum (BP).