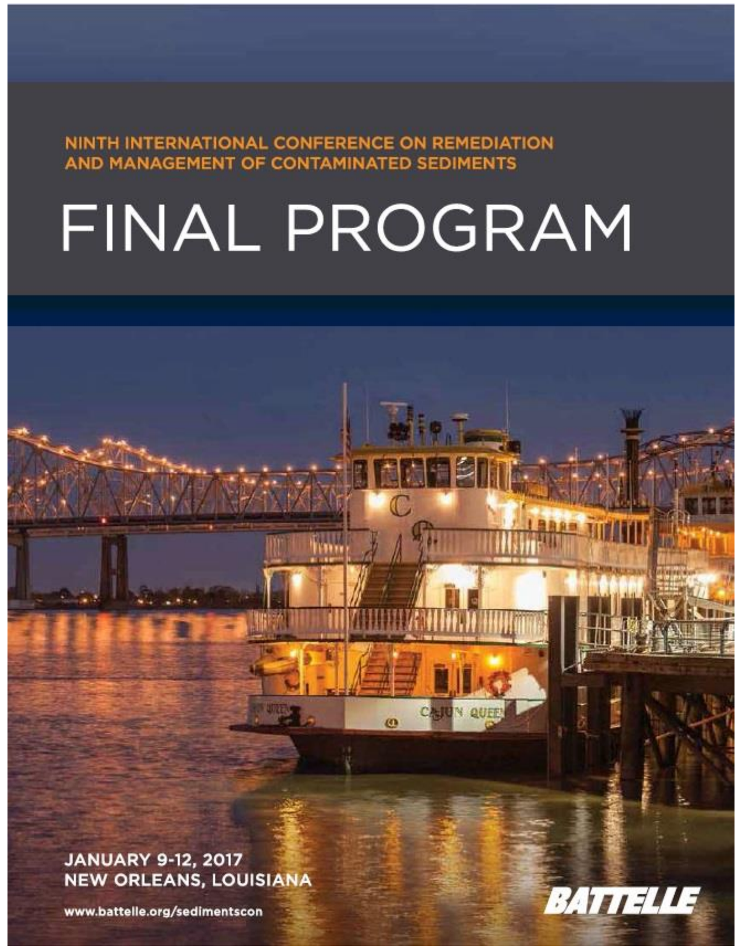

AquaBlok®
Composite Particle System

AUTHOR, COAUTHOR, AND RELATED PLATFORM AND POSTER PRESENTATIONS AT THE 2017 BATTELLE SEDIMENTS CONFERENCE

AquaBlok, Ltd. is thrilled to have participated in yet another successful Battelle Sediments Conference. This year, the 9th International Conference on Remediation and Management of Contaminated Sediments included 22 technical presentations, both platform and poster, that showcased projects, testing, or materials provided by our company. Of these presentations, AquaBlok authored or co-authored only four. The remaining 18 presentations represent not only a wide range of projects, pilots and testing performed by large, well-respected firms in the sediment remediation industry, but significant growth in the successful use of AquaBlok's technologies.

I. AQUABLOK AUTHOR OR COAUTHORED PLATFORM & POSTER PRESENTATIONS

Platform

1. Active Cap Material Placement at East Branch Grand Calumet River: Quality Control and Evaluation of Sorption Characteristics
   Natural Resource Technology, J.F. Brennan, SAO Environmental, AquaBlok

Posters

1. Machado Lake Ecosystem Rehabilitation
   CDMSmith, AquaBlok

2. Modeling and Construction Overview of Active Cap at Passaic River Mile 10.9
   CH2M, AquaBlok

3. Combined Technologies for In-Situ Stabilization/Isolation of Mercury Contamination in Remote Locations
   Provectus, AquaBlok

II. AQUABLOK RELATED PLATFORMS & POSTER PRESENTATIONS

Platforms

1. A Slough of Challenges: Navigating Columbia Slough Sediment Remediation Permitting Hurdles
   Apex Companies, LLC

2. Chemical and Physical Monitoring for a Carbon Amendment Field Pilot Test in an Intertidal and Subtidal Zone
   CH2M/USA

3. Using a Low-Permeability Sediment Cap in an Integrated Remedy on Lake Michigan: Construction Lessons Learned
   CH2M

4. Monitoring and Mapping the Transport Pathways of Contaminated Sediments Using Dual Signature Geologic Tracers: Two Case Studies
   Partrac, Ltd.

5. Sediment Remedial Activities under the Great Lakes Legacy Act Program
   Foth

6. Evaluation of Amendments for In-Situ Sequestration of Mercury in Sediments
   Geosyntec

7. Optimizing Designs for In Situ Sediment Treatment Using Activated Carbon
   Anchor QEA

8. PCB Tissue Concentrations and Benthic Community Impacts at a Carbon Amendment Pilot Study in the Intertidal and Subtidal Zones of San Francisco Bay
   CH2M, Texas Tech University

9. Evaluation of PCBs Availability in Sediment after In Situ Activated Carbon Amendment at an Active Naval Shipyard
U.S. Navy SPAWAR Systems Center Pacific

Posters

1. Field Demonstration of Fluorescent Paramagnetic Particle Tracers for Sediment Transport Studies near Remedial Caps
Navy SPAWAR Systems Center Pacific, Partrac, Ltd.

2. A Comparison of In Situ Passive Sampling with PE and PDMS in the Evaluation of Available Concentrations of PCBs in Sediment Porewater
Geosyntec Consultants, Ramboll Environ

3. Remediation of Coal Tar-Impacted Intertidal Sediment in the Fore River, Portland Harbor, Maine
Amec Foster Wheeler Environment & Infrastructure

4. Site-Specific Treatability Studies to Evaluate Cap Amendments to Sequester Contaminants of Potential Concern from the Gowanus Canal
Geosyntec Consultants

5. To Each Area, Its Own Remedy: Combining Removal, Residual Management, Restoration and *In Situ* Treatment
CDMSmith

6. Treatability Study for Under-Pier Activated Carbon Amendment Treatment of Contaminated Sediments, Pearl Harbor, Hawaii
U.S. Navy, NAVFAC Pacific, AECOM

7. Innovative Reactive Media Sediment Remedies
Arcadis U.S.

8. Overcoming Implementation Challenges: Activated Carbon Placement on the Lower Columbia Slough
Apex Companies, LLC., Oregon DEQ

9. Evaluation of Porewater Reductions due to Carbon Placement via Sedimite and AquaGate at a Contaminated Sediment Site
Texas Tech University, CH2M, U.S. Navy, NAVFAC Pacific

AQUABLOK AUTHORED PLATFORM PRESENTATION

Tuesday, January 10, 2017

C2. Cap Construction and Operation

Active Cap Material Placement at East Branch Grand Calumet River: Quality Control and Evaluation of Sorption Characteristics

Active Cap Material Placement at East Branch Grand Calumet River: Quality Control and Evaluation of Sorption Characteristics

John Collins (jcollins@aquablok.com) and John Hull (AquaBlok, Ltd., Swanton, OH, USA)
Joe Jersak (SAO Environmental Consulting, Ystad, Skåne County, Sweden)
Tyler Lee (Great Lakes Sediment Remediation, LLC, La Crosse, WI, USA; J.F. Brennan Company, Inc., La Crosse, WI, USA)
Eric Hritsuk (Great Lakes Sediment Remediation, LLC, La Crosse, WI, USA; Natural Resource Technology, Inc., Milwaukee, WI, USA)

Background/Objectives. The specification and design for the East Branch of the Grand Calumet River (EBGCR) project called for an active cap consisting of organoclay materials having certain minimum sorptive properties (partition coefficients – K_d values) for two target dissolved phase PAH contaminants. To construct the active cap, GLSR selected AquaGate+Organoclay (manufactured by AquaBlok) as the active capping product and J.F. Brennan placed the materials with their proprietary broadcast spreader system. AquaBlok provided quality control data on the as-manufactured/shipped product and Natural Resource Technology (NRT) performed monitoring and quality control during subaqueous installation of the cap materials in accordance with project specifications. After installation of the active layer, NRT collected additional samples of as-placed cap materials for AquaBlok. AquaBlok subsequently engaged SAO Environmental Consulting to oversee laboratory sorption testing to evaluate the relative sorption characteristics of both manufactured and as-placed product samples.

