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Department of Environmental Protection
8800 Baymeadows Way West, Suite 100
Jacksonville, Florida 32256

Attention: Rick Rachal, P.G.
Section Supervisor, Waste Cleanup

Subject: Comments on the January 15, 2014 Feasibility Study
For the Confederate Park Site prepared by Geosyntec
Jacksonville, Florida
CRA Project Number 090476

Dear Mr. Rachal:

Pursuant to the request of the Florida Department of Environmental Protection (FDEP) at the meeting with the City of Jacksonville (Jacksonville) and Continental Holdings, Inc. (CHI) on October 31, 2014, **Conestoga-Rovers & Associates, Inc. (CRA)** is pleased to submit these supplemental comments to the above-referenced Feasibility Study Report (FS) prepared by Geosyntec and dated January 15, 2014. As directed at the meeting, CRA will present a variation of Alternative 1, entitled Alternative 1A, which uses hydraulic control along with institutional controls as part of a site remedy. CRA also provides a present-value cost-benefit comparison between Alternative 1A and Alternatives 2 and 3 (which incorporates a slurry wall and either excavation or *in situ* stabilization, respectively). Finally, CRA provides a recommendation with regard to the feasibility of the proposed alternatives.

Executive Summary:

The original FS described three Alternatives (Alternative 1: Hydraulic Control, Alternative 2: Excavation and a Slurry Wall, and Alternative 3: *In Situ* Stabilization (ISS) and a Slurry Wall) to address Underground Storage Tank (UST)-related and Manufactured Gas Plant (MGP)-related impacts to soil and groundwater at the Confederate Park site. Alternative 1A is a variation of Alternative 1 that was presented in the FS, which uses (i) alternative liners (i.e., Aquablok or concrete cloth), (ii) alternative discharge options for pumped groundwater (i.e., infiltration gallery or surface water), and (iii) additional recovery wells for groundwater recovery.

- **Liners:** Aquablok and concrete cloth both (i) block UST-related or MGP-related chemicals from entering surface water to below detectable levels (equivalent to the liner proposed in the FS), (ii) are widely accepted by Federal and state regulatory agencies, and (iii) are dramatically less expensive.
- **Pumped Groundwater Disposal Options:** Either discharge to an exfiltration gallery or surface water provides an efficient and much more cost-effect means to dispose of treated groundwater.

- **Groundwater Pumping Strategy:** Three recovery wells can be used to recover groundwater such that the existing steady-state plume is captured at 8.5 gallons per minute, even under worst-case conditions presented in a sensitivity analysis.

Calculating a Net Present Value (NPV) cost for the three Alternatives, Alternative 1A is more than $10,000,000 less expensive as compared to the other options. Importantly, the more expensive Alternative 2 and 3 provide no additional risk reduction. Furthermore, there are several advantages that Alternative 1A has, namely: no uncontrolled source material is left in place, optimization is possible to account for future changes in hydraulic gradients, it does not require re-routing of Hogan's Creek, utilities, or traffic, and no building demolition or floodplain infringements are required, it does not create real risks due to large-scale heavy construction or contaminated dust in the neighborhoods, it does not consume as much fuel or produce as many greenhouse gases, and Alternative 1A is dramatically less expensive. CRA recommends Alternative 1A to be included in the options considered acceptable in the FS, and we request a memorandum that clarifies the FDEP's policy that Alternative 1A is an engineering control that can be used, along with institutional controls, to obtain closure under Chapter 62-780 FAC.

<u>Background:</u>

The original FS described three alternatives by which the Confederate Park site (**Figures 1 and 2**) could be brought to closure under Chapter 62-780 Florida Administrative Code (FAC). All three alternatives required Risk Management Option (RMO) III, which incorporates on-site and off-site institutional controls to address impacts to soil and groundwater associated with UST-related and MGP-related source material present at the site.[1] Controls are needed because all three alternatives allow source material to remain in place, and all three Alternatives achieve closure by eliminating the hypothetical future exposure pathways. The three original remedial alternatives from the FS were:

- <u>Alternative 1 – Hydraulic Control:</u>
  - As the feasibility-level modeling results indicated, pumping from the decorative pond (5.5 gallons per minute (gpm)) and one additional recovery well (3 gpm) with a flow rate of 8.5 gpm is sufficient to hydraulically control the groundwater impacts associated with the UST petroleum and MGP-related groundwater impacts.
  - Per the FS, the recovered groundwater will be treated onsite through a granular activated carbon (GAC) unit and discharged into the publically owned treatment works (POTW).
  - In addition, the creek bed will be lined using a high-density polyethylene (HDPE) material.

[1] The FS prepared by Geosyntec did not address in detail the scope of institutional controls that will be required as part of any remedy selected for the Confederate Park Site.

- Alternative 2 – Barrier Wall with Excavation and MNA:
    - A vertical slurry wall (i.e., cement-bentonite slurry near infrastructure and soil-bentonite slurry on the remaining portions) with a geosynthetic clay liner cap will be constructed to contain the source material and constituents of potential concern (COPCs).
    - Excavation and backfill will be conducted for the impacted area beneath the creek and the portion of the park north of the creek.
    - The source material left beyond the barrier wall and excavation will be remediated through monitored natural attenuation (MNA), or a more aggressive means (e.g., hydraulic control) may be needed if the plume resulting from new flow patterns associated with the installation of the slurry wall is not at steady state.
    - Building demolition (i.e., parking garage structure on the Park View Inn property, and the one-story building on the E. H. Thompson property), utility relocation or bypass (i.e., city water, electricity, natural gas, communications, storm water, and gravity fed sanitary sewer along Orange Street) are required.
    - Floodplain compensation is also required.

- Alternative 3 – Barrier Wall with ISS and MNA:
    - A vertical slurry wall (i.e., cement-bentonite slurry near infrastructure and soil-bentonite slurry on the remaining portions) with a geosynthetic clay liner cap will be constructed to contain the source material and COPCs.
    - In-situ Stabilization (ISS) will be conducted for the impacted area beneath the creek and the portion of the park north of the creek.
    - The source material left beyond the barrier wall and ISS will be remediated through monitored natural attenuation (MNA), or a more aggressive means (e.g., hydraulic control) may be needed if the plume resulting from new flow patterns associated with the installation of the slurry wall is not at steady state.
    - Building demolition (i.e., parking garage structure on the Park View Inn property, and the one-story building on the E. H. Thompson property), utility relocation or bypass (i.e., city water, electricity, natural gas, communications, storm water, and gravity fed sanitary sewer along Orange Street) are required.
    - Floodplain compensation is also required.

In the FS Report, all three alternatives also had several common elements: i) surface soil excavation (i.e., 25,000 tons of 2-ft thick soil in the park) and ii) sediment removal (i.e., approximately 2,400 tons of sediment from the decorative pond). In all three alternatives, closure was to be achieved using engineering and institutional controls under RMO Level III, because all three alternatives left UST-related and MGP-related source material in place, thereby requiring long-term operation and maintenance (O&M) of the engineering control. It is important to note that "source material" includes not only MGP-related wastes, but also petroleum discharges from USTs for which State funding may be available.

Alternative 1A:

CRA developed Alternative 1A based on discussions that occurred at the meeting on October 31, 2014. Specifically, CRA analyzed the use of alternatives to HDPE for lining the creek and pond, an alternative pumping strategy, and different discharge options for the pumped groundwater. CRA also performed a sensitivity analysis of the proposed groundwater-pumping scenario in Alternative 1A in order to understand the average and worst-case potential pumping requirements. The primary differences in Alternative 1 and 1A are summarized below:

Changes from Alternative 1 to Alternative 1A (Hydraulic Control)

CRA proposes modifications to Alternative 1 that include:

1. Line the pond and a segment of Hogan's Creek with low permeability liners such as AquaBlok or concrete cloth instead of HDPE.
2. Implement hydraulic control of the groundwater impacts using 3 or 4 recovery wells instead of pumping water from the decorative pond.
3. Discharge the treated groundwater through an infiltration gallery or to surface water through an NPDES permit instead of discharge to a POTW.

Alternative 1A Pond and Creek Lining

As was originally proposed in the FS, the existing pond and creek sediments will be removed and disposed of offsite (which is included in all the Alternatives). While HDPE lining for the creek was originally proposed in the FS, CRA found that two cost-effective materials exist that are sufficiently impermeable, have a long lifetime once applied, have widespread regulatory approval, and are dramatically more cost-effective.

AquaBlok, an innovative clay-based (bentonite) composite material, is effective at controlling contaminant transport, and it is composed of a material similar to that used in the slurry wall proposed for Alternative 2 and 3. AquaBlok has been widely applied at sites as a low-permeability treatment barrier/cap over contaminated sediment (**Appendix A**). Since its first application as an environmental remediation technology at a Superfund site in Alaska known as Eagle River Flats in 1994, AquaBlok has been applied at numerous sites throughout out the US. The study in *Demonstration of the AquaBlok® Sediment Capping Technology: Innovative Technology Evaluation Report* (EPA/540/R-07/008) indicates that over the three years of monitoring, i) the AquaBlok® material is highly stable, and likely more stable than traditional sand capping material even under very high bottom shear stresses and ii) the AquaBlok® material is also characteristically more impermeable. The EPA/540/R-07-008 reported that AquaBlok had been successfully deployed as a sediment remediation technology at 10 project sites, beginning in 1994.

Concrete cloth is a flexible, cement-impregnated fabric that hardens when hydrated to form a durable waterproof concrete layer. Concrete cloth can be used extensively as creek lining, slope protection, pipeline protection, and building (**Appendix B**). For example, concrete cloth is used as creek lining material at Sheldon Min Tailing Pile (EPA Region 9). Concrete cloth is used for the widely applied as a vertical wall and cap, and it is made of a similar material as the slurry wall (i.e., cement-bentonite and soil-bentonite slurry).

One concern raised by the City of Jacksonville in the meeting was whether AquaBlok® and concrete clothe were "impermeable enough" for this application as compared to HDPE. None of the proposed materials is completely impermeable, and "impermeable enough" is operationally defined by an acceptable mass flux through the liner. Per the *Evaluation of Subsurface Engineered Barriers at Waste Sites* published by the EPA (EPA 542-R-98-005), field studies have shown the permeability of slurry walls varied from $1x10^{-6}$ to $9x10^{-9}$ cm/s (**Appendix C**). As quoted from EPA 542-R-98-005, "Generally, 1×10^{-7} cm/sec ± is an industry-accepted achievable permeability for soil-bentonite barriers. Permeabilities of 1×10^{-6} cm/sec ± generally are accepted for cement bentonite barriers of various types, such as soil-cement-bentonite and cement-bentonite." EPA conducted a review of above ground tank (AST) regulations for the 50 States to gather information on liner requirements and identified nine (9) States have promulgated or proposed regulations that specify the use of "impermeable" secondary containment systems, liners or other diversionary structures and systems to prevent discharges of oil from reaching soil, groundwater, or surface water. The permeability rate ranges from $1x10^{-7}$ to $1x10^{-4}$ cm/s (EPA 540-R95-041) (**Appendix C**). As quoted from EPA 540-R95-041, "Although the Federal UST and HWST regulations do not specify liner materials or designs, these regulations establish performance criteria for containment materials and structures. For example, the UST regulation mandates a permeability for liners of $1x10^{-6}$ centimeters per second (cm/sec)."

In the FS, the recommendation of Geosyntec was that the "permeability of the wall will be $1x10^{-6}$ centimeters per second or less." AquaBlok (permeability = $1x10^{-9}$ cm/s) and concrete cloth (permeability = $1x10^{-10}$ cm/s) are well below this level and they both meet the requirements for physical slurry walls as required by the EPA document (EPA 542-R-98-005). Although HDPE has a lower permeability at $1x10^{-12}$ cm/s, this lower permeability achieves no meaningful reduction in exposure (see inset Table below), and it is cost prohibitive as the liner for the decorative pond and Hogan Creek (see cost section below).

Mass Flux and Breakthrough Time – Lining Material Comparison			
Parameter	**AquaBlok**	**Concrete Cloth**	**HDPE**
Thickness (inches)	6	0.5	0.1
Reported Permeability (cm/s)	1.00E-09	1.00E-10	1.00E-12
Estimated Velocity (ft/day)	7.00E-06	8.50E-07	8.50E-09
Breakthrough Time (years)	193	137	2,642
Estimated Penetration Flow (gpy)	3.7	2	0.02
Benzene Flux* (ug/min)	0.007	0.004	0.00004
Naphthalene Flux* (ug/min)	0.24	0.13	0.0013
Benzene Conc. in Creek# (ug/L)	0.0002	0.0001	0.000001
Naphthalene Conc. in Creek# (ug/L)	0.008	0.004	0.00004

Notes:
gpy – Gallons per year
* Based on maximum measured groundwater concentrations from the FS report.
# Assumes creek flow rate at 8.5 gallons per minute (per the preliminary groundwater modeling).
The Surface Water Cleanup Target Level (SWCTL) for benzene and naphthalene are 71.28 and 26 µg/L, respectively.
The Contract Required Quantitation Limits (CRQLs) for benzene and naphthalene are 1 and 10 µg/L, respectively, by SW-846 Methods 8260 and 8270.

CRA calculated the breakthrough time and mass flux for each type of liner. From the Inset Table, which uses Darcy's Law and the site conditions (i.e., existing creek length, width, and depth, hydraulics gradients from the FS, the lining material permeabilities, and the estimated creek flow rate), it can be seen that the average steady-state permeability for all three liners allow some naphthalene to penetrate the liner. Importantly, none of the liners allow a detectable level of naphthalene (i.e., the theoretical naphthalene concentration would be well below the detection limit and several orders of magnitude below the regulatory level). As shown in **Appendix D**, under the available product specifications (i.e., thickness, permeability) and the site conditions (i.e., hydraulic gradients, creek width and length, COPCs concentrations), all three materials have a breakthrough time of well over 100 years.

After breakthrough, the calculated theoretical naphthalene concentration in surface water (i.e., a primary constituent in groundwater) is four orders of magnitude lower than the freshwater SWCTL, per Chapter 62-777 FAC of 26 ug/L and the Contract Required Quantitation Limit of 10 µg/L by SW-846 Method 8270. Specifically, Aquablok would theoretically allow 0.008 ug/L of naphthalene as a steady-state concentration in surface water, concrete cloth 0.004 ug/L, and HDPE 0.00004 ug/L. Importantly, any theoretical concentration would be superimposed on an urban background. To that point, sediment sampling results indicate that there is no difference in naphthalene concentrations upstream and downstream of the site under the existing uncontrolled, unlined conditions. Thus, both AquaBlok and concrete cloth can meet the EPA performance criteria in regard to permeability, and at a permeability lower than the slurry wall proposed in Alternatives 2 and 3 achieves.

Importantly, AquaBlok and concrete cloth are well accepted by regulators nationwide. Examples are provided in **Appendix A** and **Appendix B.** These lining materials have been accepted by EPA and numerous states for use on similar sites (e.g., Chattanooga Creek Superfund site (US EPA Region 4) and Arkansas River site (EPA Region 6)). Chattanooga Creek in Tennessee Products Superfund Site is an example in Region 4 that involves DNAPL. Coal tar material from the coal carbonization operation impacted the Chattanooga Creek and during the excavation of the creek sediment in 2005, black color non-aqueous phase liquid (NAPL) was observed infiltrating the bottom of the excavation. In 2006, EPA selected AquaBlok as the protective barrier to isolate any residual NAPL source material remaining in the subsurface. The five-year monitoring and review report demonstrate that i) the Aquablok cap is effectively maintaining surface water concentrations below relevant surface water criteria, and ii) there is little change between the 2009 and 2010 PAH concentrations in the cap material suggesting that no significant migration of contaminants is occurring up through the AquaBlok barrier. Given its similarity in composition of the material in the slurry wall to Aquablok, AquaBlok should have equivalent longevity as the slurry wall in Alternative 2 and 3. Significantly, these products achieve this level of performance for lining the creek segment at a cost that would be $2,200,000 less expensive than HDPE (see cost section below).

Alternative 1A Pond and Creek Lining Summary

Based on this analysis, CRA presents the following comments and conclusions:

- AquaBlok and concrete cloth provide a permeability that (i) meets EPA requirements for barriers and (ii) has a lower permeability than the slurry wall proposed in Alternatives 2 and 3.
- AquaBlok and concrete cloth are widely accepted by state and Federal regulators for similar uses.
- The use of AquaBlok or concrete cloth instead of HDPE will reduce the cost of Alternative 1A by $2,200,000, with no consequential increase in exposure or risk.

<u>Alternative 1A Discharge Options</u>

The discharged of the treated groundwater into the POTW was proposed in the FS, which is the most expensive disposal option for the treated groundwater. Alternative discharge options are available either to groundwater through an infiltration gallery or to surface water through the decorative pond (or the creek) under a National Pollutant Discharge Elimination System (NPDES) permit. One option is the construction of an infiltration gallery either up-gradient (JEA property) or down-gradient (City of Jacksonville) of Confederate Park along the Hogan Creek (**Appendix E**). Using a hydraulic conductivity value from the FS of 4 ft/day and a water mounding gradient of 0.5 ft/ft, an infiltration gallery that was approximately of 20 ft by 100 ft will be sufficient for the discharge of the treated water at 10 gpm based on Darcy's Law equation. The actual design of the infiltration gallery will be determine upon the available location and field test using double-ring infiltrometer.

NPDES permits are available for the discharge of the treated ground at hundreds remediation and industrial sites in Jacksonville area through the Northeast District FDEP Office Wastewater Facility Regulation (WAFR) (http://www.dep.state.fl.us/water/wastewater/facinfo.htm). Other than the many POTWs and industrial wastewater that discharge into the surface water (e.g., St. Johns River), NPDES permits have been granted for long-term groundwater remediation sites (**Appendix F**). For example, CSX Transportation has a permit for discharge of air stripper-treated groundwater into McCoy Creek. Three Petroleum Cleanup sites have long-term groundwater remediation NPDES permits for discharge of treated water into storm water systems, which eventually discharge into surface waters.

Alternative 1A Discharge Options Summary

Based on this analysis, CRA has the following comments and conclusions:

- Discharge of treated groundwater to a nearby infiltration gallery and discharge to a surface water body using an NPDES permit are both feasible and much more cost-effective than discharge to a POTW.

Alternative 1A Pumping Scenario

Instead of pumping from the decorative pond to maintain hydraulic control as proposed in the FS, the pond will be lined and three groundwater recovery wells will be used to capture the plume. CRA conducted feasibility-level modeling with sensitivity analyses by varying the hydraulic conductivity and pumping rate. The three-dimensional numerical model constructed with Visual MODFLOW that was used for the report entitled *Confederate Park Hydraulic Control Design Evaluation* dated November 2013 was used to simulate various groundwater recovery scenarios to assess hydraulic control of the dissolved plume. Modifications to the model included modeling the sides and bottom of the decorative pond with a liner (AquaBlok) using a hydraulic conductivity of 1E-9 centimeters per second (cm/s). The sides and bottom of approximately 375 meters of Hogan's Creek were also similarly modeled. The sides of the pond and Hogan's Creek were both simulated with the "wall" feature. The bottom of the pond and the creek were simulated by adjusting the vertical hydraulic conductivities associated with the MODFLOW "Lake" and "River" packages.

The recovery wells extend vertically to the deep zone through multiple layers of varying hydraulic conductivity. The recovery wells from the three-well model were all located southeast of the pond and north of Orange Street (**Appendix G**). The scenario was modeled using total pumping rate of 8.5 gallons per minute (gpm). The hydraulic conductivity of the unconfined aquifer (4.0 ft/day), which was determined by Geosyntec using tidal response data, was used for the model simulations. Importantly, the tidal response data provide an areal estimate of hydraulic conductivity over the volume from which groundwater will be pumped, providing a much better estimate than slug test data (i.e., it uses a much larger sub-surface volume in the development of the estimate of hydraulic conductivity and is not influenced by localized well effects, as are slug test data).

In order to determine the sensitivity of the model to changes in hydraulic conductivity, a range of hydraulic conductivities were modeled including 2.0, 10, and 19 ft/day. The hydraulic conductivity values were derived from the Site and nearby sites based on slug testing (i.e., PVI, geometric average from EHT, 7-11 Store (south of PVI), geometric average from Clara & Simon (south of Warren Partnership), and Horne Earl (northwest of Confederate Park), respectively). While these values are on the order of those derived using areal onsite data, they were derived from slug tests, which are not as reliable as the testing done on-site through the tidal analysis. The hydraulic conductivity was reported as 0.000581 ft/day using slug test at EHT site; however, after examining the raw data of the slug tests, CRA found that the units were reported incorrectly and the correction for the porosity of the filter pack was not conducted. After corrections, CRA estimated the geometric average of hydraulic conductivity as 3.1 ft/day at EHT. CRA also examined the underlying data from the slug tests at Clara & Simon site, and, in fact, two of the three slug tests used to calculate the 19 ft/d value were in error (including data associated with the sand pack instead of the formation itself – a common mistake). The corrected values yielded a hydraulic conductivity of approximately 5 ft/day. Hence, the data from across the area yield a tight dataset centering on 4 ft/day, which was the value used in CRA's modeling effort. Nevertheless, for sensitivity testing, the upper range, uncorrected values will be used as representing the bounds for the worst-case scenario.

Similar to the modeling results based on recovery of water from the decorative pond, the modeling results (hydraulic conductivity equals 4.0 ft/day) indicate that a flow rate of 8.5 gpm flow can effectively capture the groundwater plume. In fact, more groundwater is captured at this pumping rate than is required to encompass the entire plume, meaning that a reduction in this pumping rate may be possible during full-scale design by further optimizing the recovery well locations. The sensitivity analysis used a series of hydraulic conductivity values that indicated capture is feasible at 8.5 gpm. That is, if hydraulic conductivities range from 2 to 19 ft/day, a pumping rate of 8.5 gpm will still create sufficient drawdown to result in adequate plume capture, despite the increase in hydraulic conductivity. Because the goal of the hydraulic control is capture, this pumping rate is sufficient. The results of the CRA modeling are provided in **Appendix G**.

Alternative 1A Pumping Scenario Summary

Based on this analysis, CRA has the following comments and conclusions:

- The best estimate of hydraulic conductivity is 4.0 ft/d based on the tidal response data. At this rate, 8.5 gpm will capture the plume using three recovery wells. This pumping rate may be reduced by optimization during full-scale design.
- A sensitivity analysis using a series of hydraulic conductivity values ranging from 2.0 ft/day to 19 ft/day (i.e., the uncorrected values from nearby locations using slug tests) indicates that 8.5 gpm will capture the groundwater plume.

