Treatment of Hydrocarbon Impacted Groundwater from a Former Refinery using Multi-Stage Constructed Wetlands

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Objectives

- Provide overview of multi-stage constructed wetland groundwater treatment system design and operation

- Summarize operating conditions

- Discuss treatment efficiency and Lessons Learned
Site Background Information

• Location
  - Northwest New York State
  - Former Refinery now occupied by SUNY campus
  - 110 acre site adjacent to approx. major river
  - Majority of site within 100 yr. floodplain
  - Former Operations included: ASTs, Process Areas and Landfill
Project History / Regulatory History

- Project History
  - 1901 to 1958: Operated as refinery
  - 1958: Second major fire destroyed refinery
  - 1968: SUNY begins operation
  - 1983: Placed on National Priority List
    - Operable Unit 1: Central Elevated Landfill Area
    - Operable Unit 2: Site Wide Subsurface Groundwater
  - 1985 – ongoing: Investigation, Design, Remediation of OU 1 and OU 2
Project History / Regulatory History

- Operable Unit 2: Site Wide Groundwater
  - 1990s: Air Sparge/Soil Vapor Extraction
  - 1999 – 2008: Groundwater extraction from 3 recovery wells / treatment using GAC
  - 2008 - present: Groundwater extraction:
    - 8 large diameter collection sumps
    - 3,000-ft interceptor trench
    - Water treatment using multi-stage constructed wetlands
  - 2012 - present: Site Remediation Complete / Long-Term OM&M
Multi-Stage Constructed Wetland Treatment System

• Basis of Design:
  - Constituents of Interest (COI) include (volatile, semi – volatile organics, and metals)
  - Multi-stage aerobic process using cattails to remove organics and metals from groundwater
  - Existing topography facilitates hydraulic profile gradient
  - Limited O&M, except for iron solids management
  - Design flow rate: 80-150 gpm, 14 day retention time
Multi-Stage Constructed Wetland Treatment System

• Design Components
  - Cascade Aerators (4 corrugated culverts)
  - Sedimentation Pond (1 pond)
  - Surface Flow Wetlands (3 ponds)
  - Aeration basins in Surface Flow Wetlands to facilitate removal of organics during winter months
  - Vertical Flow Wetlands (5 ponds)
  - Splitter box structures to divert flow to wetland ponds
  - Gate valves to control water level / flow rate in Surface / Vertical Flow Wetlands
Construction of Wetland Treatment System

• Sequence of Work Completed
  - September 2008: Wetlands constructed
  - December 2008: Initial Start-Up, limited plantings
  - May 2009: Supplemental plantings
  - June 2010-2015: Iron Solids Removal (Sedimentation Pond Cleanout)
  - October 2011: Construction of Water Level Control Berm constructed
  - June 2012: Installation of muskrat exclusion fencing
Cascade Aerators

• **Purpose:**
  - Oxidize metals (Fe, Mn) and allow precipitate to settle out
  - Gas exchange for organic compound removal

• **Design Features:**
  - Divides flow equally from conveyance line discharge and splitter structure
  - 4 - 18 inch diameter, corrugated metal culverts
  - Discharges into sedimentation pond
Cascade Aerators 2011
Sedimentation Pond

• Purpose:
  - Allow settling of oxidized metal precipitates
  - Periodic removal of iron sludge for drying/disposal
  - Place in onsite drying beds / offsite disposal

• Design Features:
  - 60 mil lined pond, rip rap edges, concrete bottom
  - 18,000 sq. ft.
  - 248,000 gallons
  - Discharges to surface flow wetlands via gravity feed drain

• Sludge Drying Beds:
  - 4 concrete basins, 60-mil-lined, sand drainage filter system, periodic removal
Open Water, Surface Flow Wetlands (SFW)

• Purpose:
  - Aeration to remove volatile and semi-volatile organic compounds
  - Biodegradation to remove organic compounds
  - Supplemental metals precipitation and filtering of suspended solids

• Design Features:
  - 3 pond structures, each having:
    ▪ 3 aeration basins (4-5 ft. water depth)
    ▪ 2 benches for microbial and plant rhizosphere development (2-3 ft. water depth)
  - 91,000 sq. ft.
  - Combined 598,500 gallons;
  - 60 mil lined pond bottom/slopes, soil benches, vegetated edges
  - Discharges to vertical flow wetlands via gravity feed drain and weir gates
  - Benches planted with cattails (Typha angustafolia)
Surface Flow Wetlands 2011
Open Water, Vertical Flow Wetlands

• Purpose:
  - Restoration of alkalinity lost from metal precipitation
  - Supplemental suspended solids removal
  - Supplemental biodegradation

• Design Features:
  - 5 pond structures, each having:
    ▪ 1 passive limestone gravel aeration basin
    ▪ Gravel surface planted for microbial growth/rhizosphere development
    ▪ 60 mil lined bottom/slopes, vegetated edges
    ▪ Discharges to outfall 001 via siphon drains, pulsation
  - 29,000 sq. ft.
  - Combined 179,500 gallons
  - Limestone beds planted with cattails
Treatment Efficiency Results 2008 - September 2015

• Summary of Data Trends

  - Influent concentrations:
    - VOCs: Benzene 5-20 ppb; Ethylbenzene 2-35 ppb; Toluene 3-10 ppb; Xylene 5-25 ppb
    - SVOCs: Nitrobenzene: 2,000 – 12,000 ppb; Aniline: 50-1,600 ppb
    - Metals: Iron: 20 – 43 ppm; Manganese 3-7 ppm
Treatment Efficiency Results
2008 - September 2015

• Summary of Data Trends
  - Effluent concentrations significantly reduced:
    ▪ VOCs: Non-Detect
    ▪ SVOCs: Non Detect
  - Since 2008 approx. 450 million gallons of groundwater treated
Nitrobenzene Results

![Graph showing concentration of nitrobenzene over time in influent, effluent, SPDES limits, and SFW categories.]

- Influent
- Effluent
- SPDES Limits
- SFW

Concentration, ug/L

Multi-Stage Constructed Wetlands 111715
Conclusions and Lessons Learned

- Wetland treatment system effectively treats VOCs, SVOCs, and Metals
  - **Influent**
    - VOCs display decreasing trends
    - SVOCs display stable to decreasing trends
    - Metals display stable trends, naturally occurring at background concentrations above limit
  - **Effluent**
    - VOCs, SVOCs non detect
    - Metals vary seasonally, near NPDES Limit

- Winter operation requires augmentation using pond aeration system (SFW)
Conclusions and Lessons Learned

• Transplanting cattails more efficient than root stock plantings

• Muskrat Mitigation Program to include exclusion fencing / annual trapping / hut removal

• Highly cost-effective system, low carbon footprint, very sustainable long-term solution

• Iron solids removal is long-term O&M issue (annual)

• ROD requires site groundwater discharge to meet MCLs

• Operation of multi-state wetland treatment system expected for additional 30+ years

• Site reclassified as Class 4 (Properly remediated as specified in ROD)
Q & A

Thank you,