Approach/Activities. This presentation will provide an overview of placement and on-site quality control activities surrounding placement of the EBGCR active cap. In addition, the approach, methodology, and results for laboratory sorption testing of the active capping product will also be provided. The objective of the additional laboratory-based work in this study was to determine possible detrimental impacts that either the AquaGate manufacturing process (incorporating CETCO's organoclay powder material into a coated particle) or the act of placing the product in the river may have had on the organoclay sorption capability for either separate phase contamination (oil) and/or dissolved-phase contaminants (selected PAH compounds, including naphthalene; phenanthrene; pyrene, and benzo(a)pyrene).

Results/Lessons Learned. Data to be presented demonstrate that use of the project's approach for delivering active-treatment materials to the sediments provided a result that supports the modeling assumptions which were incorporated into the EBGCR remedial design. It can be concluded that such an approach enables full-scale application of active capping materials and construction methods which allows for verification of both the quantity and post placement material properties relative to project material specifications, design standards, performance goals, and objectives.

AQUABLOK AUTHORED & COAUTHORED POSTER PRESENTATIONS

Machado Lake Ecosystem Rehabilitation
CDMSmith, AquaBlok

Modeling and Construction Overview of Active Cap at Passaic River Mile 10.9
CH2M, AquaBlok

Combined Technologies for In-Situ Stabilization/Isolation of Mercury Contamination in Remote Locations
Provectus, AquaBlok

Machado Lake Ecosystem Rehabilitation

John Collins (jcollins@aquablok.com, AquaBlok, Toledo, OH, USA)
Eric Blischke (CDM Smith, CDM Smith, Helena, MT, USA)
Brian Murphy (CDM Smith, Denver, CO, USA)
Kendrick Okuda (City of Los Angeles, Los Angeles, CA, USA)

Background/Objectives. Machado Lake is located in the Ken Malloy Harbor Regional Park near Harbor City, California. The park is approximately 290 acres and contains the 45-acre Machado Lake. The Machado Lake ecosystem represents one of the largest remaining coastal wetlands areas in Southern California. The lake has been identified as an impaired water body as a result of pollution in storm water and urban runoff flowing from its 15,553-acre watershed. The Machado Lake ecosystem was invaded with nonnative plants, clogged by urban litter, and has filled with sediment over the years, causing eutrophication and other water quality impairments. The primary goal of the project is to improve the water quality in Machado Lake, while enhancing the surrounding natural habitat and the recreational features of the park.

Approach/Activities. While the overall project is significant in total scope (i.e. invasive plant removal, replanting of native species and park improvements such as fishing piers, fencing, and walkways), this abstract will focus on the in-water improvements that included dredging approximately 240,000 cubic yards of lake sediment, capping the lake bottom with a thin-layer, low-permeability chemical isolation barrier, using a sediment trap system to address storm water inputs and rehabilitating the dam structure at the south end of the lake.

Results/Lessons Learned. During remedial design activities, dredging and disposal costs became a project cost driver, so a thin layer cap design utilizing reactive materials was utilized to minimize removal and maximize depth. The purpose of the cap was to isolate contaminants such as lead and PCBs while at the same time preventing phosphorous from being reintroduced into the water column from the sediment-water interface. Bench scale testing was conducted to support design of the cap and to evaluate sediment dewatering options. Contaminated sediments were removed to improve the water quality conditions, visual aesthetics, and biological diversity of the ecosystem to attain and sustain its desired uses and characteristics (i.e., recreational fishing, wildlife habitat, environmental education), and to meet total maximum daily load (TMDL) requirements. Rehabilitation activities undertaken at Machado Lake included removal of non-native and invasive plants and replacement with appropriate native species designed to work with the natural processes to strengthen streambanks, reduce erosion, and provide channel stability. The final project included habitat and park improvements including invasive species removal, construction of walking trails and educational features and the construction of habitat features including wetland improvements and nesting and foraging habitat for native bird species. Successful implementation of the project was accomplished through designing integrated ecological and engineering strategies and solutions involving watershed-based management approaches, in-lake rehabilitation and stream bed assessment techniques, riparian system enhancements, and treatment best management practices (BMPs) at strategic areas in the park.

Modeling and Construction Overview for Active Cap at Passaic River Mile 10.9

George Hicks (george.hicks@ch2m.com) (CH2M, Evansville, IN, USA)
John Collins (jcollins@aquablok.com) (AquaBlok, Ltd., Swanton, OH, USA)

Background/Objectives. The Lower Passaic River is a highly contaminated urban river that has been the subject of numerous investigations for more than 30 years. In June 2012, a group of potentially responsible parties signed an agreement with USEPA Region 2 to remove contaminated sediment from a mudflat at River Mile 10.9, adjacent to Riverside Park in Lyndhurst, New Jersey. This area was identified during remedial investigation within the Lower Passaic River Study Area. A removal action was developed to address the contaminated sediment. The design included removal of approximately 15,000 cubic yards of impacted sediment from the river followed by the placement of 5.5 acres of an amended cap in the dredge area. The specification and design for the amended cap was determined based on modeling that indicated a loading requirement for activated carbon mixed with a sand/aggregate layer.

Approach/Activities. The design, preparation, control, placement and documentation of the 'active layer' consisting of a sand/aggregate/activated carbon mixture will be presented and discussed. The fundamental challenge associated with installation of any activated carbon material through the water column is the need to overcome the relatively low bulk density of the material compared to sand to ensure the desired mixing at installation. The presentation will detail how the project overcame this obstacle by providing a powder activated carbon (PAC) coated around an aggregate core. Once the PAC is available in this form, it can then be mixed with other relatively high density materials such as sand and be placed directly through the water column onto the sediment. To construct the active cap, a two hopper mixing system that allowed for a simple means to verify the quantity of active material in relationship to the sand component, and a Telebelt® broadcast spreading method to place the materials accurately within the river.

Results/Lessons Learned. Sand and AquaGate+PAC at 10% were blended to provide a uniform 10-inch thick cap layer. The mixture consisted of 3-inches AquaGate+PAC and 7-inches of sand, blended prior to placement. The permeable reactive capping layer was covered by a geotextile and a 12-inch thick stone armor layer. The presentation will provide a an overview of the modeling/design phase through implementation, with data that supports both the project's approach for delivering active-treatment materials to the sediments and the modeling assumptions incorporated into the cap design.