Present-Value Cost Comparison for Alternatives 1A, 2, and 3

Surficial Soil Excavation in Park - Adjustments

Although the 95% UCL analysis indicated that benzo[a]pyrene (BaP) toxicity equivalents (TEQs) were above the default commercial/industrial soil cleanup target level (cSCTL), an examination of the data reveals that the soil from the majority of the park north of Hogan Creek is below the BaP cSCTL. In addition, the area of the park south of Hogan Creek is fenced and restricted to park employees, significantly reducing the risk of exposure. Thus, the excavation of the top 2 ft soil and back fill with clean material within the entire park is not necessary. The actual area requiring remediation should be determined based upon site-specific SCTLs and/or the urban background. For example, the surface soil sampling results indicate that approximately only 20% of the proposed excavation area had surface soil BaP above cSCTL and approximately 5% of the proposed excavation area had surface soil BaP above cSCTL if the park south of Hogan Creek is restricted. Additionally, no forensic evaluation has been conducted to determine the nature or sources of the PAHs present in the surface soil (e.g., urban background, UST fuel releases, or the MGP operation), which should be completed. This comment is common to all three Alternatives; thus, this cost is not included in this cost comparison, as all of the Alternatives would be affected in the same way by surface soil removal outside of the area of excavation/ISS.

Source of Petroleum Impacts- Adjustments

Underground storage tank (UST) releases have occurred at the E. H. Thompson (EHT) property, PVI property, and the Warren Partnership property. FDEP advised at the meeting that EHT and Warren Partnership sites are likely eligible for the Abandoned Tank Restoration Program (ATRP) and PVI is eligible for the Petroleum Cleanup Participation Program (PCPP) under the State Petroleum Restoration Program (PRP), formerly known as the Bureau of Petroleum Storage Systems (BPSS). Given that nature of some of the petroleum impacts found and the presence of methyl tertiary-butyl ether (MTBE), a gasoline addictive as an octane enhancer commercially available starting in 1979, found in the groundwater under EHT property, petroleum releases have occurred which would be eligible for reimbursement. During a meeting in July 2013 between Geosyntec and CRA, Geosyntec acknowledged that the free product (i.e., LNAPL) observed at north PVI (i.e., soil boring SB-4PVI) during the site assessment smells like diesel, which is likely consistent with No. 2 fuel oil from the UST at PVI. These alternative sources were incorrectly excluded from the FS. Cost recovery from the State associated with these petroleum releases may offset a significant portion of the costs for site cleanup, given the areal extent of these impacts. CRA did not attempt to allocate these costs in this cost comparison, as they would not change the total costs because the contamination is comingled.

Alternatives Present-Value Cost Comparison

CRA estimated the present-value of the cost for Alternative 1A (hydraulic control) for upfront capital expenditures and long-term O&M. The capital cost consists of the remedial design and implementation including the removal of the sediment from the decorative pond and the creek. Both the pond and the creek will be lined using AquaBlok or concrete cloth. The groundwater pumped from a recovery well network will be treated using the onsite treatment system (GAC filtration), followed by discharged to an infiltration gallery or surface water under an NPDES permit. As a comparison, the costs for the three remedial alternatives are summarized in the Inset Table below. CRA considered a 30-year and 100-year timeframe in the calculations (**Appendix H**). As can be seen, when the net present values (NPVs) are considered, little difference in costs occurs after 30 years, as anticipated. The discount rate of 7% is used in developing present value costs for remedial action alternatives during the FS (EPA/540/R-00/002). Per EPA/540/R-00/002, "for Federal facility sites being cleaned up using Superfund authority, it is generally appropriate to apply the real discount rates found in Appendix C of OMB Circular A-94. A real discount rate of 7% should generally be used for all non-federal facility sites."

The capital cost of Alternative 1A is one order of magnitude lower than those of Alternatives 2 and 3 in a direct present value comparison with all costs included. The NPVs of Alternative 1A are between approximately one quarter (i.e., from 23% to 26%) of the costs of Alternatives 2 and 3, respectively, depending on the discount rate. As illustrated in the Cost Comparison table below, the total costs changes little after 30 years with no appreciable change after 100 years, considering either discount rate. Available information suggests that Aquablok and concrete cloth will have a similar lifetime as the slurry wall. If a replacement were needed for the Aquablok, concrete cloth, or the slurry wall, replacement costs after 100+ years, the NPV cost would be minimal for Aquablok and concrete cloth given the discount rate, but would be much more costly relatively for the slurry wall, although the discount rate would reduce that cost significantly too. Given that the majority of the sites have been in operation less than 20 years and 30 years for AquaBlok and slurry walls, respectively, it is difficult to extrapolate the performance beyond 30 years. For each alternative, the capital cost would be repeated if the replacement of the slurry wall or liner is needed. Importantly, the additional cost of Alternatives 2 and 3 as compared to Alternative 1A does not afford any risk reduction, and, in fact, comes with some increases in real risk (see comparison section below).

Cost Alternatives Present-Value Summary

Based on this analysis, CRA has the following comments and conclusions:

- Costs associated with removal of the top two feet of soil from the entire park should be revised to reflect the smaller percentage that actually requires remediation. Given that the Alternatives would likely be affected generally the same way, those adjustments have not been made to the cost comparison.
- Costs associated with remediation of the UST-related petroleum impacts should be included. Because this is a cost allocation issue, no adjustments have been made to the cost comparison.
- A NPV cost comparison is provided in the following table:

Cost Comparison (Excluding the Surface Soil Removal)

Remedial Strategy	Capital (millions)	30-yr Net Present Value (millions) #,¥	100-yr Net Present Value (millions) #,¥
Alternative 1	$1.80	$3.57	$3.74
Alternative 2	$12.08	$15.31	$15.34
Alternative 3	$11.50	$14.58	$14.61

Notes:
Alternative 1 - Hydraulic Control
Alternative 1 - Barrier Wall and Excavation
Alternative 3 - Barrier Wall and ISS
- 25% Contingency
¥ - 7% discount rate during FS per NCP (EPA 540-R-00-002)

<u>Comparison of Alternatives</u>

Several significant advantages exist for Alternative 1A that were not discussed in the FS. Perhaps most importantly, no increased risk reduction is attained for the expenditure of approximately $10,000,000. In fact, the actual (as opposed to theoretical) risk increases under Alternatives 2 and 3, namely the risk of injury to workers in a large construction project, the real inhalation risks of dust and vapors to workers and residents when the buried material is brought to the surface, and the actuarial risk associated with transportation for the excavation scenario. While these risks may be small, they will actually exist, as opposed to the hypothetical risk under Alternative 1A. It should be noted that the MGP-related impacts have been in place for over 100 years with no ill effects to date. As pointed out in the FS, "while COPC concentrations have fluctuated, the overall magnitude of dissolved impacts associated with the source materials has remained steady." Additionally, Alternative 1A is a greener solution. The amount of carbon dioxide produced and fuel consumed will be much larger for Alternatives 2 and 3. The excavation alternative will also consume landfill space.

Several other important issues exist. As stated in the FS, Alternatives 2 and 3 will have some portion of source material left uncontrolled, outside the slurry wall, which is proposed to be treated by MNA. Under Alternative 1A, all of the source material is controlled, and, if site conditions change (e.g., the vertical gradient or horizontal gradient), then the hydraulic control system can be adjusted to account for the change (e.g., increase the pumping rate by 1 gpm). This is not the case for Alternatives 2 and 3, for which a change may require a major shift in treatment strategy (e.g., adding a hydraulic control system to capture the uncontrolled source material). This is because the mass outside the slurry wall is uncontrolled and the mass inside the wall has no vertical control other than the underlying clay and the current artesian conditions (e.g., which could change if regional potable water pumping strategies change in the coming 100 years). Importantly, the groundwater flow patterns will change dramatically with the introduction of the slurry wall (i.e., all the up-gradient water that flowed directly to Hogan's Creek must now flow around the slurry wall), and, for the first time in 100 years, source material outside the slurry wall will not be at steady state. While the subsurface may return to steady state relatively quickly, it is conceivable that a hydraulic control system will need to be operated if MNA proves ineffective. Additionally, any undiscovered source material will be captured by Alternative 1A, while, if such source material exists, Alternatives 2 and 3 will not address this concern except through MNA. Finally, maintaining the water level inside the slurry wall will likely require a hydraulic control system not unlike that proposed for Alternative 1A. It is critical that the mounding of groundwater behind the wall be balanced by the water level inside the wall in order to maintain the structural integrity of the slurry wall.

While none of these problems is insurmountable (i.e., a slurry wall provides an established technology, although not typical placed in flood-prone area on a hillside), Alternatives 2 and 3 will require long-term O&M and they can be as complex, if not more, than operating a small pump-and-treat system. <u>All of the systems will require operation and maintenance in perpetuity.</u> Alternative 1A requires the maintenance of a small 10-gpm system with periodic GAC switch out. The slurry wall will require regular maintenance of the water level control system inside the wall, and may be adversely affected by periodic flooding.

In addition, in the FDEP Review Memo, Mark Stuckey (**Appendix I**) provides great insight into some of the innate advantages of hydraulic control as compared to the other Alternatives. The following are quoted from the Memo:

- *"Given the estimated extent and volume of MGP waste impacted zones in the subsurface, the concentrations of associated constituents (mostly BTEX & PAHs) in groundwater are lower than what I have seen at a couple of other MGP cleanup sites. The MGP subsurface waste material has* *reportedly been in place for about 100 years, and the more mobile and degradable compounds have likely attenuated leaving mostly the less mobile contaminants bound up in the soil matrix.* ***This alone gives support to consideration of a less aggressive remedial strategy such as hydraulic control/MNA (Alternative 1) as a site remedial strategy.*** *Also, hydraulic control can serve as an engineering control for closure with conditions."*

- ***"Proposed remedial Alternative 2 and Alternative 3 would be significantly more expensive and disruptive than the Alternative 1 (hydraulic control) option that would arguably achieve the same level of protectiveness.*** *There is something to be said for what was pointed out by one of the commenters, and that is there are serious risks to human health and the environment associated with implementation of a very disruptive and hazardous construction project, such as a large scale soil removal/treatment project, conducted within a developed urban setting. It may be that this aspect of the risk analysis also favors a less disruptive remedial strategy such as hydraulic control/MNA to address site groundwater contamination."*

While both Alternative 2 and 3 are commonly used alternatives and they would provide the risk reduction needed for closure, they have some significant disadvantages as compared to Alternative 1A, as discussed above. One major disadvantage of Alternatives 2 and 3 is that the expenditure of an additional $10,000,000 will not deliver further quantifiable reduction in risk.

Comparison of Alternatives Summary

Based on this analysis, CRA has the following comments and conclusions. Alternative 1A, as compared to Alternatives 2 and 3:

- leaves no source material uncontrolled, regardless of whether the source material has been discovered;
- is an Engineering Control that provides equivalent function as a physical barrier, like a slurry wall;
- maintains and enhances the upward gradient to prevent downward migration;
- provides the potential for post-startup optimization to improve capture under varying horizontal and vertical gradients that may change with time;
- has no impact on existing utilities, structures (including historical structures), or floodplain;
- does not require the re-routing of Hogan's Creek;
- has only hypothetical exposure pathways, while implementation of Alternatives 2 and 3 results in real exposure to construction workers and off-site residents and actuarial risk of death associated with transportation and heavy construction;
- is much less intrusive, including issues with generating dust and traffic control in the neighborhoods;
- does not consume landfill space, remedial efforts release less greenhouse gas (e.g., carbon dioxide), and consume much less fuel;

- does not utilize a slurry wall, which itself may require O&M of the long-term hydraulic control system; and
- costs $10,000,000 less without a measurable difference in risk reduction.

Conclusion

In all three alternatives, closure is achieved via engineering and institutional controls under RMO Level III per Chapter 62-780 FAC, and all three alternatives leave source material in place, requiring long-term (likely mechanical) operation and maintenance (O&M) of the engineering control. Alternative 1A has some unique advantages over Alternatives 2 and 3 because Alternative 1A achieves the same risk reduction goals as Alternatives 2 and 3, but at a much lower cost, which makes Alternative more resistant to challenge.

CRA recommends Alternative 1A to be included in the options considered acceptable in the FS, and we request a memorandum that clarifies the FDEP's policy that Alternative 1A is an engineering control that can be used, along with institutional controls, to obtain closure under Chapter 62-780 FAC. Please contact me directly should you have any questions or comments.

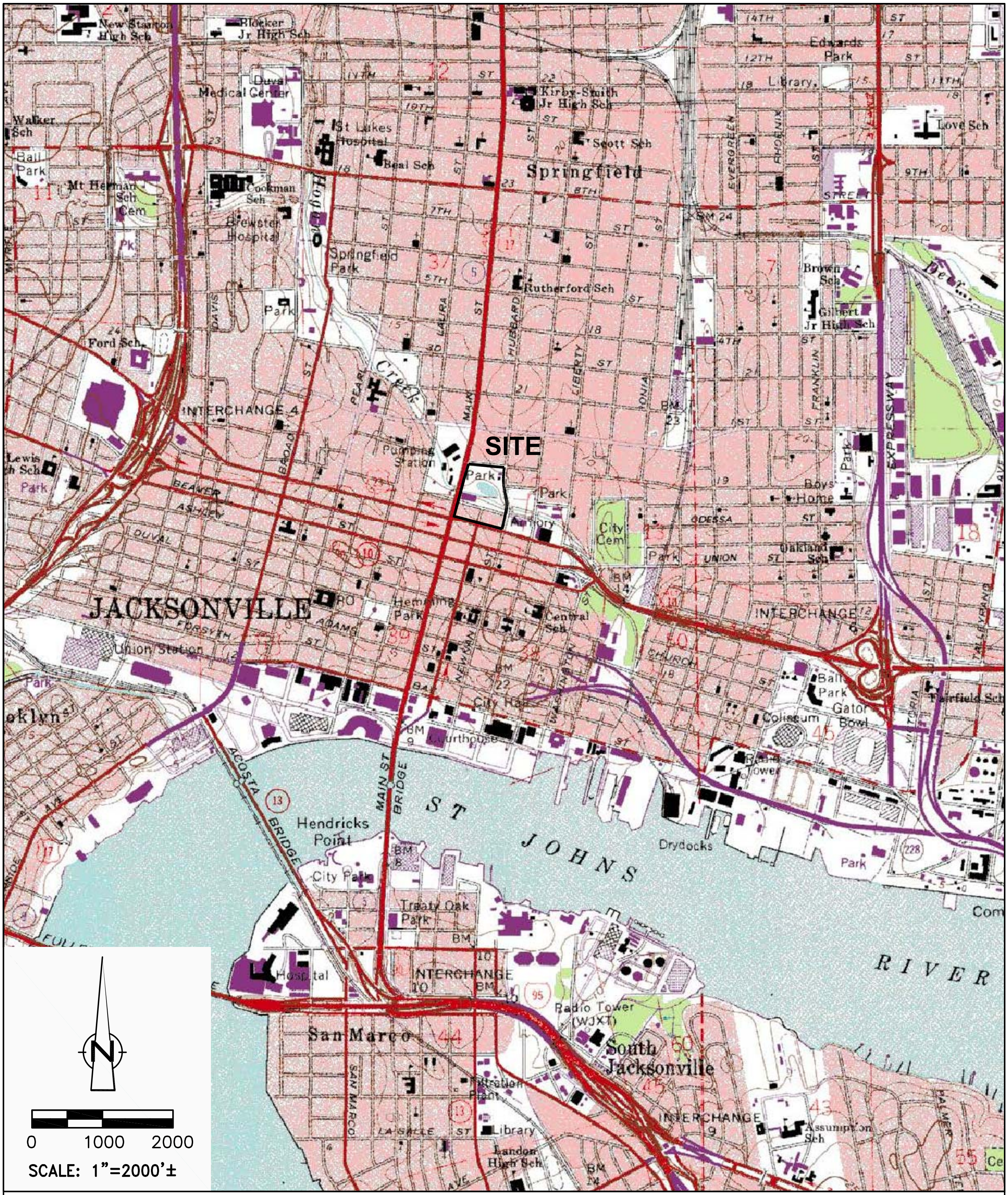
Sincerely,

CONESTOGA-ROVERS & ASSOCIATES

Richard G. Lewis, Ph.D., P.E.
Principal Engineer

RICHARD GRIGGS LEWIS II
LICENSE
No. 52009
STATE OF FLORIDA
PROFESSIONAL ENGINEER

Figures

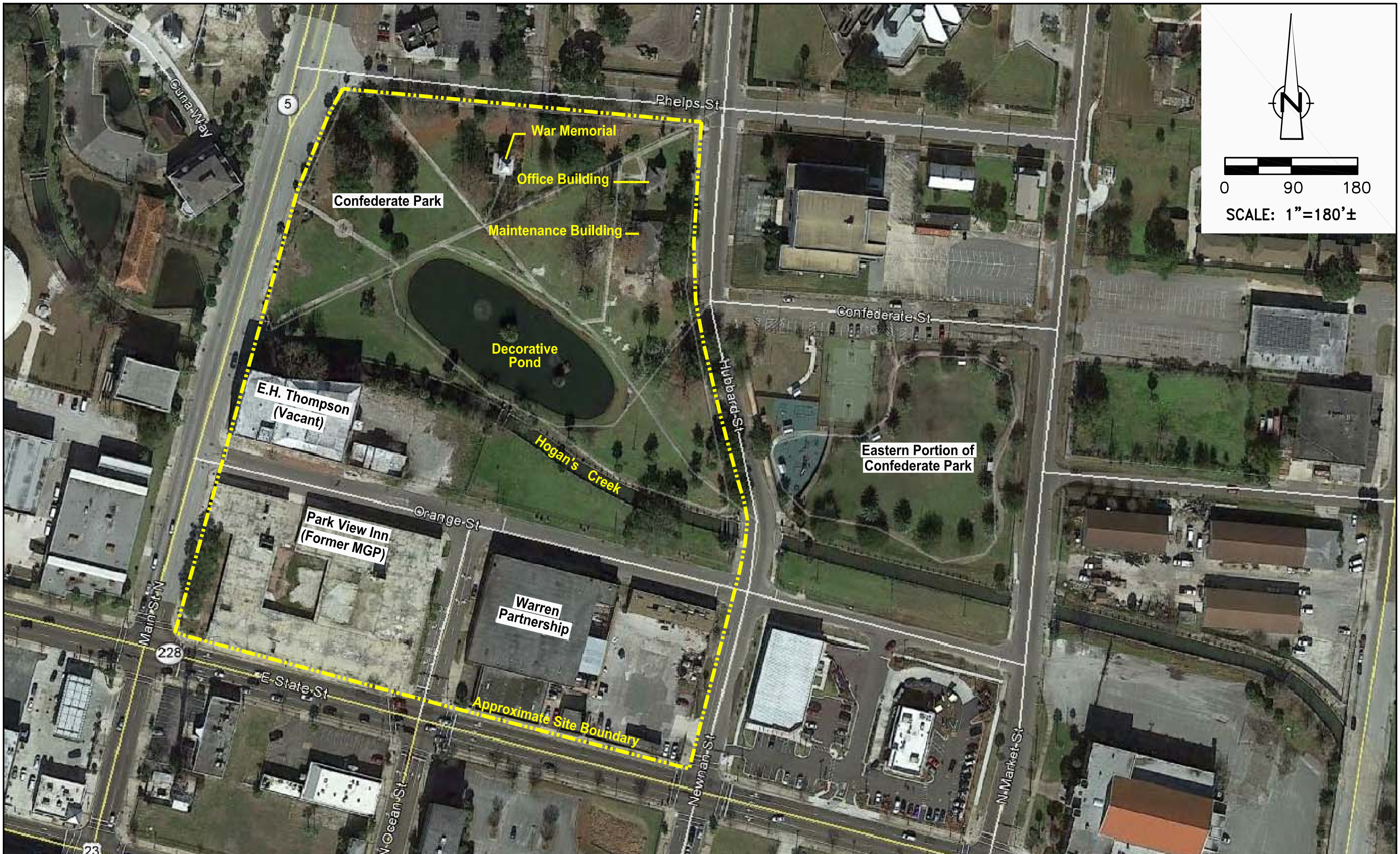


SOURCE: JACKSONVILLE, FLA., U.S.G.S. QUADRANGLE MAP 1964, PHOTOREVISED 1992

Figure 1

SITE LOCATION
CONFEDERATE PARK
CONFEDERATE STREET
JACKSONVILLE, FLORIDA

090476-01 12/8/14



SOURCE: 2014 GOOGLE EARTH AERIAL PHOTOGRAPH

Figure 2

SITE LAYOUT
CONFEDERATE PARK
CONFEDERATE STREET
JACKSONVILLE, FLORIDA

090476-01 12/8/14

Appendix A

AquaBlok Application Cases

AquaBlok® Installation Profiles

Site Location: *US EPA Region 4*

Chattanooga Creek, Tributary of Tennessee River, Chattanooga, TN

Project Status: Two Phase Installation - Completed in Fall 2007

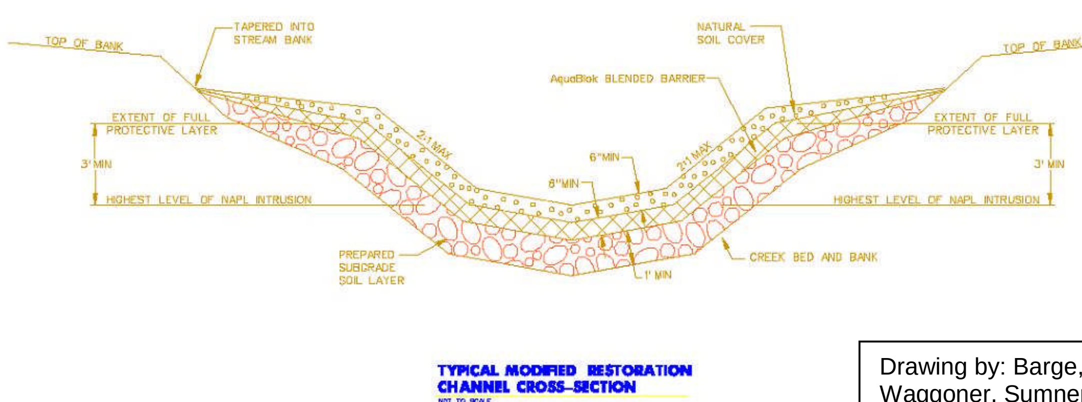
Setting / Purpose: Freshwater creek and floodplain area. Provide a seal / liner to isolate and sequester the water body from mobile contaminants in surrounding area.

Contaminant(s) of Concern: DNAPL - PAHs (polynuclear aromatic hydrocarbons). Creek bed was experiencing seepage of hydrocarbon-based contaminants.