Combined Technologies for In Situ Stabilization/Isolation of Mercury Contamination in Remote Locations

Greg Booth (greg.booth@provectusenv.com) and Jim Mueller
(Provectus Environmental Products, Inc., Freeport, IL, USA)
John Collins and John Hull (AquaBlok, Ltd., Swanton, OH, USA)
Juan Felipe Molina (Ecosoluciones / Provectus Colombia, Bogota, Colombia)

Background/Objectives. Illegal gold mining activities in Latin America have contaminated vast soil, sediment and water resources with elemental mercury (Hg) and other chemicals that have caused significant harm to environmental and human health. In Colombia alone, it is estimated that >250 metric tonnes of Hg is spent annually, with illegal and improper use contaminating 70% of the rivers with Hg, and causing over one million people to have unsafe levels of Hg in their bodies. In many cases, immediate action or "emergency response" is required to at least stabilize the Hg in place and minimize the immediate threats; once the acute toxicity is addressed and the situation is at least partially stabilized, additional efforts can be made for more detailed analysis, risk assessment and subsequent remedial actions, where required.

Approach/Activities. To address the issues, two generalized, "triage-like" emergency response approaches were considered for Hg contamination at these sites: (1) physical removal/recovery, and (2) active/reactive capping for physical isolation and stabilization of the contaminants. The best choice depends on a wide variety of site-specific issues, demands and conditions. However, the remote locations of these impacts - coupled with the scope and magnitude of the problem and estimated resource requirements – are such that physical removal is of limited practical usefulness. Hence, in situ capping/physical isolation and long-term stabilization was considered to be a more viable approach. Beyond the logistical challenges, one major complication of any such capping application is that the implementation/construction processes themselves typically create an initial spike of methanogenic activity, which is problematic from several perspectives, including: i) stimulation of anaerobic microbial activity can lead to methylation of Hg and other heavy metals with many negative consequences, and ii) the production of methane can create gas bubbles (ebullition), which can transport contaminants via surface tension phenomena through localized cap failures due to gas build-up. To help address the special challenges associated with Hg impacts, we combined Provect-CH4® methanogen inhibitors and other additives, such as PAC, to create AquaGate-CH4™, which is a composite particle technology that can be manufactured locally and is easily deployed through water in large, remote areas impacted by Hg. The resulting physical isolation barriers created will immediately provide chemical isolation of existing Hg at a given site and stabilize the contaminant *in situ* while controlling methane production following its application.

Results/Lessons Learned. This presentation will provide an overview of the Hg contamination problem in Colombia along with our strategic plan for site prioritization. We will present generalized designs for using the AquaGate-CH4 technology as a remedy for high priority sites. Challenges associated with logistics and operations in remote applications will be presented along with economics of amendment production and implementation.

AQUABLOK RELATED PLATFORM PRESENTATIONS

A Slough of Challenges: Navigating Columbia Slough Sediment Remediation Permitting Hurdles
Apex Companies, LLC

Chemical and Physical Monitoring for a Carbon Amendment Field Pilot Test in an Intertidal and Subtidal Zone
CH2M/USA

Using a Low-Permeability Sediment Cap in an Integrated Remedy on Lake Michigan: Construction Lessons Learned
Partrac, Ltd.

Monitoring and Mapping the Transport Pathways of Contaminated Sediments Using Dual Signature Geologic Tracers: Two Case Studies
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Sediment Remedial Activities under the Great Lakes Legacy Act Program
Foth

Evaluation of Amendments for In-Situ Sequestration of Mercury in Sediments
Geosyntec Consultants

Optimizing Designs for In Situ Treatment Using Activated Carbon
Anchor QEA

PCB Tissue Concentrations and Benthic Community Impacts at a Carbon Amendment Pilot Study in the Intertidal and Subtidal Zones of San Francisco Bay
CH2M, Texas Tech University

Evaluation of PCBs Availability in Sediment after In Situ Activated Carbon Amendment at an Active Naval Shipyard
U.S. Navy SPAWAR Systems Center Pacific

A Slough of Challenges: Navigating Columbia Slough Sediment Remediation Permitting Hurdles

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Jennifer Sutter (Sutter.jennifer@deq.state.or.us)
(Oregon Department of Environmental Quality, Portland, OR, USA)

Background/Objectives. The Columbia Slough comprises a 19-mile main channel that parallels the Columbia River, with approximately 12 additional miles of secondary waterways which drain over 32,700 acres of land. Much of the land use immediately adjacent to the Slough is industrial and stormwater runoff and historical discharges have contaminated sediment and fish tissue throughout the waterway. PCBs are present in the sediments and elevated fish tissue levels represent the primary risk driver in the Slough. DEQ's cleanup approach includes three primary components:

1. Pollutant source reduction/control
2. Cleanup of "hot spot" zones of contaminated sediment
3. Long-term monitoring of natural recovery.

Two contaminated sediment hot spots have been identified in the Lower Columbia Slough adjacent to stormwater outfalls, an industrial settling pond, and corresponding discharge pipes. DEQ is conducting remedial actions to address the two hot spots, including an activated carbon amendment implementation in the summer of 2016 at one site, and preparatory activities for a future cleanup action to address the sediment impacts at the second site. This paper summarizes the permitting process and presents lessons learned for the two state-led projects.

Approach/Activities. In late 2015, the two state-led sediment cleanup projects were prioritized for summer 2016 implementation. Permits necessary to implement the project include U.S. Army Corps of Engineers (USACE) Nationwide 38, Oregon Department of State Lands (DSL) Removal/Fill, and a City of Portland (City) Remedial Action Exempt Review for a Site Development Permit. In addition, access agreements necessary for project implementation included adjacent property owners, DSL, and the City Parks Bureau. Initial correspondence with the USACE and DSL commenced over one year prior to proposed implementation to establish permitting and timeline requirements. Following the initial correspondence, preparation of the permits began and included additional correspondence with federal, state, and local entities, and multiple property owners; a City pre-application conference; a Streamlining Team meeting to pre-address project-specific permit concerns; and identification of additional requirements outside of the standard USACE/DSL removal/fill application process.

Results/Lessons Learned. Activities completed in association with the permitting process culminated in submittal of the pre-identified permit applications, responses to comments, access agreements, and fees between March and July 2016. During the process, additional state and local agency requirements were identified, as well as additional applications, permits, and fee requirements, including those pertaining to environmentally sensitive species (mussels and turtles). The permitting process was substantially more complex and extensive than anticipated, requiring significantly more preparatory effort, regulatory involvement, and cost than identified in the initial permitting inquiries. As of June 2016, it is anticipated that one of the two projects will be completed in 2016, with additional permitting and waiver requirements needed prior to implementation of the second. The presentation will focus on strategies used to streamline the permitting process, identifying permitting hurdles, agency communication approaches, and managing timeline and cost considerations.