Photo 1 – Prior Excavation of Creek Bed

Photo 2 – DNAPL Seepage in Creek Bed

AquaBlok Cap Design / Site Area: Layer of 3070FW Blended Barrier product was applied in 8" thickness in prepared creek bed and hydrated. A 6" layer of native soil was applied over the cap. Site area was comprised of a 2,000-foot segment of the creek which included an oxbow, for a total of over 175,000 SF.



Drawing by: Barge, Waggoner, Sumner & Cannon

AquaBlok Blended Barrier Cap Material: AquaBlok 3070FW Blended Barrier was selected.

Comparison of Blended Barrier™ to AquaBlok Only Capping Material

	AquaBlok Only Cap	Blended Barrier Cap
Cap Composition	Composed of 100% AquaBlok Particles.	Composed of a blend of AquaBlok Particles and locally available aggregate particles.
Hydraulic Conductivity	Displays low hydraulic conductivity, typically ~ $5x10^{-9}$ cm/s depending on formulation.	Displays a low hydraulic conductivity, typically ~ $2x10^{-8}$ cm/s depending on formulation.
Placement Options	Placement is made simple with convenient packaging and many equipment options for placement to meet even the most unique project needs.	Aggregate can be obtained from local sources and blended with AquaBlok on-site prior to cap placement. Placement is made simple with convenient packaging and many equipment options for placement to meet even the most unique project needs.
Cost	AquaBlok cost varies depending on site location, cap designs, and cap dimensions.	A cost savings of up to 40% may be realized by using the Blended Barrier Technology relative to the cost of an AquaBlok only cap when used for thicker designs or in high energy environments.

AquaBlok Installation: AquaBlok 3070FW #8 material was shipped to the project site in bulk bags on flat bed trucks and stored on site. The AquaBlok was blended with locally sourced aggregate on site in conventional mixer trucks and driven to the creek. Long stick excavators placed the material directly onto the creek bed. Stakes were placed for thickness measurement, but minimal labor was required for the actual placement.

Photo 3 – Preparation of AquaBlok Blended Barrier

Photo 4 – Application of AquaBlok to Creek Bed

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AquaBlok® Installation Profiles

Site Related Challenges: The project site experienced a number of significant rainfall events over the course of the installation. During the Phase I installation, the site contractor was forced to abandon the site after the Tennessee Valley Authority released water upstream on the Tennessee River and caused the entire work area to become inundated from water moving upstream on the Chattanooga Creek. In addition, site pumps were overwhelmed on at least two occasions and the temporary dams on the creek were breached once.

Photo 5 – View of Total Flood Event

Photo 6 – Finished Creek Section After Flood Event

Current Status: Since the completion of installation in 2007 the barrier has been successful in sequestering potential residual contamination. The EPA has made statements that suggest that there is a potential for additional measures for passive or active product recovery of contaminants that may remain on the site. But the AquaBlok has been characterized as "extremely stable" by Craig Zeller, USEPA project manager for Region 4.

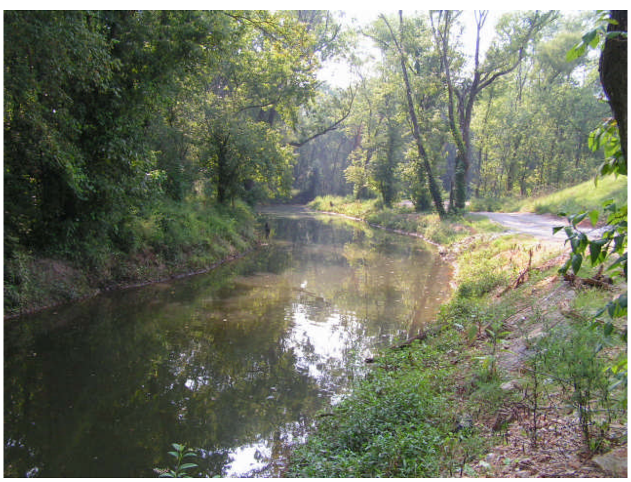

Photo 7 – A view of a section of the creek bed completed in fall of 2006. Photograph taken in August 2007 indicates a rapid recovery of natural stream habitat.

Photo 8 – A close up view of the AquaBlok in the completed section of the creek bed. The product was stained by the clay cover to resemble the natural stream bed.

AquaBlok® Installation Profiles

Site Location: *US EPA Region 6*

Arkansas River – Tulsa, OK

Project Status: Completed Fall of 2012

Setting / Purpose: Freshwater river bank and sediments. Intermittent sheening (depending upon river level) has been observed at many locations along the river bank. Objective is to provide both adsorptive treatment materials in combination with a low-permeability cap to limit the migration of residual contaminants within the shoreline to the river. River bank stabilization was also accomplished with the design.

Contaminant(s) of Concern: DNAPL - PAHs (polynuclear aromatic hydrocarbons) from active refinery site.

AquaBlok Cap Design / Site Area: The site area comprised a number of different shoreline conditions and combinations of material. Both AquaBlok (low-permeability materials) and AquaGate (permeable treatment materials) were incorporated into the design. Below is a summary description of some of the areas addressed together with photos of placement of materials.

<u>Area A</u> This segment consisted of approximately 1,200 feet of river bank with a steep slope (nearly 1 H :1 V) and a vertical drop from the crest of the slope to the river bank of approximately 30 feet. The river bank is heavily vegetated (estimated 30+ year old trees) and covered with demolition debris consisting of concrete, bricks, pipes, etc. In and amongst the demolition debris acid sludge has been observed in addition to river bank sheening. It was determined that Area A would receive a Horizontal Funnel & Gate capping system that consists of a permeable treatment system. No sub-base preparation would be performed, other than the removal of any woody debris, plants etc. from the shoreline capping area. Following this preparation, the AquaGate+Organoclay permeable treatment material would be placed along the base of the demo debris out into the river approximately 20 feet at an application rate of approximately 7 lb/SF directly over the existing sediment surface at a thickness of approximately 1 inches (+/- 0.5 inch). After placement of the permeable treatment layer, the low-permeability AquaBlok layer would be placed directly over the AquaGate+Organoclay with the material working back up the shoreline slope. Placement of the AquaBlok continued beyond the organoclay layer up over the existing demo debris. The application rate is estimated to be approximately 40 lb/SF to achieve a nominal 5 inch dry thickness (+/- 1.0 inch), which will swell when hydrated to achieve a final layer thickness greater than 6 inches.

Above – Demo Debris Area - Before

Above – Demo Debris Area - After

Area B LNAPL: Approximately 400 feet downstream (west) of the river bank improvement project (just described) consists of a tiered slope that contains an intermediate access road. The access road is approximately 11 feet above the water level and slopes down at approximately 1.5 H : 1V to the river. In this area sheening has been observed from the river bank and also from the river bottom sand further away from the river bank (approximately 10-40 feet beyond the toe of the river bank slope). This sheening and petroleum (rainbow) staining may be indication that an LNAPL plume has reached the riverbank.

Above – Placement of AquaGate+Organoclay

Left – Close-up of Telebelt Material Placement

Below – View of Telebelt During Armor Stone Placement

It was determined that Area B would receive a Horizontal Funnel & Gate capping system of essentially the same construction as Area A above. No sub-base preparation would be performed. AquaGate+Organoclay permeable treatment material was placed along the base of the rip rap zone out into the river approximately 50 feet at an application rate of approximately 7 lb/SF directly over the existing sediment surface at a thickness of approximately 1 inches (+/-0.5 inch). After placement of the AquaGate, a low-permeability AquaBlok layer was placed directly over the AquaGate with the material working back up the shoreline slope. The application rate is estimated to be approximately 40 lb/SF to achieve a nominal 5 inch dry thickness (+/-1.0 inch), which will swell when hydrated to achieve a final layer thickness greater than 6 inches.

AquaBlok® Installation Profiles

Area C Rip Rap & LNAPL: Approximately 4-5 years ago a remediation project was completed in this area that included a river bank improvement (installation of clay, geotextile, and nominal 12-18 inch rip rap) along approximately 1,300 lineal feet of river bank. It has been determined that this approach failed as the result of observed sheening along a portion of the river bank. Sheening was observed at the toe of the slope and also emanating from the river bed sand approximately 10-20 feet beyond the toe of the slope. Some sheening was observed on the slope amongst the rip rap. This area is open and easily accessible, so it was determined that two approaches would be employed at this location. First, a layer of rip rap was removed and a layer of low permeability AquaBlok was placed along the slope of the shoreline as a means to cut-off seepage through the GCL and existing rip rap. Secondly, an attempt was made to place AquaBlok directly over and between the openings in the rip rap to determine if it would be possible to provide a low permeability barrier to prevent seepage without removal of the rip rap.

Photo 1 – Prior Removal of Rip Rap

Left – Placement of AquaBlok Over Rip Rap
Below - Using Blower to Distribute AquaBlok

Current Status: Since the completion of installation of each of the above river segments, no visible sheen has been reported by the facility. Efforts are underway to perform further monitoring of the capping zones, but the areas addressed are considered to be successful in accomplishing the objectives outlined by the engineer and site owner.

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AquaBlok® Installation Profiles

Site Location: *US EPA Region 2*

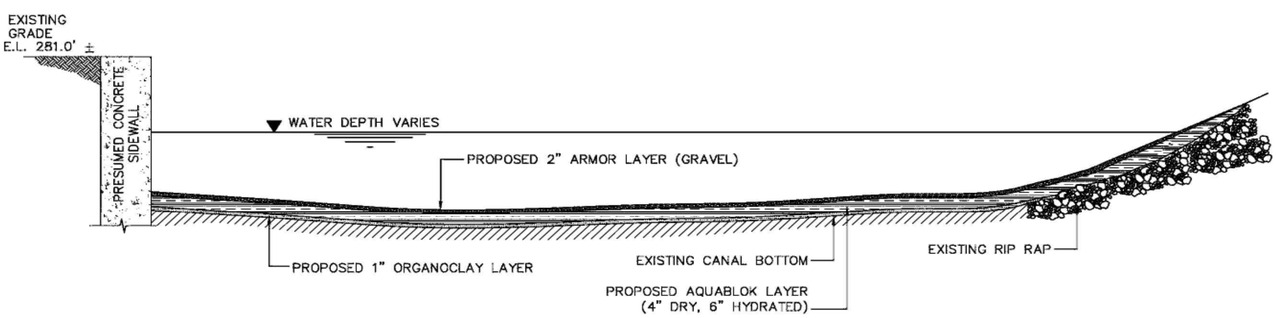
Glens Falls, New York (Hudson River)

Project Status: Completed February 2008

Completed Cap with Armor and rip rap on slope

Setting / Purpose: Canal/River (freshwater). MGP Site – Treatment barrier and low permeability barrier/cap over contaminated sediments. Site area was approximately 4,000 square feet.

AquaBlok Cap Design / Site Area: Multi-layer design comprised of a one inch basal layer AquaBlok+ORGANOCLAY covered with a hydrated layer (~6 inches in target thickness) of AquaBlok 3070FW. The cap was then armored with a two inch layer of AASHTO #2 stone.



PROPOSED SECTION A–A
SCALE 1/4"=1'–0"

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AquaBlok® Installation Profiles

Contaminant(s) of Concern: Coal Tar associated with historic MGP site, including PAH (polynuclear aromatic hydrocarbons) and DNAPL (Dense Non-Aqueous Phase Liquids).

Placement of AquaBlok+ORGANOCLAY product through the water for treatment/adsorption of petroleum-based hydrocarbon contaminants

Placement of stone armor over AquaBlok low permeability capping material

Method of AquaBlok Placement: Shore-based excavator

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AquaBlok® Installation Profiles

Site Location: *US EPA Region 2*

Genesee River, Wellsville, NY

Project Status: Completed September 2010

Setting / Purpose: Historic refinery site (Sinclair Refinery) along the Genesee River. Provide isolation of residual hydrocarbon contamination in sediments. AquaBlok was used as a low permeability base layer in the excavated area to minimize the potential for residual contaminant seep to the clean backfill and habitat restoration layers.

Contaminant(s) of Concern: Sediments in the river impacted by petroleum hydrocarbon contaminants and DNAPL (dense non-aqueous phase liquid).

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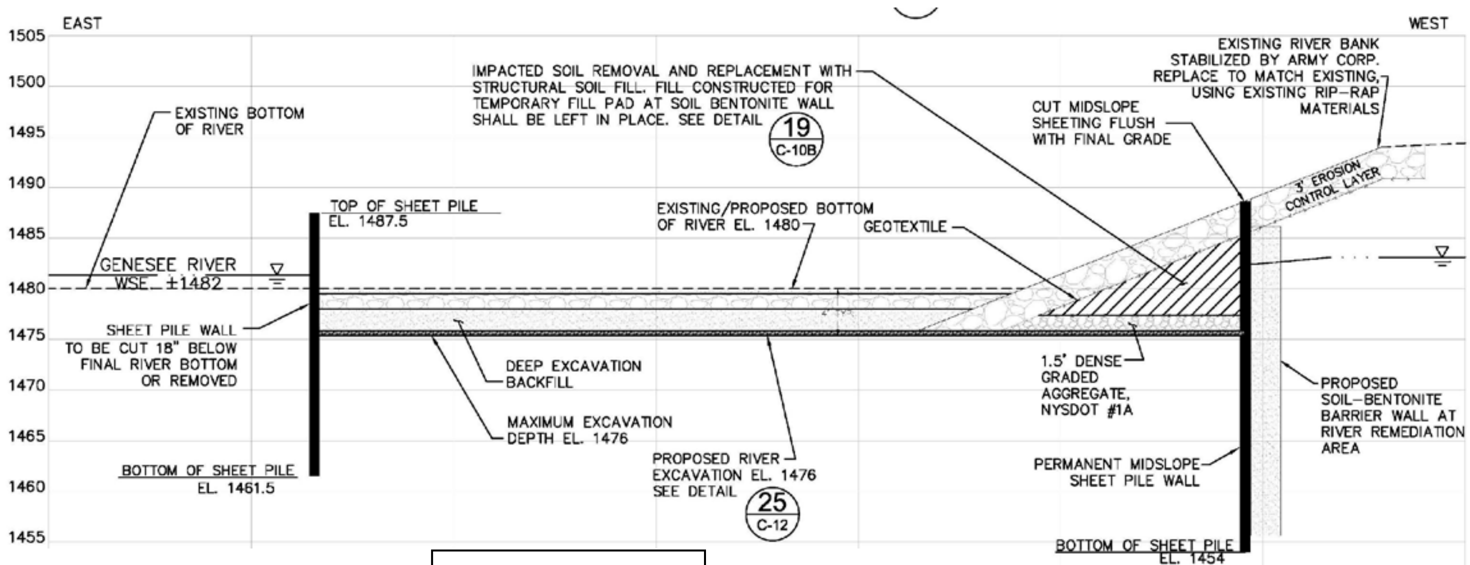
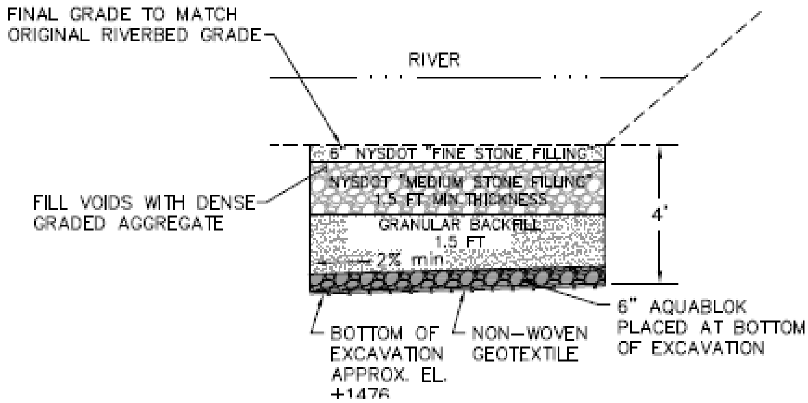
AquaBlok Cap Design / Site Area: The cap area was excavated in the dry using sheet pile isolation of the river from the removal area. As shown in the drawing below, a multi-layer backfill was placed using AquaBlok 2080FW #8 material as the base low permeability layer. A six-inch thick layer was placed over an approximate total area of 60,000 square feet. Additional excavated areas were capped with sand where lower residual contamination levels were lower.



Drawings by URS



25 C-12 TYPICAL BACKFILL DETAIL - DEEP SEDIMENT REMOVAL AREA
SCALE: 1" = 3'

Placement: AquaBlok material was delivered to the project site in approximately 2,500lb bulk bags (supersacks) and stored prior to installation. The bags were lowered into the excavation area where material was placed directly from the bulk bags by a skid steer unit. The same equipment then used a small bucket to evenly spread the layer over the geotextile under-layment. Site quality control was performed by simple direct measurement of the layer thickness. A primary benefit was the ability of the material to conform to the irregular shape of the steel sheet pile. This was particularly important since the geotextile was not anchored or connected to the sheet pile in any manner – the AquaBlok material, placed in bulk along the edge of the wall provided this seal without additional work by the installation crew.

Contractor: Enviorcon

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United States
Environmental Protection
Agency

Demonstration of the AquaBlok® Sediment Capping Technology

Innovative Technology Evaluation Report

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

EPA/540/R-07/008
September 2007

Demonstration of the AquaBlok® Sediment Capping Technology

Innovative Technology Evaluation Report

Final

National Risk Management Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

Abstract

AquaBlok® is an innovative, proprietary clay polymer composite developed by AquaBlok, Ltd. of Toledo, OH, and represents an alternative to traditional sediment capping materials such as sand. It is designed to swell and form a continuous and highly impermeable isolation barrier between contaminated sediments and the overlying water column, and claims superior impermeability, stability, and erosion resistance and general cost-competitiveness relative to more traditional capping materials. AquaBlok® is generally marketed as a non-specific capping material that could encapsulate any class or type of contaminant as well as theoretically any range of contaminant concentration. Although there is claimed to be no practicable limit to the depth at which the material would function, AquaBlok® is typically formulated to function in relatively shallow, freshwater to brackish, generally nearshore environments and is commonly comprised of bentonite clay with polymer additives covering a small aggregate core. In addition, other specific formulations of AquaBlok® are available, including varieties that can function in saline environments and advanced formulations that incorporate treatment reagents to actively treat or sequester sediment contaminants or plant seeds to promote the establishment or regrowth of vegetated habitat.

Under the U.S. Environmental Protection Agency (EPA) Superfund Innovative Technology Evaluation (SITE) Program, the effectiveness of AquaBlok® as an innovative contaminated sediment capping technology was evaluated in the Anacostia River in Washington, DC. Sediments in the Anacostia River are contaminated with polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), heavy metals, and other chemicals to levels that have hindered commercial, industrial, and recreational uses. The performance of AquaBlok® was assessed through the SITE demonstration by monitoring an AquaBlok® cap over an approximately three year period using a multitude of invasive and/or non-invasive sampling and monitoring tools. The performance of AquaBlok® was compared to the performance of a traditional sand cap relative to three fundamental study objectives, and control sediments were also monitored to provide critical context to the data evaluations. Specifically, the study objectives were to determine the physical stability of AquaBlok® relative to the traditional sand cap material, the ability of AquaBlok® to prevent hydraulic seepage relative to traditional sand cap material, and the impact of AquaBlok® on benthic habitat and ecology relative to traditional sand cap material and conditions in the native river system.

There were field data collection issues and inherent data uncertainties within the SITE demonstration that limit the usefulness of certain data and minimize the power of certain evaluations and interpretations, and the conclusions of the demonstration must be reviewed in this context. However, the overall results of the AquaBlok® SITE demonstration indicate that the AquaBlok® material is highly stable, and likely more stable than traditional sand capping material even under very high bottom shear stresses. The AquaBlok® material is also characteristically more impermeable, and the weight of evidence gathered suggests it is potentially more effective at controlling contaminant flux, than traditional sand capping material. AquaBlok® also appears to be characterized by impacts to benthos and benthic habitat generally similar to traditional sand capping material.

Five-Year Review Report

First Five-Year Review Report
for
Tennessee Products Superfund Site

EPA ID # TND071516959

Chattanooga
Hamilton County, Tennessee

September 2011

Prepared By:
TDEC-DoR.
540 McCallie Ave, Suite 550
Chattanooga, Tennessee 37402

For:
United States Environmental Protection Agency
Region 4
Atlanta, Georgia

Approved by:

for Franklin E. Hill
Director, Superfund Division

Date: 9/27/11

10802756

Table of Contents

Tables

Figures

List of Acronyms

4C	Chattanooga Creek Cleanup Committee, LLC
ARAR	Applicable or Relevant and Appropriate Requirement
ATSDR	Agency for Toxic Substances and Disease Registry
BTEX	benzene, toluene, ethylbenzene, and xylenes
BWSC	Barge, Waggoner, Sumner and Cannon, Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
COCs	Chemicals of Concern
DoR	Division of Remediation
EC's	Engineering Controls
EE/CA	Engineering Evaluation/Cost Analysis
EPA	United States Environmental Protection Agency
ESD	Explanation of Significant Differences
FYR	Five-Year Review
ICs	Institutional Controls
NAPL	Non-Aqueous Phase Liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
O&M	Operation and Maintenance
OU	Operable Unit
PA	Preliminary Assessment
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated biphenyls
PDMS	Polydimethylsiloxane
PRP	Potentially Responsible Party
RA	Remedial Action
RAO	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RPM	Remedial Project Manager
SARA	Superfund Amendments and Reauthorization Act
SESD	Science and Ecosystems Support Division SESD
SI	Site Inspection
SPME	Solid Phase Micro Extraction
TAL	Target Analyte List
TCL	Target Compound List
TDEC	Tennessee Department of Environment and Conservation
TDWQC	Tennessee Division of Water Quality Control
TPS	Tennessee Products Superfund Site
TVA	Tennessee Valley Authority

Introduction

This is the first Five-Year Review (FYR) for the Tennessee Products Superfund Site (TPS). The triggering action for this statutory review is the on-site construction start date of the remedial action, which was October 12, 2005. The FYR is required due to the fact that hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure. The Site consists of one Operable Unit, which was addressed in two remedial action phases of work, all of which are addressed in this FYR.

The TPS Site includes approximately a 2.5-mile section of Chattanooga Creek that contained sediments contaminated primarily with polycyclic aromatic hydrocarbons (PAHs). During the last several decades, a coke plant complex and adjacent industrial facilities in an urban industrial and residential area of south Chattanooga were owned and operated by various entities. The nature of operations and waste disposal practices led to the contamination of Chattanooga Creek sediments. Numerous discharges of contaminated water to Chattanooga Creek via tributaries were documented. Results of previous investigations and subsequent evaluations indicated that then existing conditions posed an unacceptable risk to human health, if exposure to the contaminated sediments were to occur.

The TPS Site is surrounded by mixed use areas, consisting of commercial, residential and industrial. Although most of the Site is fairly isolated and inaccessible to residents due to being surrounded by wooded floodplain, portions of the Site may be accessed by road crossings at two locations.

In order to minimize risks posed by the contaminants to human health and the environment, a remedy was chosen that consisted of a combination of the following: excavation, stabilization, treatment, recycling, offsite disposal and stream restoration. During the first phase of removal, emphasis was placed on waste-to-fuel recycling of the excavated and stabilized sediments. Due to changing economic conditions and associated cost constraints, the second phase of remedial work opted for chemical stabilization and offsite disposal of the excavated sediments in lieu of recycling. In situations where excavation was not practicable, the sediments were covered in place and physically stabilized.

Remedial Action Objectives

The Remedial Actions Objectives (RAO's), as specified in the Record of Decision (ROD) are:

- Minimize direct contact by the public and workers with soil and sediments containing excessive levels of Chemicals of Concern (COCs).

- Minimize direct contact by the public and workers with surface water containing excessive levels of COCs.

- Minimize direct contact by the public and workers with groundwater containing excessive levels of COCs.

- Minimize transport of contaminated soil and sediment by erosion to water courses, including the Tennessee River.

• Minimize potential for leaching of COCs to groundwater from areas of high concentration.

Technical Assessment

Conclusions from the Solid Phase Microextraction (SPME) monitoring indicate the AquaBlok® cap is effectively maintaining surface water concentrations below relevant surface water criteria. Therefore, the implemented remedy at the TPS remains protective of both human health and the environment.

However, the EPA ORD task order only included annual SPME monitoring for three years in 2009, 2010, and 2011. There should be some mechanism in place for continued monitoring and regular inspections to ensure the future protectiveness of this remedy. The most appropriate mechanism is likely the TDEC RCRA Post-Closure Permit for the SWP facility, which is where the AquaBlock® installation lies.

On November 23, 2010, EPA submitted official comments to TDEC on the planned modification of SWP's Post-Closure permit. The substance of those comments was that the modified permit should require SWP to take some regular action toward ensuring that the barrier in the creek remains effective. On June 13, 201, and again on September 12, 2011, personnel from the EPA Region 4 Superfund Division met with representatives from Southern Wood Piedmont (SWP) and the Tennessee Department of Environment and Conservation (TDEC) RCRA Program to discuss the requirements of the TDEC RCRA Post Closure Permit for the SWP facility. EPA proposed to SWP and TDEC that future inspection and monitoring of the AquaBlok® cap performance should be included in the Final RCRA Post Closure Permit issued by TDEC. The Final permit for the SWP facility was not issued by the time this FYR was issued, so follow up with SWP representatives and the TDEC RCRA program is required to verify that inspection and monitoring were incorporated.

Conclusion

Two years of SPME monitoring of the AquaBlok® cap indicate the barrier is effectively isolating any residual NAPL source material remaining in the subsurface. Porewater concentrations in the upper layers of the cap are very low (e.g. in the parts per trillion range) and do not exceed chronic surface water quality criteria. It is important to note that comparisons of porewater concentrations to surface water quality criteria is very conservative in that substantial dilution would be expected between porewater and surface water. Moreover, there is little change between the 2009 and 2010 PAH concentrations in the cap material suggesting that no significant migration of contaminants is occurring up through the AquaBlok® barrier. Therefore, the remedy implemented at the Tennessee Products Site remains protective of human health and the environment.

Appendix B

Concrete Cloth Specifics and Applications

09.11.UK

MADE IN UK

CONCRETE CANVAS™

Concrete Impregnated Fabric...

ROAD RAIL AGRO OTHER DESIGN

MIP most innovative products AT WORLD OF CONCRETE
2011 Expert's Choice Winner
Most Innovative Product

POZNAN INTERNATIONAL FAIR
MTP Gold Medal Award
BUDMA 2011

Material ConneXion® MEDIUM AWARD MATERIAL of the YEAR 20
Material Connexion
Material of the Year 2009

INDEX:
Design to Improve Life Award
Nominee, 2011

www.concretecanvas.co.uk

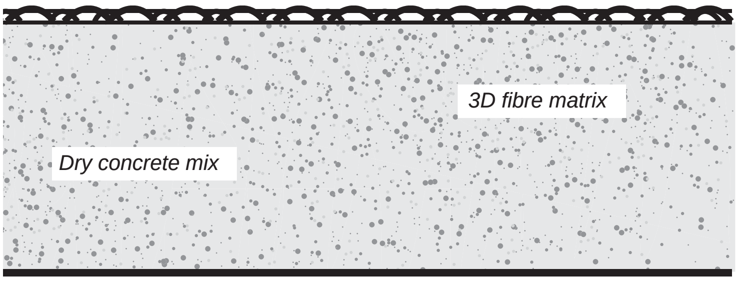
Concrete Canvas™

What is it?

Concrete Canvas (CC), is a flexible, cement impregnated fabric that hardens when hydrated to form a thin, durable, water and fire proof concrete layer. CC allows concrete construction without the need for plant or mixing equipment. Simply position the Canvas and just add water.

CC consists of a 3-dimensional fibre matrix containing a specially formulated dry concrete mix. A PVC backing on one surface of the Canvas ensures the material is completely water proof. The material can be hydrated either by spraying or by being fully immersed in water. Once set, the fibres reinforce the concrete, preventing crack propagation and providing a safe plastic failure mode. CC is available in 3 thicknesses: CC5, CC8 and CC13, which are 5, 8 and 13mm thick respectively.

Concrete Canvas section



CC Key Facts

Easy To Use

CC is available in man portable rolls for applications with limited access or where heavy plant equipment is not available. There is no need for mixing or measuring, the concrete is premixed and cannot be over hydrated. It will set underwater and in sea water.

Rapid

Once hydrated, CC remains workable for 2 hours and hardens to 80% strength within 24 hours. Accelerated or retarded formulations can be produced to meet specific customer requirements.

Environmentally Friendly

CC is a low mass, low carbon technology which uses up to 95% less material than conventional concrete for many applications. It has minimal impact on the local ecology due to its limited alkaline reserve and very low wash rate.

Flexible

CC has good drape characteristics allowing it to take up the shape of complex surfaces including those with a double curvature. Unset Canvas can be cut or tailored using basic hand tools.

Strong

The fibre reinforcement prevents cracking, absorbs energy from impacts and provides a stable failure mode.

Durable

CC is chemically resistant, has good weathering performance and will not degrade in UV. CC has an expected life of over 50 years.

Water Proof

The PVC backing on one surface of the Canvas ensures that the material is completely water proof and chemically resistant.

Fire Proof

CC is fire-safe, does not contribute to the surface spread of flames, has a low level of smoke development and minimal hazardous gas emissions. CC has achieved Euroclass classification B-s1, d0.

Batched rolls

Bulk roll

For further information or technical support contact:
+ 44 (0) 845 680 1908
info@concretecanvas.co.uk
www.concretecanvas.co.uk

CC Applications

Ditch Lining

CC can be rapidly unrolled to form ditch or tank lining. It is significantly quicker and less expensive to install than conventional concrete ditch lining and requires no specialist plant equipment. The 30m ditch shown above was lined in 45min.

Pipeline Protection

CC can be used as a coating for overland or underwater pipeline protection, providing a superior tough rock shield. In remote areas it can be used to coat steel pipe on site without expensive wet concrete application plants. CC will set underwater and provide negative buoyancy. CC13 meets the requirements of ASTM G13 .

Ground Resurfacing

CC can be secured with ground anchors to rapidly create a concrete surface for flooring, pedestrian walk-ways or dust suppression. CC8 and CC13 have been tested to EN 1991-1-1:2002 (Resistance to Imposed Loads on Vehicle Traffic Areas)

Bund Lining

Earth containment bunds can be quickly lined with CC to provide an efficient, chemically resistant alternative to concrete walling.

Slope Protection

CC can be used as slope stabilisation and other erosion control applications such as temporary and permanent slope protection, retaining walls, boulder fences, low level bunds and river bank and dam revetments.

Architectural Applications

CC can be used to create organic and custom moulded decorative panels for building refurbishment and exterior installations/pavilions. CC meets the requirements of EN 12467 (Fibre-Reinforced Cement Boards for Wall Cladding).

Mining Applications

CC can be used as an alternative to poured or sprayed concrete or as a quick way of erecting strong permanent or temporary blast and vent structures and spall lining. CC has been successfully trialled in Mpumalanga, South Africa.

Other Applications

Other applications include roofing, retaining walls, scour protection, culverts, blinding layers, shotcrete replacement, weed inhibiting, basement lining, water tanks, flood defences, tunnel lining...

Concrete Canvas™ Material Data

Physical Properties*

CC	Thickness (mm)	Batch Roll Size (sqm)	Bulk Roll Size (sqm)	Roll Width (m)
CC5	5	10	200	1.0
CC8	8	5	125	1.1
CC13	13	N/A	80	1.1

CC	Mass (unset) (kg/m2)	Density (unset) (kg/m3)	Density (set) (kg/m3)
CC5	7.0	1500	+30-35%
CC8	12.0	1500	+30-35%
CC13	19.0	1500	+30-35%

Setting

Working Time 1-2 hours subject to ambient temperature

CC will achieve 80% strength at 24 hours after hydration.

Method of Hydration

Spray the fibre surface with water until it feels wet to touch for several minutes after spraying.

Re-spray the CC again after 1 hour if:
- Installing CC5
- Installing CC on a steep or vertical surface
- Installing in warm climates

Notes:
- CC cannot be over hydrated and an excess of water is always recommended.
- Minimum ratio of water:CC is 1:2 by weight.
- Do not jet high pressure water directly onto the CC as this may wash a channel in the material.
- CC can be hydrated using saline or non-saline water.
- CC will hydrate and set underwater.
- CC has a working time of 1-2 hours after hydration. Do not move CC once it has begun to set.
- Working time will be reduced in hot climates.
- CC will set hard in 24 hours but will continue to gain strength for years.
- If CC is not fully saturated, the set may be delayed and strength reduced. If the set is delayed, re-wet with a large excess of water.

Reaction to Fire

CC has achieved Euroclass B certification:
BS EN 13501-1:2007+A1:2009 B-s1, d0

Strength

Very high early strength is a fundamental characteristic of CC. Typical strengths and physical characteristics are as follows:

Compressive tests based on ASTM C473 – 07
- 10 day compressive failure stress (MPa) 40
- 10 day compressive Youngs modulus (MPa) 1500

Bending tests based on BS EN 12467:2004
- 10 day bending failure stress (MPa) 3.4
- 10 day bending Youngs modulus (MPa) 180

Tensile data

	Tensile strength (kN/m)	
	Length direction	Width direction
CC5	6.7	3.8
CC8	8.6	6.6
CC13	19.5	12.8

Abrasion Resistance (DIN 52108)
- Similar to twice that of OPC Max 0.10 gm/cm2

MOHS hardness 4-5

CBR Puncture Resistance EN ISO 12236: 2007 (CC8 & CC13 only)
- Min. Push-through force 2.69kN
- Max. Deflection at Peak 38mm

Resistance to Imposed Loads on Vehicle Traffic Areas
EN 1991-1-1:2002 (CC8 & CC13 only)
- Category G compliant
- Gross weight of 2 axle vehicle 30 to 160kN
- Uniformly distributed load not exceeding 5kN/sqm

Standard Test Method for **Impact Resistance of Pipeline Coatings**
ASTM G13 (CC13 only) Passed

Other

Freeze-thaw testing (BS EN 12467:2004 part 5.5.2) Passed

Soak-Dry testing (BS EN 12467:2004 part 5.5.5) Passed

Water impermeability (BS EN 12467:2004 part 5.4.4) Passed**

Moisture vapour transmission rate
PVC Thickness 0.42 mm
PVC MVTR range 0.836 - 0.924 g.mm / (m^2.day)

CC Static Head < 3000mm

Patent Information

Patent Protected
Pat Pend/Granted:
CA 2655054, EP 2027319, GB 2455008, US US-2010-0233417-A1, ZA 2009/00222, SA 12/303,864, WO 2010/086618 and other patents pending.

* Indicative values

** For tanking applications where a 100% waterproof seal is required, it is recommended to use a protective CC overlay in combination with an appropriate sealed membrane liner. CC is not recommended as the sole barrier layer where 100% impermeability is critical.

Contact

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Milliken®

Concrete Cloth™

Changing the way you think about concrete.

Imagine being able to use concrete on slopes, in water, and in other hard to reach places - with no forms, no mixing, and minimal equipment. Concrete Cloth is flexible and will bend and curve, enabling it to follow the natural contours of the land, including ditches and slopes.

Unlike regular concrete, Concrete Cloth can be installed in the rain, and other wet conditions, virtually eliminating rescheduling due to weather conditions. It comes in a variety of sizes, including portable rolls that two men can carry, reducing the need for heavy machinery.

The fabric structure also reinforces the concrete and reduces cracking, while using up to 95% less concrete than conventional methods. Concrete Cloth has a low alkaline reserve and a low wash rate for a low ecological impact. It meets many ASTM and other standards and is resistant to chemicals, weather, wear, and UV.

Licensed from

CONCRETE CANVAS™

Milliken™

Concrete Cloth installs in four fast, easy steps

Roll it

- Hang vertically over slopes and in tunnels
- Lay in trenches and ditches
- Shape over embankments, or around other structures

Secure it

- Seam together if needed
- Fasten to surface with staples, screws, pegs, weights or ties

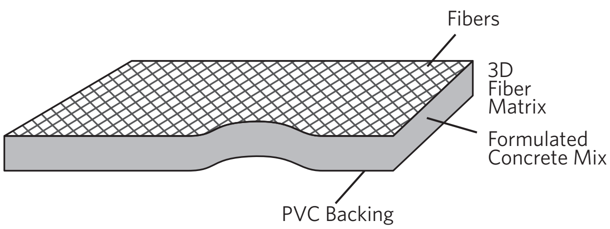
Wet it

- Hydrate with at least a 1:2 ratio of water to Concrete Cloth
- Reshape for up to 2 hours
- Rewet in 1-2 hours in hot and dry climates
- Can not over saturate
- Install in the rain or under water

Use it

- Cures to 80% strength in 24 hours

Concrete Cloth Section



The unique structure of Concrete Cloth facilitates ease of installation. Cement mix is trapped in a flexible 3D fabric, backed with a waterproof layer. The fabric can be hung vertically, laid in trenches, or cut and formed into shapes to create a durable layer of concrete, all without the need for molds or mixers. Wet the fabric to activate the concrete, and within 24 hours, the concrete has cured to 80% strength.

concretecloth.milliken.com

Milliken™

EPA United States Environmental Protection Agency

Technical Support Project

ENGINEERING FORUM TELECONFERENCE
January 8, 2014

- Technical Presentation: Concrete Cloth
- Technical Support Projects Co-Chair Call Update
- Follow-Up on 2013-2014 EF Technical Topics and the Evergreen List
- Update On 2014 NARPM Courses
- EF Greener Clean Ups Subcomittee Update
- News From EPA Office of Superfund Remediation and Technology Innovation
- Next Engineering Forum Teleconference
- Participants

TECHNICAL PRESENTATION: ENVIRONMENTAL APPLICATIONS OF CONCRETE CLOTH™

Concrete Cloth™ is a flexible cement-impregnated fabric that hardens when hydrated to form a thin, durable concrete layer. It has applications such as erosion control, ditch or canal lining, slope protection, and buildings. At a Superfund site in Prescott, AZ a fresh water collection/transfer system was installed. This Concrete Cloth™ was selected as the protection medium. Several other environmental applications specific to water management and protection were presented.

TECHNICAL SUPPORT PROJECTS CO-CHAIR CALL UPDATE

- No update for this call. No TSP co-chair call occurred on January 7, 2014.

FOLLOW-UP ON 2013-2014 EF TECHNICAL TOPICS AND THE EVERGREEN LIST

The high and medium priority projects were updated on the Evergreen List. A brief summary on progress is provided for the topics below.

- Longevity issues with vertical engineered barriers: Team performed an independent review of documents and will discuss on next team call.
- Discussion board: Set up a forum using the new EPA tool: Team will meet on Jan. 13th to discuss available tools, etc.
- Estimating time frames for cleanup and achievable concentrations, tools, and models: No update was stated on the call. However, Mark Rothas provided an update via email after the call on his efforts during talks between the EPA/U. S. Army Corps of Engineers (USACE) regarding this project. EPA headquarters staff expressed interest in developing some kind of tools/database to help support and document information regarding remediation technology performance, etc., and thought that this work team could potentially support that effort. Mark has received concurrence from EPA headquarters staff and USACE management to participate in the initial work scope/work product planning effort and conference calls. EPA headquarters staff indicated an interest in their staff participating w/the EF work team in the planning process. Mark has drafted a proposal which he has provided to the co-chairs to review. A copy of the draft will be posted on the Environmental Science Connector (ESC) website for interested members to review.
- Lessons Learned fact sheet in-situ thermal: Work in progress.

UPDATE ON 2014 National Association of Remedial Project Managers Conference (NARPM) COURSES

- Summary on EF technical presentations (Team: Mike, Suzanne) (NARPM point of contact (POC): Charlie Root)
  - Abstract submitted and two of the three presenters for this course have been confirmed.

- Greener cleanups and the role of best management practices. (Team: Carlos, Hilary, Julie, Stephanie) (NARPM POC: Charlie Root). Abstract approved. Most panelists from the 2013 NARPM session will be able to participate. No presentations have been collected to date.
- Full-day Dense, Non-Aqueous Phase Liquids training (Team: Kira) (NARPM POC: Steve Tzhone)
  - Held conference call with course leads and worked on refining the material. Kira is looking for team members that would be interested in helping on the course development, etc.

- Environmental footprint methodology training (Team: Carlos, Hilary, Julie, Stephanie, Karen) (NARPM POC: Charlie Root)
  - Team met and discussed updating the course material and incorporating sites where the spreadsheets for environmental footprint analysis (SEFA) have been used as part of the case studies.

- In-Situ Chemical Oxidation lessons learned session (Team: Raji, Ground Water Forum, and Scott Huling) (NARPM POC: Steve Tzhone). Abstract submitted.
  - Case study – U.S. Marine Corps site in North Carolina
  - Sodium persulfate and permanganate – Lessons Learned

- Site Assessment Tools and Emerging Technologies (Felicia Barnett, Rob Weber, John McKernan)
  - Abstract submitted and presenters have been confirmed.

- Using Models to Assist with Cleanup Goal Development During Removal and Remedial Actions (Felicia Barnett, Rob Weber, Dave Burton, John McKernan)
  - Abstract submitted and presenters have been confirmed.

EF GREENER CLEAN UPS SUBCOMITTEE UPDATE

- December 11: Green Remediation Discussed the *American Society for Testing and Materials* (*ASTM)* Greener Cleanup guidance standards. Groundwater adaptation fact sheets have been issued and new web page has been launched. Working on a NARPM course on the groundwater adaptation fact sheet. Next remedy type to be looked at under the climate change adaptation project will be containment remedies.
- December 12: Call with Greener Cleanup POCs. Feedback on the footprint methodology (Regions 2, 3, 4, 5, 6, 9, & 10). Region 9 has the most examples of use of SEFA. Will be incorporated into the NARPM training.
- Greener Cleanup Memo: Memo has been edited and going through final review. A final memo maybe issued by the end of the month.

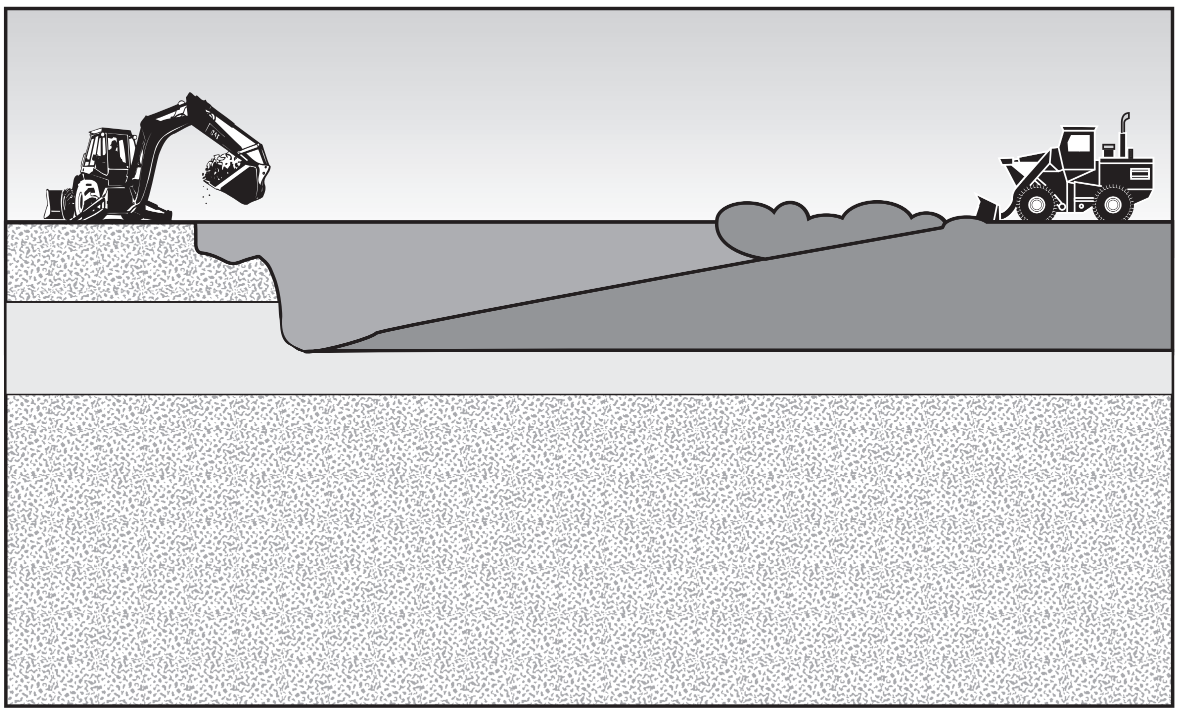
Appendix C

Excerpts from EPA 542-R-98-005
Excerpts from EPA 540-R98-041

United States Environmental Protection Agency
Office of Solid Waste and Emergency Response (5102G)
EPA 542-R-98-005
August 1998
www.clu-in.com

EPA

Evaluation of Subsurface Engineered Barriers at Waste Sites



1.1.1 Historical Development of Engineered Barriers

Historically, vertical barriers have been used on construction projects to prevent inflow of groundwater into deep excavations, as well as to support excavation. Sheet pile walls (first of wood and later of steel) have been installed throughout the world for many decades. The 1950s saw the development of slurry trenching technology, in which bentonite was used to support the sides of trenches under excavation before they were backfilled. That development took place independently in Europe and in the United States.