Chemical and Physical Monitoring for a Carbon Amendment Field Pilot Test in an Intertidal and Subtidal Zone

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Background/Objectives. Hunters Point Naval Shipyard (HPNS) is located in southeast San Francisco on a peninsula that extends east into the San Francisco Bay. Historical site activities resulted in the release of chemicals to offshore sediments in Parcel F, which includes approximately 457 acres of sediment within San Francisco Bay that bounds HPNS to the north, east and south. The southern portion of Parcel F—referred to as South Basin—has been affected by the release of PCBs from on-shore activities. Treatability studies conducted under three SERDP/ESTCP projects have indicated activated carbon (AC) will be effective in reducing the bioavailability of PCBs. These studies were performed in the very shallow intertidal areas near the shoreline; this field pilot study is being conducted in deeper water more representative of the depths and tidal ranges where the full-scale technology is anticipated to be utilized.

Approach/Activities. The pilot study was designed to assess efficacy of two types of carbon amendment in reducing ecological risk associated with PCB-contaminated sediment. The AC amendments selected for testing were (1) a composite particle system based on the AquaGate+ PAC™ technology platform (AquaBlok Ltd., Toledo, OH), and (2) SediMite™ (Sediment Solutions, Ellicott City, MD). Two distinct plots within a 1-acre area were designated for placement of each amendment. Plot areas were each approximately 0.4 acres and separated by a 45-foot buffer zone. The target application thicknesses were 1.2 to 1.8 inches for AquaGate+PAC™ and 0.5 to 0.8 inches for SediMite™. This study included placement of the AC amendments in shallow and deeper water on the sediment surface without any mechanical mixing. Performance objectives included: assessing the stability of the amendment over time through the use of sediment profile imaging (SPI) and coring, and assessing the effectiveness at reducing the bioavailability of PCBs using chemical analysis for parameters including PCBs, total organic carbon, and black carbon.

Results/Lessons Learned. Representative images from baseline and post-placement SPI monitoring confirmed good amendment placement in both plots. AquaGate+ PAC™ was viewed as coarse-sand-gravel aggregate grains and SediMite™ was viewed as fine-sandy silt. The buffer zone and the reference stations showed only trace amounts of amendment. AquaGate+PAC™ was observed to be significantly thicker than the SediMite™ amendment layer; the average thicknesses were found to be 2.2 ± 0.16 inches and 1.0 ± 0.14 inches, respectively. TOC and black carbon analysis was conducted on sediment samples at three depth intervals (0.0–0.2 ft, 0.2–0.4 ft, and 0.4–0.6 ft). Comparisons of post-placement mean sediment content of TOC and black carbon to baseline values show that the mean TOC and black carbon contents of sediment core samples collected during the baseline monitoring event were consistent over the entire pilot area and over the depth intervals analyzed. Mean TOC and black carbon content increased in the top 0.2 feet of sediment following amendment placement, although carbon content variability increased. There was no statistical difference in carbon among the post-placement results for the two test plots, suggesting the doses applied increased sediment carbon content by approximately equal amounts. A related HPNS abstract discusses associated measured changes in PCB bioavailability to clams.

Using a Low Permeability Sediment Cap in an Integrated Remedy on Lake Michigan: Construction Lessons Learned

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John Collins (jcollins@aquablok.com) (AquaBlok, Toledo, OH, USA)

Background/Objectives. A former Tie Treating Plant is located above Little Bay De Noc, an inlet connected to Lake Michigan near Escanaba, Michigan. In 1995, a seep of nonaqueousphase liquid (NAPL) was discovered emanating from the shoreline. Investigation determined the seep material was creosote and the nature and extent of creosote were delineated. Impacts were found to extend into a sand flat in Lake Michigan. An area was identified on the flat where concentrations of creosote constituents in sediment porewater (naphthalene) exceeded Michigan Part 201 standards for the groundwater/surface water interface (GSI). Remedial alternatives for managing the creosote were evaluated using a groundwater flow model (MicroFEM©) to determine groundwater flow paths and travel times under various simulations. Calibration to baseline conditions were used to determine the groundwater travel time associated with naphthalene concentrations attenuating to below the GSI standard. Remedial measures were simulated with the flow model to slow the groundwater flux, direct the groundwater discharge and elongate the groundwater flow paths. The reduced groundwater flux increase groundwater travel times and in combination with the elongated flow path, allows naphthalene to attenuate before reaching the GSI standard.

Approach/Activities. The remedial alternative selected included a soil bentonite cutoff wall extending to the underlying clay layer which directs groundwater flow around the upland creosote source area; a shoreline barrier wall constructed of both fully penetrating and partially penetrating structural steel sheet pile to direct remaining groundwater to Lake Michigan from within the cutoff wall; and to address NAPL impacts in surface sediment in the sand flat, excavation of sediment to a depth of 5 feet and construction of an impervious cap to elongate the groundwater flow path prior to discharge to Lake Michigan. The groundwater flow model predicted that interruption, redirection and extension of the flow path would result in sufficient degradation and attenuation of naphthalene such that the GSI standard could be met in Lake Michigan within the near future.

Results/Lessons Learned. The remedial action was implemented beginning in August 2015 and was completed in December 2015. It was implemented as a voluntary action in accordance with Part 201 of Michigan's Natural Resources and Environmental Protection Act. The soil bentonite cutoff wall was constructed with a one pass trencher; the sheet pile wall was conventionally constructed; the sediment was dredged mechanically with a barge-mounted rig; the cap was constructed with levelling sand then overlain with a low permeability bentonite-based aggregate then brought to pre-dredge grade using sand. All dredge spoil was dewatered then sent offsite for disposal/reuse. This presentation will present the overall sequencing of the construction and lessons learned from construction of this combined remedy designed to meet Michigan's Part 201 GSI standard.

Monitoring and Mapping the Transport Pathways of Contaminated Sediments Using Dual Signature Geologic Tracers: Two Case Studies

Kevin Black (kblack@partrac.com) (Partrac Ltd., Glasgow, UK)
Jim Leather (SPAWAR, San Diego, USA)
Matthew Wright and Jack Poleykett (Partrac Ltd., Glasgow, UK)

Background/Objectives. Contaminated sediments are found in numerous ports and harbor environments worldwide, where they comprise legacy deposits from historical industrial activities as well as more recent deposits from ongoing contamination. Management approaches directed towards decontamination and/or of contaminated seabed sediments require information on the range of processes governing the transport and fate of the contamination. This study demonstrated the utility of a novel, dual signature sediment tracer as a tool to monitor the transport pathways of contaminated sediments and to assess the efficacy of a proposed mitigation strategy. The overarching aim of the study was to undertake field campaigns to investigate two facets of contaminated sediment management: 1) direct assessment of the near and far field impact of an unregulated point source of contamination on marine waters at San Diego Naval Base; and, 2) assessment of the stability against wave and tidal erosion of an activated carbon amendment cap deployed at Hunters Point, San Francisco.

Approach/Activities. In coastal waters it is difficult to monitor the source – sink dynamics of sediments as it is difficult to distinguish between the sediment in transit and the native sediment load. Consequently, a sediment that can be unequivocally identified vis-à-vis the native sediments, and which can be easily deployed, monitored and recovered from the environment, is required. For this purpose geologic analogues called 'sediment tracers' can be used. This study utilised proprietary, 'dual signature' sediment tracers; 'dual signature' tracers are particulate tracers which have two signatures: fluorescence and ferrimagnetism. The tracers are natural minerals (silts; sands; gravels) coated with the two signatures, and consequently they possess highly similar hydraulic properties to natural mineral sediments but are tagged, to enable unequivocal identification within the environment. A fluorescent–magnetic tracing methodology was developed to monitor suspended and bed erosion transport in order to elucidate the transport pathways and investigate the sedimentation pattern of solids in the nearshore coastal zone. This approach utilised powerful, in situ moorings of permanent magnets, sediment grabs and in situ fluorimetry.