A market existed in Europe for the construction of deep excavations in urban areas adjacent to existing buildings, even historical structures. That demand created a need to develop technologies for rigid support systems and for limiting the drawdown of the water table outside the excavation to minimize subsidence. Secant pile walls first were used after World War II; later, in the 1950s, concrete slurry wall technology was developed. That development was a natural evolution of the secant wall technology, with the goal of decreasing the number of joints between piles, thereby minimizing the risk of blowouts in the mass excavation through faulty joints. By the end of the 1960s, cement-bentonite cutoff wall technology also had been developed in Europe to allow deep excavation below the groundwater table for power plants and locks, or to act as a cutoff through pervious overburden soils on dam projects. In Europe to date, the use of cement-bentonite (quite often in conjunction with a geomembrane) remains the preferred technique for seepage control, with applications including hazardous waste sites.

The development of slurry trenching technology in the United States, occurring independently from its development in Europe, took place in the late 1940s and early 1950s and was based on the use of the soil-bentonite technique (still unused in Europe). The main goal was to prevent the flow of water into deep excavations for lock and dam projects, or to minimize seepage beneath and through dams and dikes. The first industrial application of the soil-bentonite technique took place in 1950 at the Terminal Island project in California. Slurry trenches then were used extensively in the 1960s and 1970s for dam projects as permanent cutoff walls and for the construction of the Tombigbee Waterway.

More recently, by the late 1970s and early 1980s, vertical engineered barriers have been used in the United States to isolate hazardous wastes from groundwater, as slurry walls, primarily soil-bentonite cutoffs, began to be used to contain hazardous wastes. Initially, the goal was to contain contaminated groundwater for a “limited” period of time. A 30-year life span for the containment was often the objective. By the late 1980s, the concept of establishing a reverse gradient appeared. In such applications, an extraction or pumping system is installed in the contaminated zone, in addition to the peripheral cutoff wall. This approach allows maintenance of an inward flow through the wall at a very low rate. This approach has its advantages, since it decreases, if not eliminates, the risk arising from deficiency in design or installation or even localized anomalies in the aquitard layer.

In recent years, new concepts and developments in subsurface engineered systems have been introduced. Among them are:

- The funnel and gate, or permeable reactive wall: A contaminant plume is channeled between impervious vertical walls, referred to as the funnel, and flows naturally through a permeable reactive barrier gate, where the pollutants are treated in situ during the flow process.

- The use of slurry trenching technology to install a deep groundwater extraction trench, instead of an impervious cutoff wall: The slurry used to support the trench is made from a biodegradable material (instead of bentonite, which would reduce flow to the trench). After excavation, the trench is backfilled with a pervious material, and the slurry filling the voids of the pervious material biodegrades. Drains installed by this biopolymer method typically are from 20 to 50 feet deep, and sometimes deeper.

Quite recently, engineers began to be concerned not only about the hydraulic transport of contaminants, but also about the diffusion of contaminants through vertical barriers, a chemical process. This issue is crucial for the long term (usually considered to be well in excess of 30 years), in terms of the integrity of vertical barriers. New technologies are emerging to increase the sorption capacity of vertical barriers, primarily through the use of additives in the backfill materials.

In addition, improvements in barrier construction technology allow the installation of vertical barriers to depths as much as 400 feet, through various soil and rock conditions, and in hostile environments (such as brackish water and water contaminated with chemicals).

Caps have been used to prevent the downward flow of surface runoff and precipitation inside contaminated sites. The concept is similar to the use of impervious blankets on the upstream slope of a dam. At first, caps included clay blankets. The introduction of chemically resistant geosynthetic materials that have minimal diffusive conductivity has significantly improved the quality and the ease of installation of caps. Caps have been used at sites as large as 400 acres.

1.1.2 Types of Engineered Barriers

Engineered barriers, as discussed in this report, are vertical barriers and caps. Appendix A provides details of the design, construction, and construction quality assurance (CQA) and construction quality control (CQC) for vertical barriers and caps. Significant features of vertical barriers and caps are discussed below.

Note: This study does not include engineered bottom barriers, a recent development in which an impervious horizontal stratum is created below a hazardous waste site, when no aquitard exists, by grouting or other techniques now in the developmental phase.

Vertical Barriers

Vertical barriers control the subsurface flow of water into or out of a hazardous waste site. They are classified into various categories. The most common ones are briefly discussed below:

Barriers Installed with the Slurry Trenching Technology: Such barriers consist of a vertical trench excavated along the perimeter of the site, filled with bentonite slurry to support the trench and subsequently backfilled with a mixture of low-permeability material (1×10^{-6} cm/sec or lower) (see Figure 1-1). Such walls are keyed into an aquitard, a low-permeability soil or rock formation, or a few feet below the groundwater elevation when the objective is to contain light nonaqueous phase liquids (LNAPL). Significant features of a vertical barrier are, at a minimum:

In general, three trench slurry compatibility tests should be conducted (unless incompatibility is known not to exist). Conducting more than three tests was considered better than acceptable, and fewer than three, less than acceptable.

The compatibility of trench slurry was evaluated at most of the sites studied; the number of tests varied from 2 to 5.

Testing of Backfill Permeability

The permeability of the backfill used to construct the barrier wall is a key design parameter that should be tested adequately. For the soil-bentonite technique, the objective is to establish proportions of on-site or imported materials needed to achieve the target permeability and physical properties of the barrier backfill. References and sources differed significantly on what constitutes standard practice. Site conditions, availability of borrow materials, and procedures for testing permeant compatibility affect the number of tests required. However, the consensus average was approximately three permeability tests of the backfill (the same or similar batches), using acceptable laboratory procedures that simulate in situ conditions. Conduct of three tests was considered acceptable. Conduct of more than three tests was considered better than acceptable, and of fewer than three, less than acceptable.

The permeability of backfill at the sites studied varied from 1×10^{-6} to 9×10^{-9} cm/sec. The number of tests conducted to verify the permeability varied from 2 to 5.

Long-Term Compatibility of Backfill

Since chemical reaction with contaminants can increase the permeability of the backfill, the long-term compatibility of backfill with the in situ soils and groundwater should be analyzed. Typically, several permeability tests of multiple pore volumes are performed to simulate a long-term condition and identify degradation through changes in permeability with time. Such tests often are combined with the testing of permeability of the backfill. Conducting three tests was considered acceptable. Conducting more than three tests was considered better than acceptable, and fewer than three, less than acceptable.

Compatibility testing was done at all sites at which leachate or contaminants were encountered. The extent of testing varied from site to site, with rigorous testing done at some sites and very limited testing at other sites.

Barrier Penetration

Subsurface utilities present along the barrier wall alignment and located below the water table must be delineated, rerouted, or protected with watertight connections. If such conditions were not considered, the site was rated less than acceptable; if the contractor designed solutions during construction, it was rated acceptable; and if the engineer investigated the problems and designed solutions during design, it was rated better than acceptable. Barrier penetrations were encountered at only a few of the sites studied. In all those cases, the barrier penetrations were investigated and accounted for in the design by the engineer.

3.3.9 Permeability of the Backfill

The design permeability of a barrier can vary greatly, depending on the type of barrier and the design objective. Generally, 1×10^{-7} cm/sec ± is an industry-accepted achievable permeability for soil-bentonite barriers. Permeabilities of 1×10^{-6} cm/sec ± generally are accepted for cement-bentonite barriers of various types, such as soil-cement-bentonite and cement-bentonite. Grout barriers have permeabilities of approximately 5×10^{-6} cm/sec. Sampling, type of test conducted, and testing parameters can influence permeability values significantly.

Standard specifications require that an independent approved laboratory perform testing of backfill permeability. The tests should be run in a flexible-wall permeameter. Typically, the sample first will be prepared under a consolidation pressure equivalent to half the depth of the barrier. The frequency of the tests varies according to the project; however, for this analysis, a test once for every 400 to 600 cubic yards was considered standard.

Note: It takes approximately one week or longer from the time of sampling to obtain the results of a flexible-wall permeability test. For that reason, a few contractors conduct daily on-site permeability tests in a fixed-wall permeameter (filter press). That approach was not used as a rating criterion for this study. However, the project team recommends the practice, even if such tests are less accurate than laboratory tests, because its application allows the detection of deficient backfill within a few hours, rather than a week.

If all the above tests on the mixed backfill were performed once for every 400 to 600 cubic yards, the site was rated acceptable. If the tests were performed less frequently, the site was rated less than acceptable. If the tests were performed more frequently, the site was rated better than acceptable.

At the sites studied, backfill gradation was tested once for every 400 to 600 cubic yards unless the backfill borrow material was obtained from a relatively uniform source. In such a case, testing was less frequent. The backfill slump at most of the sites studied was tested once for every 400 to 600 cubic yards and varied from 3 to 6 inches. Testing of the backfill permeability at the sites varied from once every 250 cubic yards to once every 600 cubic yards.

3.3.10 Placement of the Backfill

Control of the placement of the backfill in the trench is an important component of successful barrier construction.

First, the bottom of the trench should be sounded and approved by the engineer before the backfill is placed. Once the initial slope of the backfill has been established appropriately, the mixed backfill should be pushed on top of the backfill previously placed on the top of the trench. Free-dropping of the backfill through the slurry should not occur. The slope of the backfill should be measured at least once per shift and, if the backfill operation was stopped for more than 24 hours, at a minimum, the slope should be sounded prior to backfill placement for potential sedimentation on its surface.

If the mixing was controlled loosely and the backfill placed in the trench, the site was rated less than acceptable. If the mixing was controlled at a central location and the backfill placed in a manner that prevented segregation, the site was rated better than acceptable.

Funnel and Gate Barrier—Permeable reactive barrier that consists of a permeable curtain (gate) that contains appropriate reactive materials, and a barrier wall (funnel) that directs the groundwater to the gate.

Gas Collection—System to collect landfill gases, typically methane, produced under the cap.

Geosynthetic Materials—Generic term for all synthetic materials used in geotechnical engineering applications.

Geotechnical Investigation—Investigation of soil mechanics; rock mechanics; and the engineering aspects of geology, geophysics, hydrology, and related services.

Gradation—Distribution of physical size in a granular soil.

Groundwater Dewatering—Removal of groundwater from within a barrier system; generally, the water is treated to remove contamination.

Groundwater Cutoff Wall—Another term for a vertical subsurface barrier.

Grouting—Introduction of cemenitous materials in porous soil and fractured rock.

Head Differential—Difference in water elevation within and outside the barrier wall.

Hydraulic Conductivity—Rate of discharge of water under laminar flow conditions through a unit cross-sectional area of a porous medium under a unit hydraulic gradient and standard temperature conditions.

Hydrofracture—Fracture within a vertical barrier wall caused by earth stresses that allows groundwater flow across the barrier.

Hydrogeologic Units—Water-bearing geological units.

Inclinometers—Measurement device to monitor the movement of soil and rock materials relative to a fixed point located along an inclined or vertical borehole.

Key-in—Section of the vertical barrier where the low-permeability barrier material intersects with in-situ low-permeability soil or a rock formation to restrict the movement of groundwater, typically at the greatest depth of the barrier.

Lateral Flow—Horizontal movement of groundwater.

Low Permeability Layer—Portion of a landfill cover, vertical barrier, or liner that restricts groundwater flow to less than or equal to 10^{-7} cm/sec.

Macropore—Discontinuity in barrier materials that allows groundwater flow.

Marsh Funnel—Measurement device used to determine the viscosity of bentonite slurry.

SUMMARY OF EXISTING SUBSURFACE ENGINEERED BARRIER AND CAP TYPES AND TYPICAL CONSTRUCTION TECHNIQUES

This appendix summarizes existing subsurface engineered barrier and cap types. The summary includes descriptions of current technologies, applications, design considerations, and construction methods. The information contained herein is thoroughly documented in current engineering literature.

1.0 SUBSURFACE ENGINEERED BARRIERS

Subsurface engineered barriers can be used (1) as barriers to groundwater flow, (2) to prevent off-site migration of contaminated groundwater, and (3) to prevent on-site migration of uncontaminated groundwater. Barriers may be circumferential or open and hanging or keyed. This section describes some current barrier technologies in terms of particular design, construction, and performance characteristics. The subsurface engineered barriers (walls) described in this appendix are grouped into five categories: slurry trench barriers, grouted barriers, deep soil mixed barriers, sheet-pile walls, and treatment walls. Slurry trench barriers were the most common barrier type identified in this study; therefore, slurry trench barriers are discussed in greater detail than the other types. In addition, the appendix briefly describes biopolymer drains which use barrier technology to engineer migration of groundwater.

1.1 SLURRY TRENCH BARRIERS

The most common subsurface barrier is the slurry wall. In general, slurry walls are constructed in a two-step process. First a trench is excavated, and a slurry is placed in the trench to maintain trench stability. When the trench is excavated to the designed depth and width, a permanent backfill material is placed in the trench, displacing the slurry. The permanent backfill forms a hydraulic barrier. A slurry wall can be constructed as one continuous trench or as a continuous series of panels. A bentonite-water slurry is commonly used in slurry trenches, although a variety of slurries and backfill materials can be used. Design considerations common to all slurry walls include the wall depth and key.

Slurry trenches can typically be excavated to depths of 50 to 80 feet using backhoes. Deeper continuous and panel slurry trenches can be excavated using a crane-mounted drag line or clamshell bucket. Trenches are usually 2.5 to 3 feet wide (the width of most backhoe buckets) but may be up to 5 feet wide. Unique site or project considerations, including hydrogeology, chemical compatibility, permeability, and budget, should be addressed in selecting the type of slurry trench to be used. The following subsections describe the different types of slurry trench subsurface barriers.

1.1.1 Soil-Bentonite Barriers

Soil-bentonite (SB) barriers are the most common barrier type identified in this study. The backfill used for SB barriers is 1 to 5 percent bentonite--a montmorillonitic clay that swells when hydrated--blended with soil fill. SB barriers can reliably achieve permeabilities of 10^{-7} to 10^{-8} cm/sec. The trench is excavated using a backhoe, dragline, or clamshell, depending on depth requirements. Figures A-1 and A-2 illustrate a typical slurry wall construction site and a trench cross section, respectively.

slurry will be displaced during backfill placement. Backfill samples should be collected during backfill placement on a frequent and regular basis as established in the CQA plan. When the barrier is completed, backfill samples should be collected at regular intervals and tested for permeability. This test will establish whether the completed barrier meets the design criteria.

Handling of Contaminated Materials. At sites where contaminated backfill or slurry may be handled, precautions should be taken to ensure that potential spills or releases are contained and recovered in order to prevent exposure of site workers or other receptors.

1.1.2 Cement-Bentonite Barriers

Cement-bentonite (CB) slurry trench cutoff walls are excavated using a slurry composed of water, cement, and bentonite. The bentonite-water slurry is prepared and allowed to fully hydrate before portland cement is added. Once the cement has been added, the CB slurry is pumped to the trench. The CB slurry is left to harden in place, forming a hydraulic barrier with a permeability on the order of 10^{-5} to 10^{-6} cm/sec. The relatively high permeability is the result of the portland cement reducing the swelling properties of the bentonite. Because of their relatively high permeabilities, CB barriers are typically not used as contaminant containment applications, which often require permeabilities of less than 10^{-7} cm/sec. However, CB barriers are commonly used as cutoff barriers where higher wall strengths are necessary and low permeability is not required. A CB barrier is a homogenous, isotropic cutoff wall; therefore, the likelihood of variations being present in the wall is lower than for SB barriers because no separate backfilling step is necessary.

Alternative cement mixes have been used that display lower permeabilities and improved chemical compatibility. Ground, granulated blast furnace slag mixed with portland cement at a ratio of 3:1 or 4:1 has displayed permeabilities of 10^{-7} to 10^{-8} cm/sec. Bentonite substitutes have also been used. One such substitute is attapulgite, a clay mineral that is more resistant to chemical degradation than bentonite. The use of such additives can significantly increase the overall cost of a barrier.

1.1.2.1 Design Considerations

In general, design considerations for CB barriers are similar to those for SB barriers (see Section 1.1.1.1). Unique aspects of CB barrier design are described below.

Permeability. CB barriers typically exhibit permeability on the order of 10^{-5} to 10^{-6} cm/sec. Because of their relatively high permeabilities, CB barriers are typically not used for contaminant containment applications.

Wall Strength. CB barriers have higher shear strengths than SB barriers. The hardened trench of a CB barrier will exhibit the consistency of stiff clay. Therefore, CB barriers can be used where higher strengths are needed.

Surface Grade. CB barriers can be constructed with steeper surface grades than can SB barriers. Grade steps can be easily accomplished because the CB slurry hardens daily.

Site Access. Construction of CB barriers does not require as large a working area as construction of SB barriers because backfill mixing areas are not used.

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United States Environmental Protection Agency

EPA LINER STUDY

Report to Congress

Section 4113(a) of the Oil Pollution Act of 1990

May 1996

3. EXISTING REGULATIONS AND INDUSTRY PRACTICES FOR LINER SYSTEMS

EPA reviewed Federal and State regulations and industry practices to gather information on the specifications of liner systems and to estimate the number of AST facilities currently required to use liners. Section 3.1 discusses the results of EPA's review of Federal and State AST regulations. Section 3.2 summarizes recommended industry practices related to AST liners and double bottoms. Section 3.3 presents EPA's estimate of the number and type of facilities required to use liner systems as a result of State regulations.

3.1 REVIEW OF FEDERAL AND STATE AST REGULATIONS

3.1.1 Federal Regulations

In general, existing Federal regulations affecting AST facilities do not explicitly require the use of liners or double bottoms with ASTs. However, section 112.7(c) of the Oil Pollution Prevention regulation, which is the primary Federal regulation addressing oil discharge control and response equipment and procedures for AST facilities, requires that "appropriate containment and/or diversionary structures or equipment to prevent discharged oil from reaching a navigable water course should be provided" and that such containment be "...sufficiently impervious to contain spilled oil." This regulatory requirement could be met by constructing a secondary containment system, such as a dike, with materials that have a low permeability (i.e., resist the penetration of oil through the material) or by adding a liner to the secondary containment system to provide this protection. However, this requirement does not specify a permeability standard, such as how far oil may move through the material per unit time (e.g., 1 millionth of a centimeter per second). Although EPA does not have comprehensive data on the quality of secondary containment structures at AST facilities nationwide, information provided by EPA field personnel indicates that the quality of secondary containment systems (e.g., the permeability of the materials) varies considerably.

The Federal UST regulation under RCRA Subtitle I (at 40 CFR part 280) and the Federal Hazardous Waste Storage Tank (HWST) regulation under RCRA Subtitle C (at 40 CFR part 264) require that facility owners and operators consider the installation of liners as a protective option for USTs and HWSTs. Although the Federal UST and HWST regulations do not specify liner materials or designs, these regulations establish performance criteria for containment materials and structures. For example, the UST regulation mandates a permeability for liners of 1×10^{-6} centimeters per second (cm/sec). The HWST regulation requires that external liner systems be capable of preventing lateral and vertical migration of the waste if a release from the tank(s) should occur.

Leak detection practices or devices are required by the UST and HWST regulations. The UST regulation specifies that leak detection equipment must be able to detect a 0.2 gallon-per-hour leak and that tanks must be inspected monthly. The HWST regulation requires that leak detection systems be in continuous operation and be capable of detecting a release within 24 hours or at the earliest practicable time.

In general, ASTs (and associated piping) that have less than 10 percent of their volume below the ground surface are not subject to the Federal UST regulations. The HWST regulations affect only ASTs that contain hazardous wastes. Thus, Federal regulations do not require facilities with ASTs containing oil to have liner systems within secondary containment systems.

3.1.2 State Regulations

EPA conducted a review of current and proposed AST regulations for the 50 States to gather information on liner requirements and specifications and to determine quantitatively the extent to which States require facilities to have liner systems. The results of this review of regulations for each State is briefly summarized in Appendix A.

EPA identified nine States that have promulgated or have proposed regulations that specify the use of "impermeable" secondary containment systems, liners, or other diversionary structures and systems to prevent discharges of oil from reaching soil, ground water, or surface water: Alaska, Connecticut, Florida, Maryland, New Jersey, New York, Rhode Island, South Dakota, and Wisconsin.[13] For each of these States, the following information is provided below and summarized in Exhibit 3-1:

- The applicability of the requirements to different sizes and/or types of facilities; and
- Specifications that address secondary containment (including liner specifications) and leak detection procedures and/or equipment.

Alaska (18 ACC 75): Alaska requires that all new and existing crude oil storage facilities with a total storage capacity of more than 5,000 barrels (and non-crude facilities with a storage capacity of more than 10,000 barrels) locate their tanks within a "sufficiently impermeable" secondary containment area. Secondary containment *under* tanks at new installations must include "impermeable" liners or double bottoms. Liner and permeability specifications apply to new facilities and new secondary containment areas only:

[13] Connecticut's regulations were proposed at the time of this review.

EXHIBIT 3-1

SUMMARY OF STATE REGULATORY REVIEW FOR THE NINE STATES

REGULATION	SECONDARY CONTAINMENT LINERS	UNDERTANK LINERS	LINER MATERIALS	PERMEABILITY RATE (CM/SEC)	LEAK DETECTION WITH LINERS[a]
Alaska	✓	✓	✓[b]	1×10^{-7} [b]	✓
Connecticut (proposed)	✓	N/A	N/A	1×10^{-5}	✓
Florida	✓	✓	✓	1×10^{-7}	-
Maryland	✓	N/A	N/A	1×10^{-4}	-
New Jersey	✓	✓	✓	1×10^{-7}	-
New York	✓	✓	✓	1×10^{-6}	✓
Rhode Island	✓	✓	✓	1×10^{-6}	-
South Dakota	✓	✓	✓	1×10^{-6}	✓
Wisconsin	✓	✓	✓	N/A	N/A

Notes:

✓ Regulations require these specific provisions

N/A Not applicable; these provisions are not part of the regulation

a/ States indicated by a "–" require visual detection. States indicated by ✓ also require additional measures such as inventory control or automatic leak detection equipment.

b/ New facilities are required to have a liner that has a permeability of 1×10^{-7} cm/sec (layer of manufactured material in the area under the tank) or 1×10^{-6} cm/sec (layer of natural or manufactured material) for new secondary containment structures, excluding undertank applications

- "Sufficiently impermeable" for new installations consists of a "layer of natural or manufactured material of sufficient thickness, density, and composition to produce a maximum permeability for the substance being contained of 1×10^{-6} cm/sec."

- "Impermeable" liners for new installations consist of a "layer of manufactured material of sufficient thickness, density, and composition to produce a maximum permeability for the substance being contained of 1×10^{-7} cm/sec."