Results/Lessons Learned. At San Diego Naval Base the dual-signature tracer study enabled a field-scale, 'first flush' discharge event from a storm water outfall to be simulated. This enabled the assessment of the spatio-temporal distribution of a silt-rich, sediment-laden discharge. It was hypothesised that sediment transport would be driven by the discharge jet flow and receiving current and sampling of the water column and sea bed corroborated this. These data demonstrated that the sediment transport pathways and therefore the subsequent sedimentation pattern of discharged sediment is dictated by the stage of the tide, and is therefore directly linked to the timing of discharge events. The observed sedimentation patterns show a high concentration deposit footprint, elongated significantly in the mean flow direction attributed to reduced current velocity at high water slack, and the general low ambient current velocities observed at the site. Additionally a discussion of the results of field testing at Hunters Point will be presented (the study at the time of writing is yet to be undertaken). These data will be used to: i) assess the stability against wave and tidal erosion of an activated carbon amendment cap; and ii) investigate natural deposition of the surrounding sediments onto the cap surface using a multicolor tracing approach.

Sediment Remedial Activities under the Great Lakes Legacy Act Program

Stephen Garbaciak Jr., P.E. (steve.garbaciak@foth.com), Staci Goetz and Ronald French
(Foth, Green Bay, Wisconsin, USA)

Background/Objectives. The Great Lakes in the northern United States encompass the largest body of freshwater in the world. They hold approximately 18 percent of the world's supply of fresh water and the shoreline of all the Great Lakes combined equals nearly 44% of the circumference of the planet. The Great Lakes support a $4B/year fish industry and provide 56 billion gallons of water per day for municipal, agricultural, and industrial use. The Great Lakes Legacy Act of 2002 and it's reauthorization in 2008 was established to assist with the cleanup of contaminated sediment at 30 Areas of Concern in the Great Lakes. These contaminated sites have impacted the beneficial uses (e.g., commercial navigation, fishing, habitat use, recreation, drinking water) of the Great Lakes. The Great Lakes Legacy Act (GLLA) Program has been instrumental in cleaning up these Areas of Concern and this paper provides a detailed analysis of the remedial efforts under this program over the last 13 years.

Approach/Activities. To determine the level of effort expended under the GLLA in remediating contaminated sediments in the Great Lakes, we looked at each of the 30 Areas of Concern to determine the following:

- Contaminants of Concern
- Risk Drivers
- Dredging Technique
- Estimated and Actual Dredge Volumes
- Estimated and Actual Dredged Material Sent to Landfills and Combined Disposal Facilities (CDF)
- Estimated and Actual Dredged Material Used for Beneficial Use
- Volume of Contaminated Water Treated
- Estimated and Actual Area Capped
- Quantities of Cap Material Used
- Estimated and Actual Area for Monitored Natural Attenuation (MNA)
- Total Acres Restored Habitat
- Total Remediation Costs
- Total Funding from GLNPO and non-federal Sponsors
- Current Phase of Remediation

Twenty-four of the 30 AOCs have a sediment management plan in place, and these plans were reviewed, along with consultation with the Great Lakes National Program Office (GLNPO) to determine the remedial metrics listed above for each site. This information will be useful for gaging the relative size and cost of other sediment remediation programs across North America

Results/Lessons Learned. A considerable amount of resources have been used and dollars spent in the Great Lakes to remediate contaminated sediments. This paper will present a comprehensive database of the key metrics for these projects, allowing decision makers to better plan future remedial efforts.

Evaluation of Amendments for In Situ Sequestration of Mercury in Sediments

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Background/Objectives. Mercury (Hg) is present as contaminants in sediment at numerous sites around the world. Monitored natural recovery (MNR) processes have the potential to reduce bioavailability and potential risks associated with Hg in sediment. MNR relies significantly on the continued deposition of new sediment to reduce the bioavailability of contaminants, but sequestration processes can also play an important role in reducing bioavailability. MNR processes may be sufficient to control potential risks, however, in other areas, it may be necessary to enhance natural recovery processes through the use of amendments or thin-layer capping to achieve a greater level of risk reduction or to achieve this risk reduction in a shorter time frame than would be possible by relying on natural processes alone. Gaining acceptance for implementation of this type of enhanced monitored natural recovery (EMNR) remedy requires that the physical, biological and chemical processes that reduce the bioavailability of contaminants be understood and demonstrated for conditions Representative of those at a particular site.

Approach/Activities. Laboratory treatability testing was conducted at Geosyntec's SiREM Laboratory to demonstrate the potential for a variety of *in situ* amendments to reduce concentrations of Hg and methylmercury (MeHg) in water in contact with sediment from a contaminated sediment site. The concentrations of Hg and MeHg in the water in contact with the sediment in the lab are a surrogate for porewater concentrations and are expected to be an indicator of bioavailability. Sediment containing Hg and MeHg was mixed with surface water to produce a homogenous slurry that was added to identical one-liter glass jars which were then placed in an anaerobic glove box. Ten different amendments or combinations of amendments were added to the microcosm jars. Controls were also prepared to provide a comparison with the amended microcosms. The jars were mixed over a period of eight weeks and then the concentrations of PCB, Hg and MeHg in the aqueous phase were measured and the concentrations in the treated microcosms were compared with the concentrations in the controls. Additional work was conducted at the University of Guelph to evaluate the bioavailability of mercury that had been sequestered using similar amendment combinations based on a simulated fish gut extraction assay.

Results/Lessons Learned. The results of the testing demonstrated that significant reductions in the concentration of Hg and MeHg in water in contact with the sediment could be obtained with specific the amendments evaluated in the test. Iron based amendments when used along with activated carbon were successful in reducing the concentrations of Hg and MeHg relative to controls up to 91% and 94% respectively. Bioavailability testing also confirmed reductions in bioavailability of mercury using these amendment combinations.

The results of this treatability testing demonstrated the site specific capability of a combination of activated carbon and iron based amendments in reducing porewater concentrations and bioavailability of Hg and MeHg in sediment.

Optimizing Designs for In Situ Sediment Treatment Using Activated Carbon

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Background/Objectives. Extensive experimental studies and field trials have shown that, when applied correctly, in situ treatment via contaminant sequestration and immobilization using a sorbent material such as activated carbon has now progressed from an innovative sediment remediation approach to a proven, reliable technology. However, there are still significant institutional barriers that limit its application. Careful site-specific balancing of the potential benefits, risks, ecological effects, and costs of in situ treatment relative to other sediment cleanup technologies is required, along with design-level refinements to optimize its application. This presentation will summarize key tools that have proven effective in advancing this technology and in optimizing remedial designs.