Alaska requires that each tank at new and existing installations must be equipped with a leak detection system that can be used externally to "detect leaks in the bottom of the tank, such as secondary catchment under the tank bottom with a leak detection sump, a sensitive gauging system, or another leak detection system approved by the department." The owner or operator must check for the presence of leaks or spills daily at a staffed facility and at least once a month at an unstaffed facility.

Connecticut (RSCA proposed 22a 449): The proposed regulations would require facilities with aggregate storage of more than 1,320 gallons, or that have a single tank of more than 660 gallons, to have secondary containment in the form of "impermeable... dikes" around all tanks. These volume specifications are consistent with the Federal Oil Pollution Prevention regulation. These regulations would apply equally to both new and existing facilities.

- Dike permeability must be less than 1×10^{-5} cm/sec. The dikes may be either above or below grade, but the depth of a dike may not exceed 10 feet below the outside finished grade. The diked area must contain at least 100 percent of the volume of the largest enclosed tank.

Proposed leak detection specifications, like those for most of the eight other States, will require regular visual inspections around tanks and transfer piping. Connecticut also proposes to mandate weekly inventory measurement/record reconciliation procedures to detect slow leaks that have the potential to escape visual checks.

Florida (FAC 17-762): Florida law specifies "impervious secondary containment" systems. The regulations apply to all new facilities with a storage capacity of greater than 550 gallons. All existing facilities with a storage capacity of greater than 550 gallons must comply with the regulations by the year 2000, except for certain shop-fabricated tank systems.[14]

- The liner systems may be synthetic, concrete, or clay-based, and they must be capable of containing 110 percent of the largest tank enclosed by the secondary containment area, unless that tank is itself enclosed in a concrete vault, or is double walled.

- The definition of "impervious" varies depending on the liner material used. For synthetic systems, it is 1×10^{-7} cm/sec. Concrete liners must only be "product tight." Clay-based liner systems must be individually approved by the Florida Department of Environmental Protection.

[14] Vehicular fuel-storing shop-fabricated systems that store or use 1,000 gallons or less per month or 10,000 gallons or less per year also must comply with these regulations by the year 2000. Other aboveground shop-fabricated tanks may be retrofitted with double bottoms rather than an undertank impermeable liner. All alterations must be installed to regulatory specifications by the year 2000.

Specified leak detection measures consist of visual inspections or other appropriate measures. Inspections should be conducted around "tanks and integral piping," and must be conducted at least once per month.

Maryland (CMR 26:12): Maryland law specifies that secondary containment must be "capable of effectively holding the total volume of the largest storage container located within the area enclosed by the dike or wall." The regulations apply to new and existing facilities with a total storage capacity of greater than or equal to 10,000 gallons. Facilities with a storage capacity of less than 10,000 gallons, if judged to be a reasonable threat to State waters, also are subject to the regulations. The regulations prohibit the construction of tanks, dikes, or walls in wetlands or 100-year floodplains, unless a permit is obtained.

- Liner materials are not specified, nor are any designs except that the system must consist of continuous dikes or walls.
- The permeability of the system must be 1×10^{-4} cm/sec or less, for an unspecified liquid. Provisions for storm water collection/release are not specified.

Maryland requires visual inspections for leak detection. Areas to be included in each inspection are "seams, rivets, nozzle connections, valves, pumps, and pipelines directly connected to aboveground storage tanks." Inspections must be conducted at least once per month.

New Jersey (NJAC 7 1E-2): New Jersey requires that "any leak must be prevented from becoming a discharge." The regulations apply to new and existing "major facilities" -- facilities with a storage capacity of greater than or equal to 200,000 gallons. However, existing facilities are exempt from the secondary containment liner requirement if the following conditions are met: (1) the containment system (with a containment volume at least as large as the largest tank) can protect ground water for the period of time needed to clean up and repair or stop the leak; (2) the containment system allows visual inspection for leaks; and (3) the containment system is inspected daily.

- All secondary containment systems must have a permeability of 1×10^{-7} cm/sec or less.
- Dikes, berms, walls, curbing, gutters, ponds, lagoons, and basins are all listed as acceptable secondary containment designs. The system must be capable of containing 100 percent of the volume of the largest enclosed tank, plus have a means for accommodating 6 inches of rainwater.

Leak detection is required in the form of visual inspections. Areas that must be protected include the secondary containment areas and systems, storage tanks, aboveground pipes, and valves. Secondary containment/storage tank areas must be inspected at least once per week; secondary containment systems that are not impermeable (at existing facilities only) must be inspected daily.

New York (6NYCRR612-614): New York requires a "secondary containment system" around all ASTs with a storage capacity of greater than or equal to 10,000 gallons, or any tank that could reasonably be expected to discharge oil to the waters of the State. The regulations for new facilities are more stringent than the regulations for existing facilities. For example, owners of new facilities with new stationary tanks must: (1) install double bottoms on tanks; or (2) install an "impervious barrier" underneath the tanks.

- The secondary containment system may consist of a "combination of dikes, liners, pads, ponds, impoundments, curbs, ditches, sumps, receiving tanks, and other equipment capable of containing the product stored."

- The system must perform such that "spills of petroleum and chemical components of petroleum will not permeate, drain, infiltrate, or otherwise escape to the ground waters or surface waters of the State."[15] If the secondary containment system is constructed of earthen material, a release may only result in a "minimal amount of soil contamination." For diked systems, the regulation specifies the use of the performance design standards in Section 2-2.3.3 of the National Fire Protection Association's Flammable and Combustible Liquids Code (NFPA 30).

- Although the volume of the diked area need only be 100 percent of the largest tank volume (i.e., no precipitation allowance is stipulated), storm water collection must be controlled with either a manually operated sump or siphon, or a storm drain with manually controlled valves.

- For new facilities, the imperviousness of the double bottom or undertank barrier must be 1 x 10^{-6} cm/sec or better.

Visual inspection and inventory records reconciliation are required. The visual inspections must concentrate on the exterior surfaces (e.g., valves, pipes, etc.) and leak detection instruments (e.g., gauges or alarms). Visual inspections must be conducted monthly, and reconciliation of daily inventory records "must be kept current."

Rhode Island (OPCR 10-11): Rhode Island requires that a secondary containment system be in place around all oil-storing facilities that have a total storage capacity of greater than 500 gallons. New (or substantially modified) facilities are

[15] New York State provides a guidance document for inspectors and facility owners to aid in understanding the regulations. This document lists some permeability criteria for certain substances, even though no permeability rates are specified in the regulation.

regulated more stringently in that their secondary containment systems must consist of an "impermeable barrier" underneath all aboveground tanks. Rhode Island's regulations are similar to New York State's regulations; in many cases, the language is identical.

- Secondary containment may consist of a combination of dikes, liners, pads, impoundments, curbs, ditches, sumps, receiving tanks, or other equipment.

- The secondary containment system must be constructed so that petroleum spills "will not permeate, drain, infiltrate, or otherwise escape to the ground water or surface water before clean up can occur." Also, if earthen materials are used for the secondary containment structure, a spill should only be able to cause "a minimum amount of soil contamination."

- Dike construction must be in accordance with the standards are specified by Section 2-2.3.3 of NFPA 30, except that the capacity of the secondary containment area must be 110 percent of the largest tank volume.

- For new or substantially modified facilities, "impermeable" is defined as a permeability rate for water of 1×10^{-6} cm/sec or less. The barrier must not degrade in an underground environment or in the presence of oil. In addition, the entire secondary containment area (not just the undertank area) for new facilities must be constructed with a permeability rate for water of 1×10^{-6} cm/sec or less.

Regular facility inspections are required to detect potential leaks. The inspections must focus on all exterior surfaces of tanks, pipes, valves, and other equipment such as gauges, cathodic protection monitoring equipment, or other warning systems. The inspections must be conducted so that any potentially severe structural imperfections are identified, such as cracks, excessive settlement, or corrosion. These inspections must be performed at least monthly.

South Dakota (SCAC 74:03:30): The regulations are applied differently to new and existing facilities and to different sized facilities – new, large facilities are regulated the most stringently. "Small" facilities are those that have a total storage capacity of less than or equal to 250,000 gallons, and "large" facilities are those that have a total storage capacity of greater than 250,000 gallons.

- The containment system for new, "large" facilities may consist of double-walled and/or double-bottomed tanks, dikes, liners, pads, impoundments, curbs, ditches, sumps, receiving tanks, or other equipment capable of holding the material stored. For all containment designs except double-walled tanks, the containment volume must be 110 percent of the largest single enclosed tank. For "new" facilities, the containment structures may be built with native soils, clays, bentonite, or synthetic materials; however, the permeability of liquid through the finished floors and walls of the containment structure must be 1×10^{-6} cm/sec or less.

- "Small" new and existing facilities must comply with either: (1) the secondary containment requirements, as described in the bullet above; (2) the release detection requirements, as described below; or (3) certain tank performance standards, as outlined in the regulation.

- "Large" existing facilities must build a containment structure around all tanks that is capable of storing 110 percent of the volume of the largest tank. No permeability standard is provided. "Impermeable" barriers (defined as a permeability of 1×10^{-6} cm/sec or less for an unspecified liquid) must be built underneath all aboveground piping, and all piping must be cathodically protected.

"Large" (new and existing) facilities must perform specified leak detection measures; "small" (new and existing) facilities are provided with options for implementing leak detection standards, as described above. Facilities are required to use automatic leak detection equipment, and workers at the facilities also must conduct regular facility inspections. Monthly reconciliations of inventory records shall be made with daily measurements of product storage. Inspections of exterior surfaces of tanks, overfill devices, release detection devices, valves, gauges, and cathodic protection equipment must be conducted. Automatic detection systems shall be continuously engaged. Inspections of equipment must be conducted at least twice per calendar year, not to exceed 15 months between inspections in consecutive years.

Wisconsin (ILHR AR 10): Wisconsin requires lined secondary containment systems, which must perform as "impervious barriers" to the product stored for all aboveground, oil-storing tanks with a storage capacity greater than or equal to 110 gallons at new facilities.[16] Existing facilities are given a choice among various secondary containment options; in addition, existing facilities with a combined storage capacity of less than or equal to 5,000 gallons are completely exempt.

- The term "impervious" is not defined in the regulations, and permeabilities for the floors and walls of the secondary containment area are not specified.

- For new facilities, construction guidelines for dikes are specific: "Dike walls or floors made of earthen or other permeable materials shall be lined with asphalt, concrete, a synthetic or manufactured liner, or prefabricated basin." Dike design must be in accordance with Section 2-2.3.3 of NFPA 30, with the following additions: (1) the volume of the contained area must be 125

[16] For farms, this minimum storage tank capacity is increased to 1,100 gallons.

percent of the largest single tank volume, as opposed to 100 percent as specified by NFPA 30; (2) the walls *and* floors of the contained area must be impervious to the material stored; and (3) provisions must be made for the removal of collected rainwater.

- Existing facilities must comply with one or more of the following by May 1, 2001: (1) all of the secondary containment rules as described above, except that the containment volume may be *either* (a) 125 percent of the largest single enclosed tank volume, or (b) 100 percent of the largest single enclosed tank volume, with provisions for removal of rainwater (with valves or a sump); (2) leak detection, in the form of inventory control/reconciliation, tank gauging, tightness testing, vapor monitoring, or some other approved method; (3) installation of a double bottom on tanks; or (4) lining of the tank interior with a suitable product (the lining must cover the tank's bottom and extend a minimum of two feet up from the exterior grade, along the inside of the tank and the lining must then pass a series of inspections).

Leak detection is not a requirement for new facilities and is contained in the State regulations only as an option for compliance for existing AST systems.

3.2 INDUSTRY PRACTICES AND STANDARDS

EPA conducted a review of industry practices and standards related to liner systems to gather additional information on the technical aspects of these systems and when these systems are recommended. EPA found that although many industry associations have developed detailed standards related to the construction and operation of ASTs, few industry standards or practices explicitly recommend the use of secondary containment liners and/or double bottoms. However, at the time this review was being conducted, several industry associations, including Underwriters Laboratory and the International Fire Code Institute, were revising their recommended practices related to ASTs. API and NFPA recently completed their revisions, and the standards relating to liner systems are briefly summarized below.

In the July 1993 version of the API's Standard 650, "Welded Steel Tanks for Oil Storage," API adopted a policy recommending the use of release prevention barriers in new AST construction. API encourages owners or operators planning to construct new ASTs to consult this document. Double bottoms and undertank liners are both discussed as possible release prevention options. In addition, API states that if the tank owner decides the undertank area is to be constructed for leak detection, then the permeability of the leak detection barrier shall not exceed 1×10^{-7} cm/sec.

NFPA 30, "Flammable and Combustible Liquids Code" (1993 edition) states that "Facilities shall be provided so that any accidental discharge...will be prevented from endangering important facilities, or reaching waterways." Specifically, NFPA requires that discharge prevention measures be used with aboveground secondary containment-type tanks if they meet any of the following criteria: (1) tank capacity is greater than or equal to 12,000 gallons; (2) piping connections to the tank are below the normal maximum liquid level; (3) prevention systems for liquid released from the tank by siphon flow are not provided; (4) means are not provided for determining the level of liquid in the tank; (5) an alarm (triggered when the liquid in the tank reaches 90 percent of capacity) is not provided; (6) a system which automatically shuts off delivery when the liquid level reaches 95 percent of capacity is not provided; (7) spacing between adjacent tanks is less than 3 feet; (8) the tank is not capable of resisting damage form the impact of a motor vehicle, or does not have suitable collision barriers in place; or (9) emergency venting is not provided between any enclosed interstitial space.

EPA's review of industry standards regarding liner systems indicated that these standards primarily consist of recommended/suggested practices, and not requirements. EPA does not have information on the number of facilities that have installed liner systems due to voluntary compliance with these industry standards.

3.3 ESTIMATE OF THE NUMBER OF FACILITIES ALREADY USING LINERS OR RELATED SYSTEMS

The total number of facilities that could benefit from using liners, presented in Chapter 2, was adjusted to account for facilities located in States that already require liner systems. Specifically, facilities in six States currently must use liner systems that are comparable to liner systems considered in Chapter 4.[17] EPA estimated the number of facilities in these six States that meet the storage capacity threshold of the Oil Pollution Prevention regulation and that are required to comply with State liner requirements. This estimate was developed for each storage capacity tier and by SIC code, and was subtracted from the total number of facilities that meet the storage capacity threshold of the Oil Pollution Prevention regulation to estimate the number of facilities that currently do not to use liner systems. The results of this analysis are presented in Exhibit 3-2. The total number of facilities subject to the six States' liner requirements is estimated to be 83,723. This estimate includes approximately 66,000 "small" facilities, 17,000 "medium" facilities, and 723 "large" facilities. Therefore, the estimated number of facilities not using liner systems currently is about 421,000.

[17] These six states are: Alaska, Florida, New Jersey, New York, Rhode Island, and South Dakota.

Appendix D

Mass Flux and Breakthrough Calculations

Appendix D. Table 1. Mass Flux through Concrete Liner

Horizontal Flow (through sides)			Vertical Flow using AquaBlok (through bottom)		
Creek Width	20	ft	Creek Width	20	ft
Creek Length	700	ft	Creek Length	700	ft
Depth	8	ft	Depth	8	ft
Total Area	11200	ft^2	Total Area	14000	ft^2
Kh	2.83E-07	ft/day	Kv	2.83E-07	ft/day
Gradient	0.04	ft/ft	Gradient	0.15	ft/ft
Effective Porosity	0.05		Effective Porosity	0.05	
Velocity	2.27E-07	ft/day	Velocity	8.50E-07	ft/day
Flow Rate	1.27E-04	ft^3/day	Flow Rate	5.95E-04	ft^3/day
	8.82E-08	ft^3/min		4.13E-07	ft^3/min
	6.60E-07	gpm		3.09E-06	gpm

Total Flow =	**3.75E-06**	gpm
	0.0054	gpd
	2.0	gpy

Benzene Concentration in GW	263	ug/L	Maximum observed in groundwater at the site (2010 and 2013 GW Data)
Naphthalene Concentration in GW	9060	ug/L	
Acenaphthene Concentration in GW	222	ug/L	
Total of PAHs	26	ug/L	
Benzene Mass Flux	0.00373	ug/min	
Naphthalene Mass Flux	0.12866	ug/min	
Acenaphthene Mass Flux	0.00315	ug/min	
Total of PAHs Mass Flux	0.00037	ug/min	
Benzene Concentration in Creek	**0.00012**	ug/L	Assume Creek flow at 8.5 gpm per modeling results
Naphthalene Concentration in Creek	**0.0040**	ug/L	
Acenaphthene Concentration in Creek	**0.00010**	ug/L	
Total of PAHs Concentration in Creek	**0.000012**	ug/L	

Thickness of Concrete Cloth (CC13) =	13	mm		
Breakthrough Time	Horizontally		Vertically	
	188,079	days	50,154	days
	515	years	**137**	years

Reference:

Concrete permeability reported on the order of 10^{-10} cm/s (http://www.engineeringtoolbox.com/concrete-properties-d_1223.html).
Concrete effective porosity as 5% (http://www.bhrc.ac.ir/portal/Portals/2/pdf/asian%20jornal/October%202005/317.pdf).
Hydraulic gradients were estimated from Geosyntec 2011 SAR.
Benzene surface water criterion is 71.28 ug/L.
Naphthalene surface water criterion is 26 ug/L.
Acenaphthene surface water criterion is 1.2 ug/L.

Total of PAHs (Acenaphthylene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Chrysene, Dibenzo(a,h)anthracene, Indeno(a,2,3-cd)pyrene, and Phenanthrene) surface water criterion is 0.0028 ug/L.

Appendix D. Table 2. Mass Flux through AquaBlok Liner

Horizontal Flow (through sides)			Vertical Flow using AquaBlok (through bottom)		
Creek Width	20	ft	Creek Width	20	ft
Creek Length	700	ft	Creek Length	700	ft
Depth	8	ft	Depth	8	ft
Total Area	11200	ft^2	Total Area	14000	ft^2
Kh	2.83E-06	ft/day	Kv	2.83E-06	ft/day
Gradient	0.04	ft/ft	Gradient	0.15	ft/ft
Effective Porosity	0.06		Effective Porosity	0.06	
Velocity	1.89E-06	ft/day	Velocity	7.09E-06	ft/day
Flow Rate	1.27E-03	ft^3/day	Flow Rate	5.95E-03	ft^3/day
	8.82E-07	ft^3/min		4.13E-06	ft^3/min
	6.60E-06	gpm		3.09E-05	gpm

Total Flow of Theoretical AquaBlok Creek =	**3.75E-05**	gpm
	0.054	gpd
	20	gpy
Crack Fraction of Existing Creek	**10%**	
Total Flow of AquaBlok Lining Existing Concrete Creek	**7.13E-06**	gpm
	0.010	gpd
	3.7	gpy

Benzene Concentration in GW	263	ug/L	Maximum observed in groundwater at the site (2010 and 2013 GW Data)	
Naphthalene Concentration in GW	9060	ug/L		
Acenaphthene Concentration in GW	222	ug/L		
Total of PAHs	26	ug/L		
Benzene Mass Flux	0.0071	ug/min		
Naphthalene Mass Flux	0.24	ug/min		
Acenaphthene Mass Flux	0.0060	ug/min		
Total of PAHs	0.0007	ug/min		
Benzene Concentration in Creek	**0.00022**	ug/L	Assume Creek flow at 8.5 gpm per modeling results	
Naphthalene Concentration in Creek	**0.0076**	ug/L		
Acenaphthene Concentration in Creek	**0.00019**	ug/L		
Total of PAHs	**0.00002**	ug/L		

Thickness of Liner =	6	inches		
Breakthrough Time	Horizontally		Vertically	
	264,583	days	70,556	days
	725	years	**193**	years

Reference:

AquaBlok permeability reported on the order of 10^{-9} cm/s (http://nepis.epa.gov/Adobe/PDF/P10030OW.pdf).

AquaBlok effective porosity as 6% was based on the clay material (Fetter, C.W., 2001, Applied Hydrogeology, Prentice Hall,

Hydraulic gradients were estimated from Geosyntec 2011 SAR.

Benzene surface water criterion is 71.28 ug/L.

Naphthalene surface water criterion is 26 ug/L.

Acenaphthene surface water criterion is 1.2 ug/L.

Total of PAHs (Acenaphthylene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Chrysene, Dibenzo(a,h)anthracene, Indeno(a,2,3-cd)pyrene, and Phenanthrene) surface water criterion is 0.0028 ug/L.

Appendix D. Table 3. Mass Flux through HDPE Liner					
Horizontal Flow (through sides)			**Vertical Flow using AquaBlok (through bottom)**		
Creek Width	20	ft	Creek Width	20	ft
Creek Length	700	ft	Creek Length	700	ft
Depth	8	ft	Depth	8	ft
Total Area	11200	ft^2	Total Area	14000	ft^2
Kh	2.83E-09	ft/day	Kv	2.83E-09	ft/day
Gradient	0.04	ft/ft	Gradient	0.15	ft/ft
Effective Porosity	0.05		Effective Porosity	0.05	
Velocity	2.27E-09	ft/day	Velocity	8.50E-09	ft/day
Flow Rate	1.27E-06	ft^3/day	Flow Rate	5.95E-06	ft^3/day
	8.82E-10	ft^3/min		4.13E-09	ft^3/min
	6.60E-09	gpm		3.09E-08	gpm

Total Flow =	**3.75E-08**	gpm
	0.0001	gpd
	0.020	gpy

Benzene Concentration in GW	263	ug/L	Maximum observed in groundwater at the site (2010 and 2013 GW Data)
Naphthalene Concentration in GW	9060	ug/L	
Acenaphthene Concentration in GW	222	ug/L	
Total of PAHs	26	ug/L	
Benzene Mass Flux	0.00004	ug/min	
Naphthalene Mass Flux	0.00129	ug/min	
Acenaphthene Mass Flux	0.00003	ug/min	
Total of PAHs Mass Flux	0.00000	ug/min	
Benzene Concentration in Creek	**0.0000012**	ug/L	Assume Creek flow at 8.5 gpm per modeling results
Naphthalene Concentration in Creek	**0.000040**	ug/L	
Acenaphthene Concentration in Creek	**0.0000010**	ug/L	
Total of PAHs Concentration in Creek	**0.00000012**	ug/L	

Thickness of Concrete Cloth (CC13) =	2.5	mm		
Breakthrough Time	Horizontally		Vertically	
	3,616,898	days	964,506	days
	9,909	years	**2,642**	years

Reference:

HDPE permeability reported on the order of 10^{-12} cm/s (http://www.engineeringtoolbox.com/concrete-properties-d_1223.html).
Concrete effective porosity as 5% (http://www.bhrc.ac.ir/portal/Portals/2/pdf/asian%20jornal/October%202005/317.pdf).
Hydraulic gradients were estimated from Geosyntec 2011 SAR.
Benzene surface water criterion is 71.28 ug/L.
Naphthalene surface water criterion is 26 ug/L.
Acenaphthene surface water criterion is 1.2 ug/L.