Approach/Activities. An important initial step is to develop a robust conceptual site model that presents a clear understanding of sediment dynamics and stability, along with ongoing sources and background levels of contamination. This step is essential for gaining regulatory and stakeholder acceptance of specific locations within sites for which in situ treatment can be effective. Second, comparative evaluations of remedial alternatives, building on laboratory and field studies and using modeling as appropriate, are needed to accurately contrast the short and long-term impacts and effectiveness of different in situ treatment designs versus more traditional remediation methods such as dredging, capping, or natural recovery. For example, the type and size of amendments can affect kinetics, persistence, and ecological effects. Design evaluations often involve defining clear tradeoffs that have differing importance with key stakeholders and resource and regulatory agencies. Third, while there are few remaining technical issues associated with in-situ treatment that have not already been thoroughly addressed in previous field trials and full-scale applications, performing pilot studies focused on specific agency or stakeholder concerns can be pivotal to achieving acceptance. In certain situations, such trials can be important, as contaminated sediment sites often have unique physical, chemical, and hydrodynamic factors affecting remedial design. These same challenges have been used to justify pilot studies of other more traditional remediation methods, making activated carbon not unique in this regard. Finally, early identification and focus on costeffective designs and application methods that appropriately address site-specific conditions can streamline the overall evaluation.

Results/Lessons Learned. Lessons learned from completed and ongoing in situ treatment projects will be reviewed, including comparative evaluations of different designs for in situ sediment treatment in a range of representative environments, including Onondaga Lake (New York), Hunter’s Point (California), Mirror Lake (Delaware), Grasse River (New York), Duwamish Waterway (Washington), and Lauritzen Channel (California). Using the Lauritzen Channel as a representative case study, comparative evaluations supported by focused laboratory testing and kinetic modeling highlight key trade-offs associated with different in-situ treatment design options.

PCB Tissue Concentrations and Benthic Community Impacts at a Carbon Amendment Pilot Study in the Intertidal and Subtidal Zones of San Francisco Bay

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Background/Objectives. Hunters Point Naval Shipyard (HPNS) is located in southeast San Francisco on a peninsula that extends east into the San Francisco Bay. Historical site activities resulted in the release of chemicals to offshore sediments in Parcel F, which includes approximately 457 acres of offshore sediment within San Francisco Bay that bounds HPNS to the north, east and south. The southern portion of Parcel F referred to as the South Basin—has been affected by the release of PCBs from on-shore activities. Treatability studies conducted under three SERDP/ESTCP projects have indicated activated carbon (AC) may be effective at reducing the bioavailability of PCBs to benthic organisms. These previous studies have evaluated AC amendments in shallow intertidal areas. The current study assessed the effectiveness of AC amendments in deeper water that is more representative of the depths where full-scale remediation is expected and using a different AC deployment method.

Approach/Activities. The pilot study was designed to assess the efficacy of AquaGate+PAC™ and SediMite™ carbon amendments in reducing the ecological risks associated with PCB-contaminated sediment. Two plots, approximately 0.4 acres each, were treated with the AC amendment. Each plot extended from the intertidal to subtidal zone and AC was distributed on the sediment surface without any mechanical mixing. PCB tissue concentrations in clams (*Macoma* sp.) were measured 28 days after field deployment and using laboratory bioaccumulation tests. Exposure chambers based on Luthy et al. (2009) were modified to remotely deploy clams for in situ exposures and then retrieve the clams and sediment. Benthic invertebrate community composition was also determined from sediment grab samples. Baseline conditions and initial monitoring (8 and 14 months post-placement) provide an initial indication of the pilot treatment effectiveness by comparing the results among sampling periods and between the two treatment plots and a reference site. Other performance objectives included assessing the stability of the amendment over time through the use of sediment profile imaging (SPI), cores, and chemical analysis of PCBs, total organic carbon, and black carbon.

Results/Lessons Learned. The modified exposure chambers worked well in the young bay mud where sediment infiltrated the chambers to expose clams upon deployment. Tissue bioaccumulation was planned to be conducted with *Macoma nasuta* (bent-nose clam) but instead, initial measurements were made with *Macoma secta* (white sand clam) that were collected at a nearby reference location where *M. nasuta* had been previously found. The species appear similar and have similar life histories but *M. secta* had low survival in lab (23%) and field exposures (5%). Post-amendment monitoring with *M. nasuta* (>90% survival) found PCB tissue concentrations reduced up to 87% in pilot amendment areas after 14 months. Benthic invertebrate communities were not significantly different from baseline conditions or among treatments 8 months after AC deployment.

Evaluation of PCBs Availability in Sediment after In Situ Activated Carbon Amendment at an Active Naval Shipyard

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Background/Objectives. Significant and unique challenges for sediment remediation are posed by infrastructure, vessel traffic, varying water depths, and logistical requirements in active harbor areas. In situ treatment (e.g., activated carbon) is a cost-effective remedial approach to such challenges. In this project, a thin (targeted 2-inch) layer of activated carbon (AquaGate+PAC™) was placed over a targeted half-acre area of PCB-impacted sediments beneath and adjacent to Pier 7 at the Puget Sound Naval Shipyard and Intermediate Maintenance Facility, Bremerton, WA, USA.

Approach/Activities. Synchronous measurements of concentrations of PCBs in tissue and sediment porewater were measured in situ over a 2-week exposure period. Bioaccumulation testing was performed with two species, *Macoma nasuta* (bent-nosed clam) and *Nephtys caecoides* (polychaete worm), via Sediment Ecotoxicity Assessment (SEA) Rings. Sediment porewater was measured using solid phase microextraction (SPME) fibers coated with polydimethylsiloxane (PDMS). Measurements were made at 10 sample locations in a baseline characterization prior to amendment placement and three annual post-placement monitoring events to evaluate the decrease in PCB availability in sediments.

Results/Lessons Learned. In this presentation, monitoring approaches and results of 3 years of monitoring will be presented. Significant decreases in concentrations of total PCBs in *M. nasuta* and *N. caecoides* tissue were observed in all post-placement monitoring events compared to the baseline (decreases ranging from 82% to 97%), the exception of *M. nasuta* in the 10-month post-placement event in which decreases of 68% were not statistically significant (α = 0.05). Statistically significant decreases in sediment porewater concentrations were observed in all post-placement events compared to baseline (decreases from 75% to 86%). The decrease in concentrations observed in the bioaccumulation and porewater results was consistent with bench scale tests, and indicates the remedy was effective in reducing availability of total PCBs in Pier 7 surface sediments. Synchronous use of SPME and SEA Ring technologies provided a robust design for evaluating PCB availability.

AQUABLOK RELATED POSTER PRESENTATIONS

Field Demonstration of Fluorescent Paramagnetic Particle Tracers for Sediment Transport Studies near Remedial Caps
U.S. Navy SPAWAR Systems Center Pacific, Partrac, Ltd.

A Comparison of In Situ Passive Sampling with PE and PDMS in the Evaluation of Available Concentrations of PCBs in Sediment Porewater
Geosyntec Consultants, Ramboll Environ

Remediation of Coal Tar-Impacted Intertidal Sediment in the Fore River, Portland Harbor, Maine
Amec Foster Wheeler Environment & Infrastructure

Site-Specific Treatability Studies to Evaluate Cap Amendments to Sequester Contaminants of Potential Concern from the Gowanus Canal
Geosyntec Consultants

To Each Area, Its Own Remedy: Combining Removal, Residual Management, Restoration and *In Situ* Treatment
CDMSmith

Treatability Study for Under-Pier Activated Carbon Amendment Treatment of Contaminated Sediments, Pearl Harbor, Hawaii
U.S. Navy, NAVFAC Pacific, AECOM

Innovative Reactive Media Sediment Remedies
Arcadis U.S.