Total of PAHs (Acenaphthylene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Chrysene, Dibenzo(a,h)anthracene, Indeno(a,2,3-cd)pyrene, and Phenanthrene) surface water criterion is 0.0028 ug/L.

Appendix D. Mass Flux and Breakthrough Time			
Parameter	**AquaBlok**	**Concrete Cloth**	**HDPE**
Thickness (inches)	6’’	0.5’	0.1
Reported Permeability (cm/s)	1.00E-09	1.00E-10	1.00E-12
Estimated Velocity (ft/day)	7.00E-06	8.50E-07	8.50E-09
Breakthrough Time (years)	193	137	2,642
Estimated Penetration Flow (gpy)	3.7	2	0.02
Benzene Flux* (ug/min)	0.007	0.004	0.00004
Naphthalene Flux* (ug/min)	0.24	0.13	0.0013
Benzene Conc. in Creek# (ug/L)	0.00022	0.0001	0.000001
Naphthalene Conc. in Creek# (ug/L)	0.008	0.004	0.00004

Notes:

* - Based on maximum measured groundwater concentrations from the FS report.

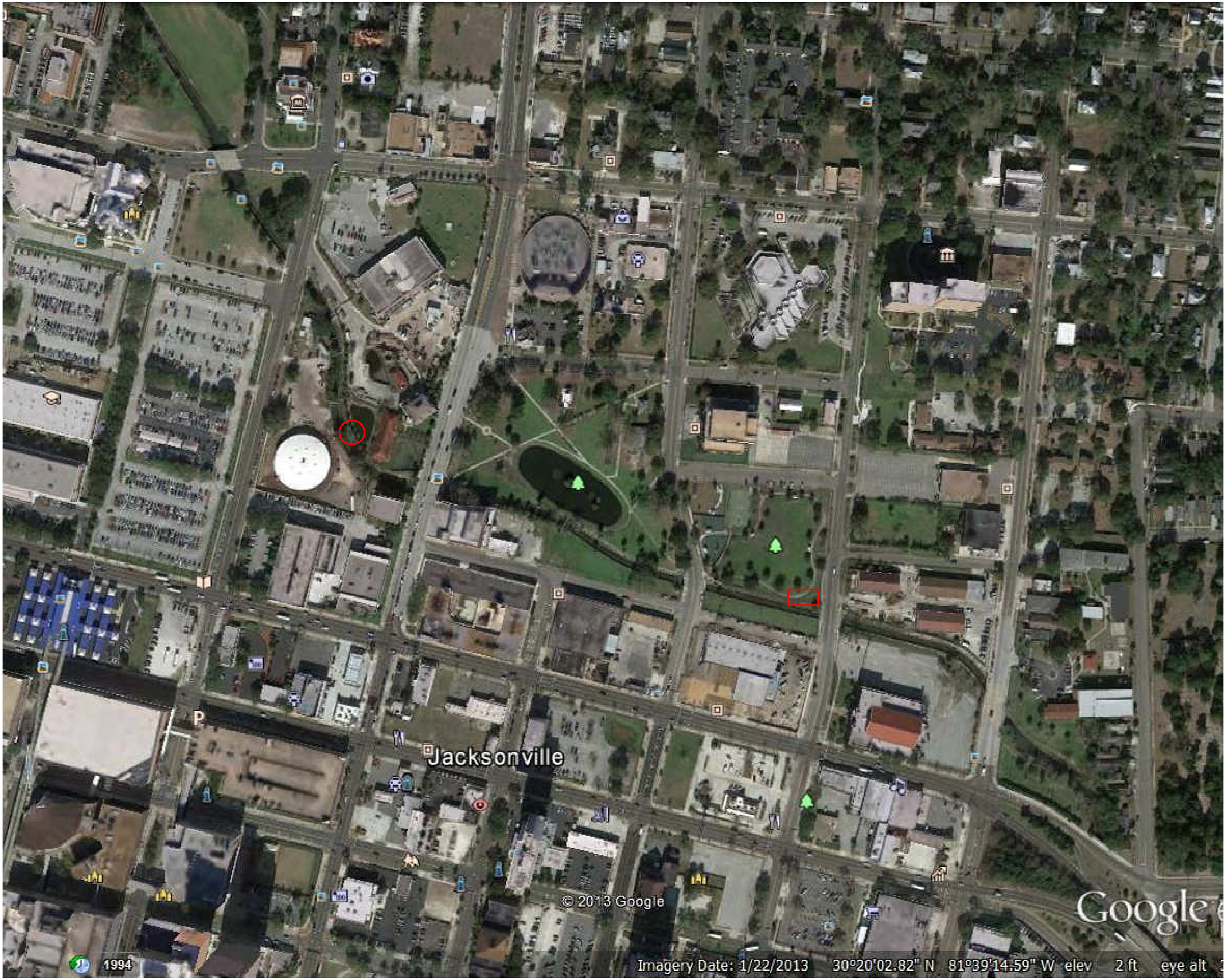
- Assume lower-bound creek flow rate at least 8.5 gallons per minute (per the preliminary groundwater modeling).

Appendix E

Potential Infiltration Gallery Locations

JEA

COJ



Jacksonville
© 2013 Google
Google
1994
Imagery Date: 1/22/2013
30°20'02.82" N
81°39'14.59" W
elev
2 ft
eye alt

Appendix F

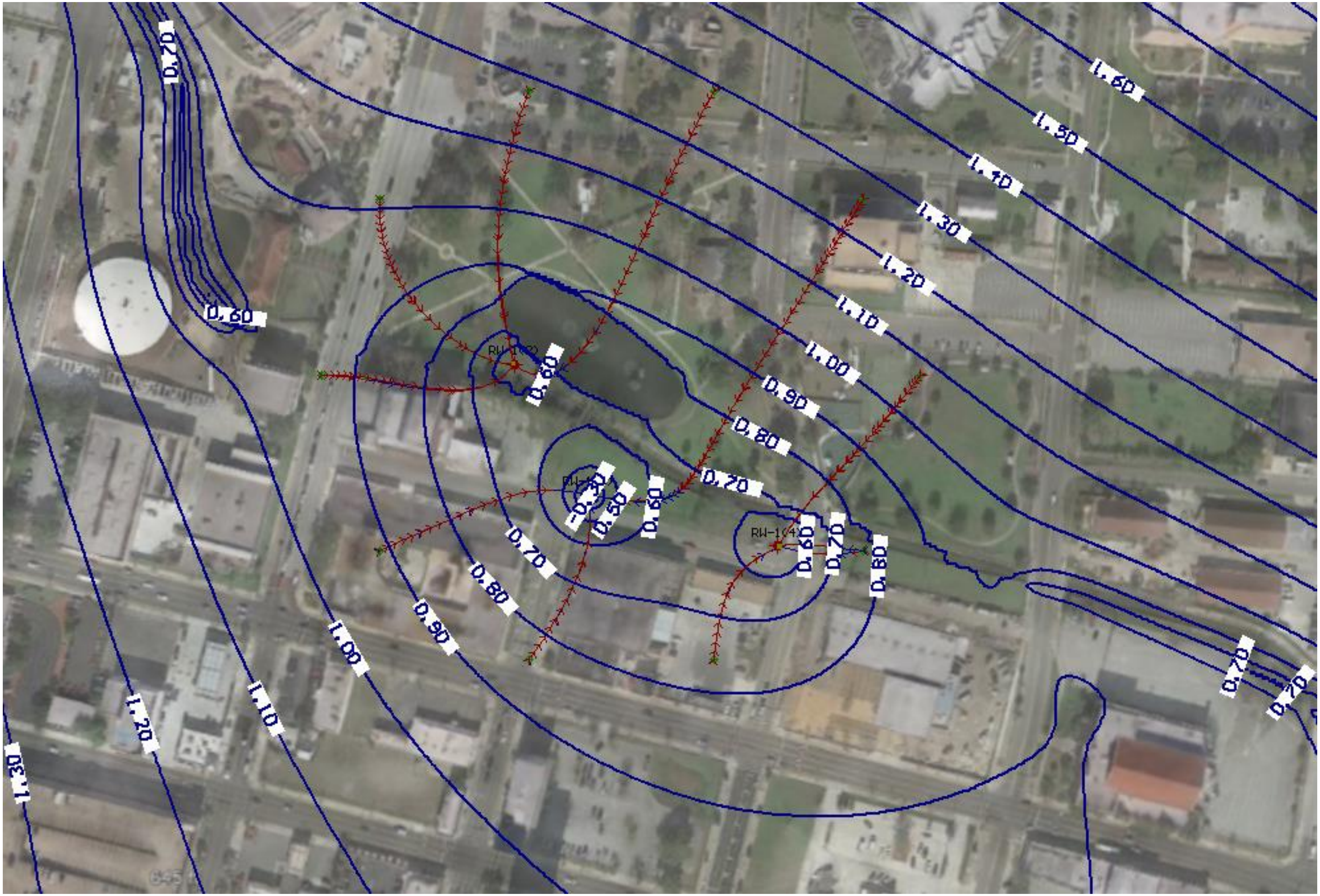
Examples of NPDES for Long-Term Remediation Projects

Appendix F. Examples of NPDES Permits for Long-Term Groundwater Remediation

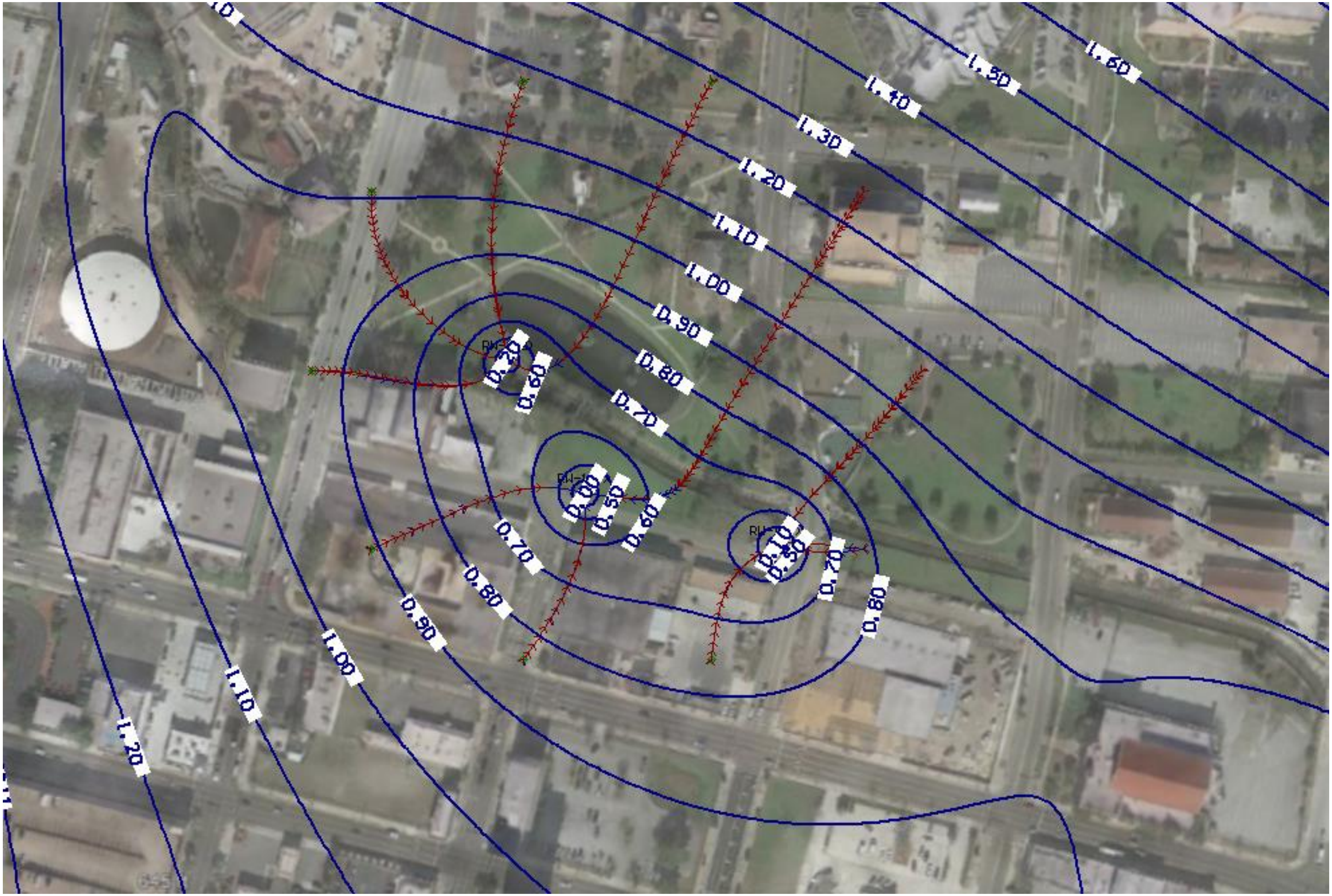
DEP OFFICE	FACILITY ID	NAME	FAC TYPE	FACIL ADDRESS 1	CITY	OWNERSHIP TYPE	NATURE OF BUSINESS	TREATMENT PROCESSS SUMMARY	CAPACITY	COMPANY NAME	EFFECTIVE_DATE	EXPIRATION_DATE	DOC_DESCRIPTION	DISCHARGE
NED	FL0176877	CSX Transportation - Moncrief Rail Yard	Industrial Wastewater	Mcduff Avenue North	Jacksonville	Private	Ground Water Remediation System	Air Strip	0.138 MGD	CSX Transportation	9/18/2013	9/17/2018	Wastewater Permit	McCoy Creek
NED	FLG914331	Lumber Unlimited	Petroleum Cleanup GP (long term)	2175 West 18th Street	Jacksonville	Private	gw remediation w/ treatment ~4.25 years	Air Strip	10 gpm	Ellis & Associates Inc	12/13/2012	12/12/2017	Generic Permit	Stormwater collection systems and eventually into Moncrief Creek
NED	FLG914351	Sunrise Food Mart #14	Petroleum Cleanup GP (long term)	10927 North Main Street	Jacksonville	Private	long-term multi-phase extraction remediation of petroleum-contaminated groundwater	air stripper, media filtrations, activated carbon.	5-6 gpm with a max. 30 gpm	Environmental Consulting & Technology	3/12/2013	3/11/2018	Generic Permit	Into an existing stormwater drain, eventually into the Broward river
NED	FLG913500	Sunrise Food Mart #21	Petroleum Cleanup GP (long term)	4354 Blanding Blvd	Jacksonville	Private	long-term multi-phase extraction remediation of petroleum-contaminated groundwater	air stripper, media filtrations, activated carbon.	6-8 gpm with a max. 30 gpm	Environmental Consulting & Technology	7/22/2013	7/21/2018	Generic Permit	into onsite stormwater system, the municipal storm system

Appendix G

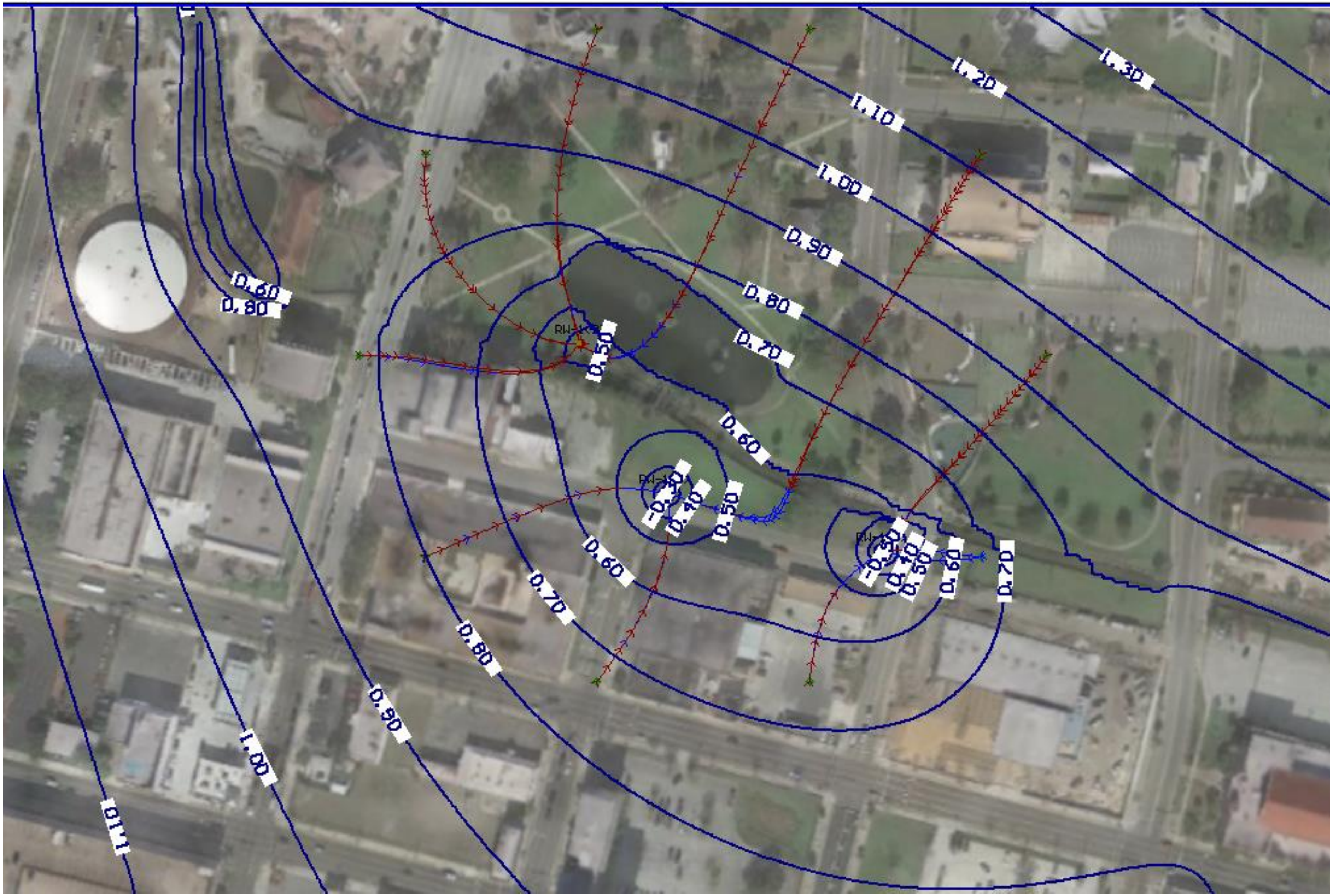
Modeling Results



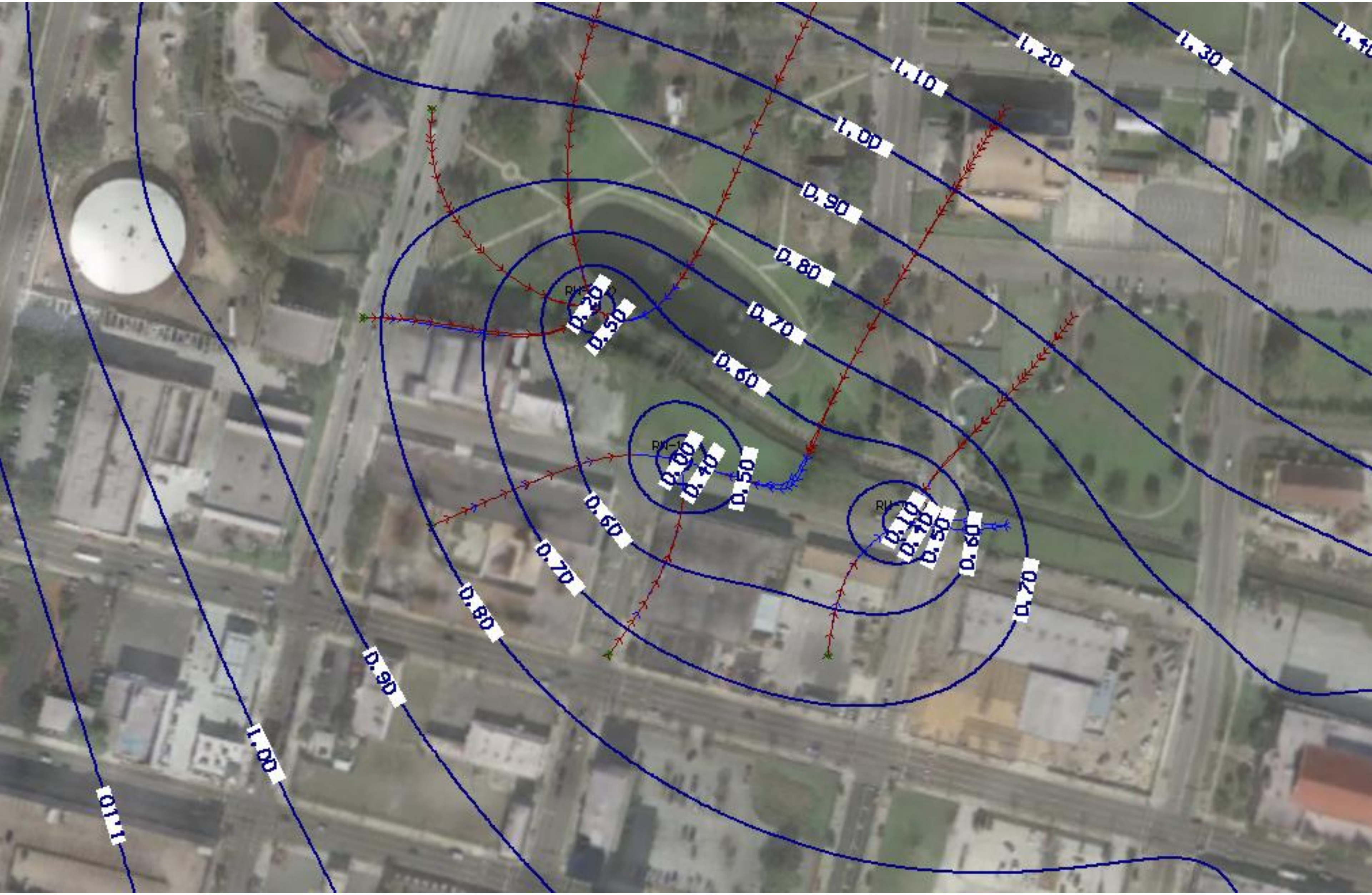
Model of USA using K=0.61 m/d and Q = 8.5 gpm



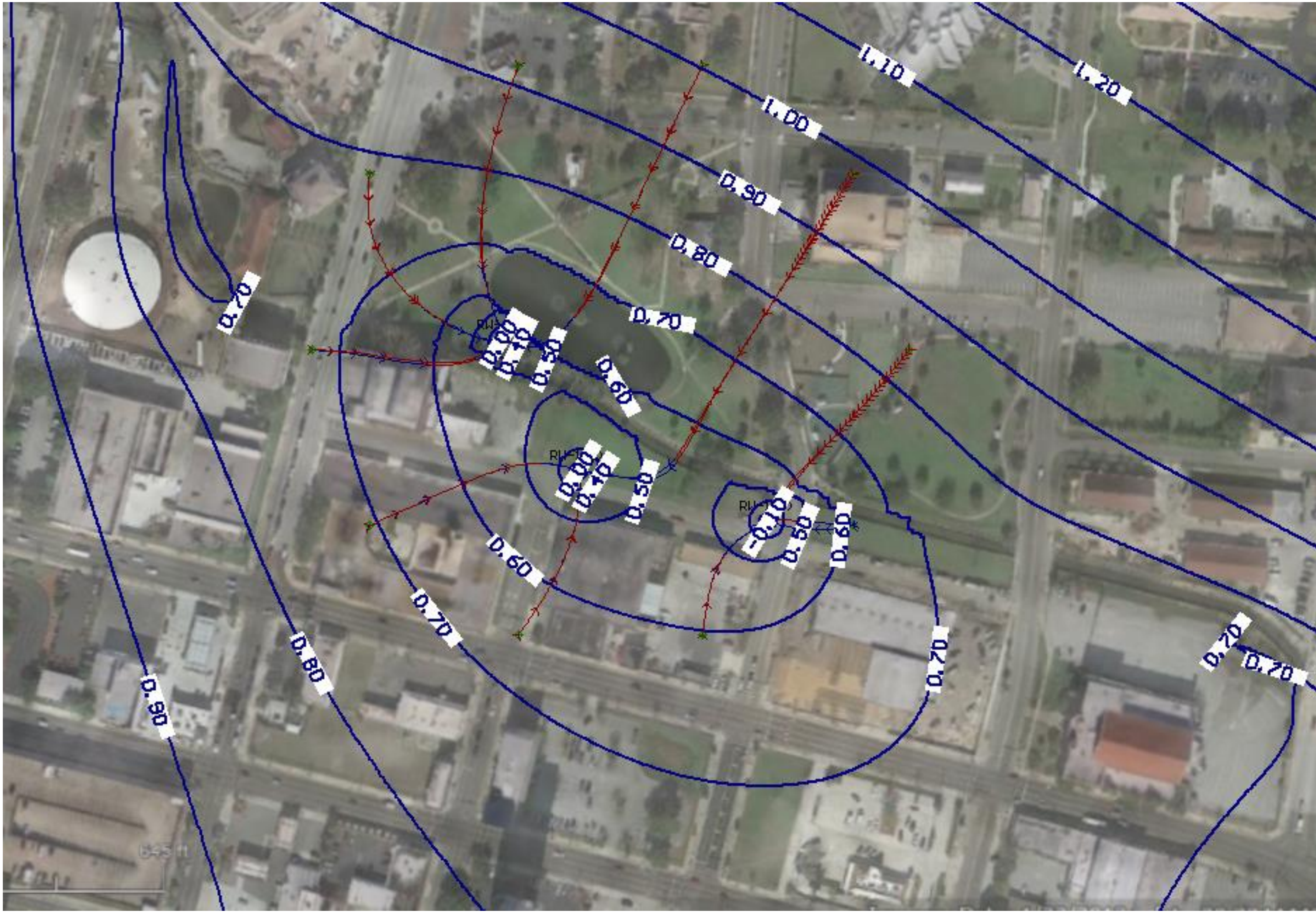
Model of LSA using K=0.61 m/d and Q = 8.5 gpm



Model of USA using K=1.22 m/d and Q = 8.5 gpm



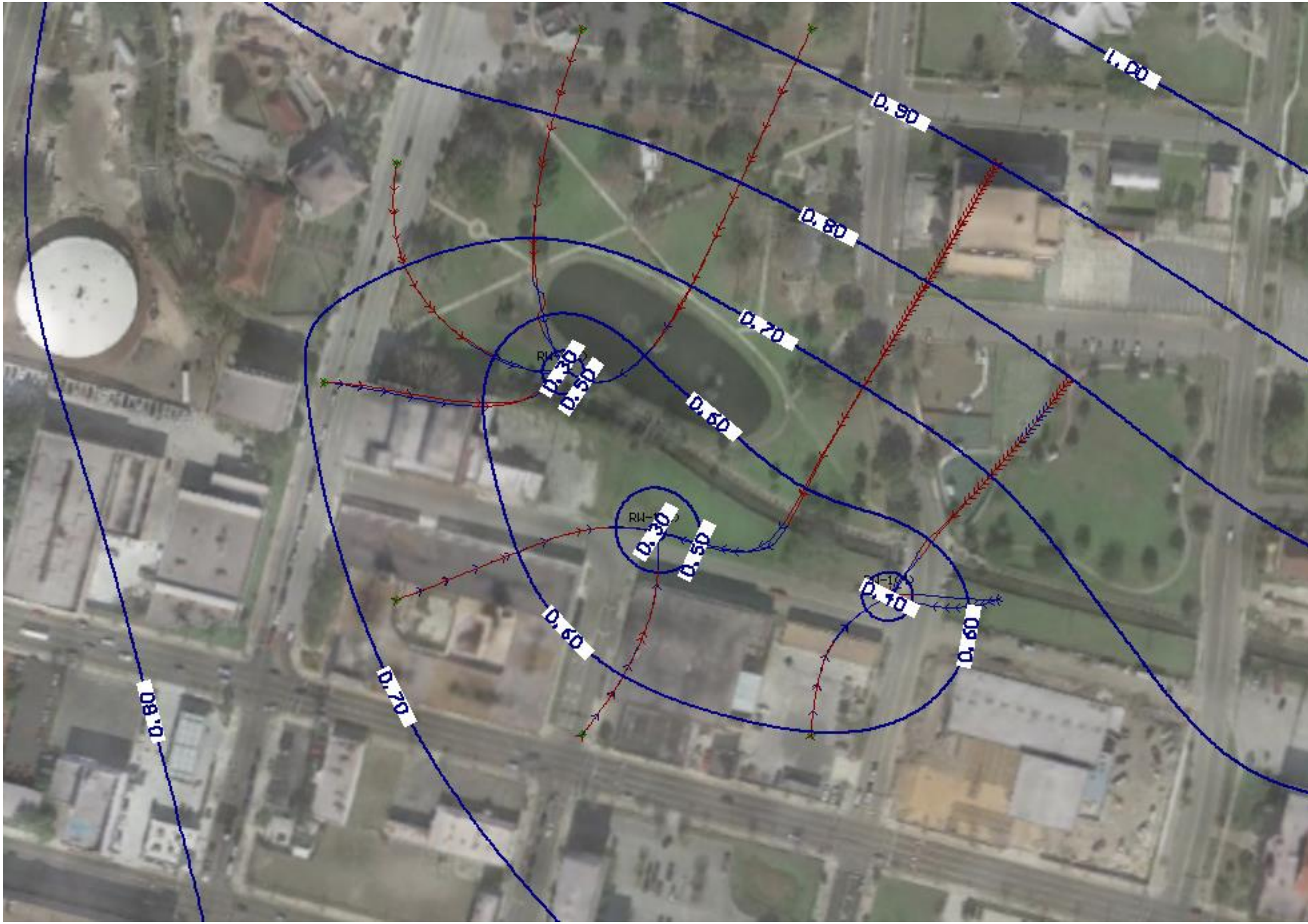
Model of LSA using K=1.22 m/d and Q = 8.5 gpm



Model of USA using K=3.05 m/d and Q = 8.5 gpm

Model of LSA using K=3.05 m/d and Q = 8.5 gpm

Model of USA using K=5.8 m/d and Q = 8.5 gpm



Model of LSA using K=5.8 m/d and Q = 8.5 gpm

Appendix H

Cost Estimate for Hydraulic Control

Appendix H. Conceptual-Level Preliminary Costs
Confederate Park Site Feasibility Study
Jacksonville, FL

Hydraulic Control - 30 Years

Item No.	Item Description	Unit	Estimated Quantity	Estimated Unit Rate (USD)	Extended Amount (USD)
I. ENGINEERING DESIGN COSTS					
1	Hydraulic Modeling (1)	LS	1	$45,000	$45,000
2	Remedial Action Plan (1)	LS	1	$95,000	$95,000
3	Environmental Resource Permitting (1)	LS	1	$65,000	$65,000
4	CQA (1)	LS	90	$1,500	$135,000
5	As-Built Drawings and Reporting (1)	LS	1	$15,000	$15,000
	PRE-CONSTRUCTION/START-UP COSTS TOTAL				**$355,000**
II. CONSTRUCTION COSTS					
General					
6	Mobilization/Demobilization (1)	LS	1	$40,000	$40,000
7	Construction Permitting (1)	LS	1	$10,000	$10,000
8	Surveying (2)	SY	125	$4	$500
10	Installation of Security Fencing and Construction Entrance/Exit (2)	LF	1,000	$5	$5,000
Materials &Installation					
11	Pumps (1) (7) (8)	LS	4	$10,000.00	$40,000
12	GAC Canister (1) (7) (8) (9)	LS	4	$5,000	$20,000
13	Treatment Building & Piping (1)	LS	1	$250,000.00	$250,000
14	CQA and Construction Oversight (1)	LS	1	$11,000	$11,000
	HC CONSTRUCTION/CAPITAL COSTS TOTAL				**$376,500**
EXISTING CREEK RESTORATION/LINING					
15	Mobilization/Demobilization (1)	LS	1	$150,000	$150,000
16	Construction Permitting (1)	LS	1	$10,000	$10,000
17	Limited Streambed Excavation or Removal of Contaminated Sediments (2) (3)	CY	800	$12	$9,600
18	Sediments Disposal (Off-site) (2)(3) (4)	TON	800	$36	$28,800
19	Creek Bypass Pumping (1)	DAY	30	$1,000	$30,000
20	Streambed Capping (2) (5)	CY	200	$815	$163,000
21	Armor Layer Placement (2) (6)	CY	100	$125	$12,500
22	Sodding/Vegetation (2)	SF	2,880	$0.60	$1,728
23	CQA and Construction Oversight (1)	LS	1	$32,000	$32,000
	CREEK CAPITAL COSTS TOTAL				**$437,628**
EXISTING POND RESTORATION/LINING					
24	Pond Dewatering (2)	DAY	10	$500	$5,000
25	Pond Sediment Excavation (10)	CY	2400	$12	$28,800
26	Off-Site Disposal of Excavated Sediment (10)	CY	2400	$36	$86,400
27	Pond Liner Using AquaBlok (11)	CY	611	$815	$497,558
28	CQA and Construction Oversight (1)	LS	1	$16,000	$16,000
	POND CAPITAL COSTS TOTAL				**$633,758**
	TOTAL CAPITAL COSTS				**$1,802,900**
III POST-CONSTRUCTION (OPERATION AND MAINTENANCE) COSTS (30 YEARS)					
29	Sampling and Lab Analyses & Semi-annual Reports (1) (12)	Event	62	$25,000	$1,550,000
30	Electricity (1) (13)	YR	30	$7,500	$225,000
31	ERP/NPDES Permit Renewal (1)	YR	30	$1,000	$30,000
32	Discharge Lab Analysis (1)	Event	360	$120	$43,200
33	Pump/GAC Repairs/Replacement (1)	YR	30	$7,500	$225,000
34	Site O&M Visit Labor Cost (1)	Event	400	$1,000	$400,000
35	General Maintenance of Creek and Pond Liner (1)	5-YR	5	$15,000	$75,000
	30 Years POST-CONSTRUCTION (O & M) COSTS TOTAL				**$2,548,200**
TOTAL COSTS (30 YEARS) (14) - PRESENT VALUE (15)					**$2,856,924**

Notes:

1. CY = cubic yards, SY = square yards, LF = linear feet, LS = Lump Sum, AC = acre.
2. "Unit Rate" and "Extended Amount" column items are provided in United States dollar (USD).

Superscripts:

1. Engineering estimate.
2. See FS unit rate sheet.
3. Assumes work area within 2 ft from the creek edge will require clearing, grubbing, and stripping.
4. Approximately 2-ft thick sediments will be excavated. Assumes sediments will need to set aside and allowed to drain, then loaded for off-site disposal.
5. Involves placement of Aquablok®. Assumed thickness required is 6 inches. Estimated unit rate provided by Aquablok, Ltd.
6. Armoring consists of approx. 3-inch thick layer of 3/4" minus stone over the Aquablok® layer.
7. The flow rate was estimated to be 8.5 gpm through groundwater MODFLOW modeling upon the available data.
8. EPA (2008) identified a "rule of thumb" that extraction rates normally exceed natural flux rates by a factor of 1.5 to 2.0.
9. One 1000-lbs Carbtrol Liquid Adsorbers.
10. Approximately 2-ft thick sediments will be excavated and offsite disposed of.
11. Assume 6-inch AquaBlok lining and 1.5-ft clean sand fill.
12. The monitoring sampling may be reduced to annual event upon approval after quarterly monitoring for the first year. The reporting fee will be reduced by a half
13. Three 2.5-HP pumps
14. The recovered water was treated and discharge to a gallery or NPDES.
15. Assume an annual discount rate = 7.0%
16. Jacksonville advised at the October 31, 2014 meeting that the costs of any retrofit of the stormwater conveyance system will be borne solely by the Jacksonville Electric Authority so there is not line item for these non-remediation improvements

Appendix H. Conceptual-Level Preliminary Costs
Confederate Park Site Feasibility Study
Jacksonville, FL

Hydraulic Control - 100 Years

Item No.	Item Description	Unit	Estimated Quantity	Estimated Unit Rate (USD)	Extended Amount (USD)
I. ENGINEERING DESIGN COSTS					
1	Hydraulic Modeling (1)	LS	1	$45,000	$45,000
2	Remedial Action Plan (1)	LS	1	$95,000	$95,000
3	Environmental Resource Permitting (1)	LS	1	$65,000	$65,000
4	CQA (1)	LS	90	$1,500	$135,000
5	As-Built Drawings and Reporting (1)	LS	1	$15,000	$15,000
	PRE-CONSTRUCTION/START-UP COSTS TOTAL				**$355,000**
II. CONSTRUCTION COSTS					
General					
6	Mobilization/Demobilization (1)	LS	1	$40,000	$40,000
7	Construction Permitting (1)	LS	1	$10,000	$10,000
8	Surveying (2)	SY	125	$4	$500
10	Installation of Security Fencing and Construction Entrance/Exit (2)	LF	1,000	$5	$5,000
Materials &Installation					
11	Pumps (1) (7) (8)	LS	4	$10,000.00	$40,000
12	GAC Canister (1) (7) (8) (9)	LS	4	$5,000	$20,000
13	Treatment Building & Piping (1)	LS	1	$250,000.00	$250,000
14	CQA and Construction Oversight (1)	LS	1	$11,000	$11,000
	CONSTRUCTION/CAPITAL COSTS TOTAL				**$376,500**
EXISTING CREEK RESTORATION/LINING					
15	Mobilization/Demobilization (1)	LS	1	$150,000	$150,000
16	Construction Permitting (1)	LS	1	$10,000	$10,000
17	Limited Streambed Excavation or Removal of Contaminated Sediments (2) (3)	CY	800	$12	$9,600
18	Sediments Disposal (Off-site) (2)(3) (4)	TON	800	$36	$28,800
19	Creek Bypass Pumping (1)	DAY	30	$1,000	$30,000
20	Streambed Capping (2) (5)	CY	200	$815	$163,000
21	Armor Layer Placement (2) (6)	CY	100	$125	$12,500
22	Sodding/Vegetation (2)	SF	2,880	$0.60	$1,728
23	CQA and Construction Oversight (1)	LS	1	$32,000	$32,000
	CREEK CAPITAL COSTS TOTAL				**$437,628**
EXISTING POND RESTORATION/LINING					
24	Pond Dewatering (2)	DAY	10	$500	$5,000
25	Pond Sediment Excavation (10)	CY	2400	$12	$28,800
26	Off-Site Disposal of Excavated Sediment (10)	CY	2400	$36	$86,400
27	Pond Liner Using AquaBlok (11)	CY	611	$815	$497,558
28	CQA and Construction Oversight (1)	LS	1	$16,000	$16,000
	POND CAPITAL COSTS TOTAL				**$633,758**
	TOTAL CAPITAL COSTS				**$1,802,900**
III. POST-CONSTRUCTION (OPERATION AND MAINTENANCE) COSTS (100 YEARS)					
29	Sampling and Lab Analyses & Semi-annual Reports (1) (12)	Event	202	$25,000	$5,050,000
30	Electricity (1) (13)	YR	100	$7,500	$750,000
31	ERP/NPDES Permit Renewal (1)	YR	100	$1,000	$100,000
32	Discharge Lab Analysis (1)	Event	1200	$120	$144,000
33	Pump/GAC Repairs/Replacement (1)	YR	100	$7,500	$750,000
34	Site O&M Visit Labor Cost (1)	Event	1240	$1,000	$1,240,000
35	General Maintenance of Creek Liner (1)	5-YR	19	$15,000	$285,000
	100 Years POST-CONSTRUCTION (O & M) COSTS TOTAL				**$8,319,000**
TOTAL COSTS (100 YEARS) (14) - PRESENT VALUE (15)					**$2,989,959**

Notes:

1. CY = cubic yards, SY = square yards, LF = linear feet, LS = Lump Sum, AC = acre.
2. "Unit Rate" and "Extended Amount" column items are provided in United States dollar (USD).

Superscripts:

1. Engineering estimate.
2. See unit FS rate sheet.
3. Assumes work area within 2 ft from the creek edge will require clearing, grubbing, and stripping.
4. Approximately 2-ft thick sediments will be excavated. Assumes sediments will need to set aside and allowed to drain, then loaded for off-site disposal.
5. Involves placement of Aquablok®. Assumed thickness required is 6 inches. Estimated unit rate provided by Aquablok, Ltd.
6. Armoring consists of approx. 3-inch thick layer of 3/4" minus stone over the Aquablok® layer.
7. The flow rate was estimated to be 8.5 gpm through groundwater MODFLOW modeling upon the available data.
8. EPA (2008) identified a "rule of thumb" that extraction rates normally exceed natural flux rates by a factor of 1.5 to 2.0.
9. One 1000-lbs Carbtrol Liquid Adsorbers.
10. Approximately 2-ft thick sediments will be excavated and offsite disposed of.
11. Assume 6-inch AquaBlok lining and 1.5-ft clean sand fill.
12. The monitoring sampling may be reduced to annual event upon approval after quarterly monitoring for the first year. The reporting fee will be reduced by a half

13.Three 2.5-HP pumps

14. The recovered water was treated and discharge to a gallery or NPDES.
15. Assume an annual discount rate = **7.0%**
16. Jacksonville advised at the October 31, 2014 meeting that the costs of any retrofit of the stormwater conveyance system will be borne solely by the Jacksonville Electric Authority so there is not line item for these non-remediation improvements

Appendix H. Cost Summary and Comparison (Excluding Surface Soil Removal Cost)				
Remedial Strategy	**Capital (millions)**	**Annual O&M (millions)**	**30-yr Net Present Value (millions) #**	**100-yr Net Present Value (millions) #**
Alternative 1	$1.80	$0.085	$3.57	$3.74
Alternative 2	$12.08	$0.013	$15.31	$15.34
Alternative 3	$11.50	$0.013	$14.58	$14.61

Notes:
Alternative 1 - Hydraulic Control
Alternative 1 - Barrier Wall and Excavation
Alternative 3 - Barrier Wall and ISS
- 25% Contingency
7% discount rate per NCP (EPA 540-R-00-002)

Appendix I

FDEP Review Memo – Mark Stuckey

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION
BOB MARTINEZ CENTER
2600 BLAIRSTONE ROAD
TALLAHASSEE, FLORIDA 32399-2400

RICK SCOTT
GOVERNOR

CARLOS LOPEZ-CANTERA
LT. GOVERNOR

HERSCHEL T. VINYARD JR.
SECRETARY

MEMORANDUM

TO: Merrilee Palcic, P.E.
Waste Cleanup Section, Northeast District

THROUGH: Brian Dougherty, Administrator
Office of District & Business Support, DWM

5/20/2014
X
BJD
Signed by: Brian Dougherty

FROM: Mark Stuckey, P.G.
Office of District & Business Support, DWM

5/20/2014
X
Signed by: Stuckey_M

SUBJECT: Confederate Park Site
Jacksonville, Duval County
Review of Feasibility Study, dated January 2014
COMET# 185118

DATE: May 20, 2014

The subject document and related public comments on it have been reviewed, and the following comments are provided to assist with evaluation of the proposed remedial options being considered.

- Given the estimated extent and volume of MGP waste impacted zones in the subsurface, the concentrations of associated constituents (mostly BTEX & PAHs) in groundwater are lower than what I have seen at a couple of other MGP cleanup sites. The MGP subsurface waste material has reportedly been in place for about 100 years, and the more mobile and degradable compounds have likely attenuated leaving mostly the less mobile contaminants bound up in the soil matrix. This alone gives support to consideration of a less aggressive remedial strategy such as hydraulic control/MNA (Alternative 1) as a site remedial strategy. Also, hydraulic control can serve as an engineering control for closure with conditions.

- Proposed remedial Alternative 2 and Alternative 3 would be significantly more expensive and disruptive than the Alternative 1 (hydraulic control) option that would arguably achieve the same level of protectiveness. There is something to be said for what was pointed out by one of the commenters, and that is there are serious risks to human health and the environment associated with implementation of a very disruptive and hazardous construction project, such as a large scale soil removal/treatment project, conducted within a developed urban setting. It may be that this aspect of the risk analysis also favors a less disruptive remedial strategy such as hydraulic control/MNA to address site groundwater contamination.

- Presumably, it is intended that the selected remedial option will address "the site" inclusive of Confederate Park and properties immediately to the south impacted by releases from both the former MGP and petroleum USTs. One of the public comments received on the FS states that "It is also significant that at the public meeting held on March 17, 2014, Geosyntec acknowledged that the contaminants entrained in the wood debris lying above the dense non-aqueous phase liquid ("DNAPL") material was likely associated with discharges from the USTs and was not MGP material. Discussion and consideration of this contamination (and its eligibility for remediation under the Department program) is conspicuously absent from the Report." It is not clear if, and how, the Petroleum Restoration Program (PRP) would be involved in implementation of the selected remedial option. However, I did find where the Park View Inn site had its PRP State funded site eligibility status revoked.

If you have any questions, please contact me at 5-8991