Overcoming Implementation Challenges: Activated Carbon Placement on the Lower Columbia Slough
Apex Companies, LLC, Oregon DEQ

Evaluation of Porewater Reductions due to Carbon Placement via Sedimite and AquaGate at a Contaminated Sediment Site
Texas Tech University, CH2M, U.S. Navy, NAVFAC Pacific

Field Demonstration of Fluorescent Paramagnetic Particle Tracers for Sediment Transport Studies near Remedial Caps

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Background/Objectives. Contaminated sediments are a continuing regulatory issue for DoD facilities. The ESTCP program has funded the field demonstration of this innovative particle tracking technology to provide actual field data that can be used along with sediment transport models for better assessments at contaminated sediment sites. For example, investigation of sediment transport following any implemented remedial efforts will allow better understanding of potential recontamination issues. At the last Battelle sediment conference we showed how tracer studies could be used to map the contaminant particle footprints near stormwater outfalls along deep water piers. Here we report on a second field demonstration at a remedial cap site to show how tracer studies can be used to address recontamination of the cap from adjacent contaminated sediments.

Approach/Activities. The innovative particle tracking technology uses both fluorescent and paramagnetic properties for the tracer particles. Up to four spectrally distinct fluorescent colors can be used to distinguish different contaminated particle grain sizes or multiple sediment source areas. Paramagnetic properties allow field magnets for collection which provide both separation and concentration of tracer particles from the surrounding sediments. This provides improvements over older tracer studies that relied on filtering particles and subsequent costly laboratory separation and counting of tracer particles. This field demonstration was conducted offshore from a former navy landfill in sediments where an acre sized remedial cap has recently been placed to compare different types of activated carbon amendments. The tracer study was conducted to determine whether remaining upland contaminated sediments are transported offshore and recontaminate the surface of the cap. A second tracer color was also used to determine how much of the cap material leaves the cap area and is transported into the surrounding sediment areas.

Results/Lessons Learned. The tracer study will be performed during the summer 2016 time period and initial results will be presented at the conference. These results will be compared to the initial demonstration results we presented at the last conference which showed how tracer field data and sediment transport models predicted similar contaminated particle distributions near stormwater outfalls.

A Comparison of In Situ Passive Sampling with PE and PDMS in the Evaluation of Available Concentrations of PCBs in Sediment Porewater

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Background/Objectives. Passive sampling measures freely dissolved concentrations of hydrophobic organic compounds (HOCs) such as polychlorinated biphenyls (PCBs) in sediment porewater as this metric correlates well with uptake into sediment-dwelling organism tissue. There are a number of passive sampling approaches, with polydimethylsiloxane (PDMS) coated solid phase microextraction (SPME) fibers and thin sheets of polyethylene (PE) being two of the most widely-used methods.

Approach/Activities. To evaluate the performance of PDMS and PE, a synchronous deployment of samplers (10-μm thick PDMS, 18-μm thick PE) were co-located in surface sediments at ten locations for a two-week in situ deployment at a 0.5-acre shipyard site in the Puget Sound, Washington.

Results/Lessons Learned. As has been observed in previous studies, the thinner PDMS layer was found to reach steady state more rapidly than PE. For example, the percentage of steady state attained during the exposure period was 1.4 times higher for pentachlorinated biphenyls in PDMS compared to PE. The difference was greater (a factor of 2.2) for hexachlorinated biphenyls. Advantages in kinetics were offset in terms of detection limits, which were typically lower with measurements using PE compared to PDMS (due to the greater volume of polymer present in the PE approach). Lower detection limits enabled more PCB congeners to be detected via PE methods than PDMS. Di- to hexachlorinated biphenyls were detected with PE passive sampling, whereas tetra- to pentachlorinated biphenyls were detected with PDMS. A consequence of a greater number of congeners detected at lower concentrations was the concentrations of total PCBs in sediment porewater were found to be greater by PE measurements compared to PDMS. With the exception of one outlier station, concentrations of total PCBs in sediment porewater were on average 2 times greater as measured by PE than PDMS methods. These results are in general agreement with previous studies that found a factor of 2 to 3 agreement between PE and either PDMS or POM passive sampling methods. The differences in detection limits can be mitigated by using additional amounts of SPME fiber; however, the logistics of working with and purchasing additional SPME fiber results in a less economical option, as will be discussed during the presentation.

Remediation of Coal Tar-Impacted Intertidal Sediment in the Fore River, Portland Harbor, Maine

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Background/Objectives. From 1852 to 1965 the Portland Gas Light Company operated a manufactured gas plant (MGP) on the shore of the Fore River in Portland Harbor, Maine. Inland portions of the former MGP site (gas and tar holders) were remediated under the Maine Department of Environmental Protection (MEDEP) Voluntary Response Action Program (VRAP) prior to 2008. Shoreline parcels impacted by cyanide (purifier box waste) and coal tar DNAPL were remediated in 2014 and 2015. The coal tar DNAPL seep that impacted intertidal sediments presented the greatest remedial design and construction challenges requiring a combination of remedies that were implemented under the operational constraints inherent to shoreline sediment removal in a busy marine port with frequent oil tanker traffic. The remedial objective that was negotiated under the VRAP was measurable and simply required elimination of sheen caused by discharge of coal tar DNAPL to the water column from disturbance of the impacted intertidal sediments by wave action. The remedy combined a grouted sheet pile barrier wall to prevent future migration of coal tar DNAPL from upland sources, a belt and suspenders secondary AquaBlok$_{TM}$ vertical barrier, an AquaBlok$_{TM}$ cap (installed over a portion of sediment that could not be excavated due to densely spaced deep wooden timber piles), and excavation of sediment behind an engineered turbidity/fish exclusion barrier anchored just inboard of the designated navigation channel. Although the fish exclusion barrier allowed some relaxation of USACE time of year (TOY) restrictions for protection of winter flounder, construction was completed between October 15 and December 31, 2015.

Approach/Activities. High resolution delineation of the upland source of the coal tar seep (via TarGost$_{TM}$ direct push investigations) and visual confirmation of the extent of the intertidal seep provided stratigraphic controls for an optimized design for the barrier wall location. The sheetpile wall was designed as a free standing wall without tiebacks using AZ50 sheetpile driven as welded pairs into underlying marine clay. Geotechnical stability of the barrier wall and depth of excavation on the exterior of the wall were critical design and constructability factors. Non-welded sheetpile joints were designed with grouted interlock channels to prevent future seepage of coal tar DNAPL through the barrier wall. The elevation of the seep source was backed with a vertical AquaBlok$_{TM}$ barrier on the exterior of the sheetpile wall as a secondary containment measure should a grouted interlock fail. The turbidity/fish exclusion barrier was intentionally designed and constructed to withstand the enormous but short duration “Tsunami” style tidal forces caused by passing oil tanker traffic. This approach had very substantial cost savings over sediment excavation behind a temporary coffer dam within an intertidal zone with over 10 feet of tidal elevation change. Excavated sediments were beneficially re-used.

Results/Lessons Learned. The remedy was successfully completed with the following lessons learned:

1. Combining multiple remedy approaches provided flexibility to achieve remediation goals.
2. Designs should consider economical “secondary” belt and suspender options to guard against potential for remedy failure.
3. With proper design and anchoring, sediment excavation behind floating turbidity barriers can be more cost effective than excavation within temporary coffer dam structures.

Site-Specific Treatability Studies to Evaluate Cap Amendments to Sequester Contaminants of Potential Concern from the Gowanus Canal

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Background/Objectives. The Gowanus Canal (the Site) is located in Brooklyn, New York and sediment at the Site contains polycyclic aromatic hydrocarbons (PAHs) from nearby historical industrial activities and sewer discharges. Non-aqueous phase liquid (NAPL) is also present beneath the sediment at the Site at a limited number of locations along the canal. The remedy to address PAH and NAPL at the Site may include areas where an active cap will be used to control potential migration of PAHs and NAPL from sediment into the water way. An initial set of treatability studies have been conducted to identify potential active cap amendments that could be used to control the potential migration of PAHs in the dissolved phase and to sequester NAPL that may be present in some specific locations at the Site. A second phase of treatability studies will be conducted using amendments identified during the initial testing in a test configuration that more closely simulates potential future cap designs in specific areas of the canal. This presentation will describe testing conducted to support the selection of amendments for a potential active cap at the Site based on their performance under site-specific conditions to adsorb site-specific target contaminants.

Approach/Activities. Treatability studies were conducted at Geosyntec's SiREM Laboratory to evaluate the capacity of activated carbon (AC) products to sorb the dissolved phase PAHs. AC will also sequester organic compounds other than PAHs but only PAHs and NAPL have been identified as contaminants of potential concern. Tests were completed using methods which were reviewed by the U.S. EPA and leading technical experts in the field. AC experiments included a kinetics test, an AC capacity screening test (of 11 commercially available types of AC) and a more extensive isotherm test using the optimal types of AC identified. All AC tests used site-specific simulated pore water which was prepared by contacting groundwater and NAPL from the Site to create a high concentration scenario. Microcosms with simulated site pore water were continually agitated throughout the 8-day tests and were amended with varying amounts of AC. Treatability studies were also conducted to evaluate the sequestration of NAPL from the Site onto oleophilic clays. Two different types of NAPL sorption capacity tests (one centrifuge method and one using a microcosm containing NAPL and potential sediment cap material) were completed using site-specific NAPL and five types of oleophilc clay.

Results/Lessons Learned. The results of the testing demonstrated that significant reductions in the concentration of dissolved PAHs could be obtained with different types of AC. All types of AC were capable of reducing concentrations of PAH in simulated pore water but optimal types of granular AC (GAC) and powdered AC (PAC) for treating simulated site pore water were identified. Isotherm testing on selected GAC and PAC provided data to be used for design purposes in sediment cap modeling. Likewise, more than one type of oleophilic clay was found to be effective at sequestering the site-specific NAPL, although there were significant differences in the capacity of different types of oleophilic clays to sorb NAPL. The Phase I treatability study experiments were successful at identifying potential AC and oleophilic clays to be used in column studies and ultimately for use in a potential active cap at the Site.

To Each Area, Its Own Remedy: Combining Removal, Residual Management, Restoration and *In Situ* Treatment

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Background/Objectives. Effectively addressing multiple environments within contiguous areas of contamination typically requires application of distinct and separate remedies. Data needs and collection methods must be targeted to each environment and remedies tailored especially to the physical dynamics of the different settings and in some cases to the specific contaminant concentrations. Coordination of multiple design and construction elements can be challenging. Comprehensive and continual communication is key to establishing the right balance of remedial elements and obtaining informed consent from all stakeholders. This presentation will highlight lessons learned from a project involving significant sediment removal, residuals management, restoration and one of the largest applications of in situ treatment to date.

Approach/Activities. The site in the mid-Atlantic region includes an upland stream, tidal and non-tidal wetlands, a large cove and a tidal creek. Sediment is impacted with PCBs, PAHs and metals. Data collection efforts included horizontal and vertical contaminant distribution, grain size distribution, bathymetric surveys, hydraulic analysis, sediment deposition rate radio-age dating, AVS/SEM toxicity analyses, and in situ amendment treatability studies. Initial remedy identification was tailored to the physical properties of each subenvironment. A community working group was convened and utilized to develop a consensus balance between removals and in situ treatment. Multi-parameter decision analysis tools were used to facilitate final remedy selection. Treatability testing was employed to document the effectiveness of proposed in situ treatment amendments.

Results/Lessons Learned. A multi-component remedy requires extensive communication and coordination. Design elements for the varied environments must mesh and construction sequences must dovetail. Permitting requirements expand with multiple regulated environments and becomes a critical path to project start. Procurement requires selection of contractors with many different areas of expertise. This presentation will document the technical approach to remediating the various environments of the subject site and the coordinated communication efforts required to obtain the regulatory approvals and the informed consent of stakeholders and the general public.

Treatability Study for Under-Pier Activated Carbon Amendment Treatment of Contaminated Sediments, Pearl Harbor, Hawaii

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Overview. Sediment contamination has been identified in under-pier areas of Pearl Harbor as the result of current and historical harbor activities. The Navy has completed a sediment feasibility study at Pearl Harbor which identifies activated carbon amendment treatment as the preferred remedy for under-pier areas, where access issues impede the implementability of more conventional remedies such as dredging or capping. A pilot treatability study (TS) is being conducted at the Navy's Pier Sierra 1B in Pearl Harbor's Southeast Loch to evaluate the preferred remedy for under-pier areas of Pearl Harbor from the standpoints of both reduction of contaminant bioavailability and implementability of the remedy in limited access, sloped areas.

Background/Objectives. Approximately 13 acres of open-pile under-pier areas in Pearl Harbor have been identified as having surface sediment contaminated with polychlorinated biphenyls (PCBs) and certain metals requiring remediation. The top 1 foot layer of sediment in these areas has been targeted for in situ treatment with activated carbon amendment. The harbor's under-pier areas present a significant remediation challenge due to several factors: 1) access is limited by fender and support pile placement, utilities, and tides; 2) the sediment surface is often steeply sloped from the shore side to the face of the pier; and 3) natural and man-made structures and debris limit removal options. The TS is necessary to evaluate the implementability and effectiveness of the preferred remedy for under-pier areas prior to full-scale implementation.

Approach/Activities. Two test plots are being studied during the TS, each using a different activated carbon amendment material (AquaGate+PAC and SediMite). Both materials are being evaluated simultaneously due to their differing physical and chemical properties. Each material was applied to a target thickness that achieves a calculated dose of activated carbon. The test plots have undergone baseline (pre-treatment) and 6 month performance monitoring analysis of PCBs and metals in bulk sediment and porewater and will be evaluated again as part of the final 18-month performance monitoring. Solid-phase microextraction samplers and diffuse gradients in thin film probes have been used for the PCB and metals porewater sampling, respectively.

Results/Lessons Learned. The TS documents the performance of each amendment material in the active harbor setting. Preliminary evaluation of the data indicates that PCB porewater concentrations have been reduced by as much as 70%. On average, black carbon concentrations were increased in the test plots by the design percentage for each amendment and both amendments are stable. Sediment cores showed evidence of bioturbation and mixing. Both amendment materials showed effectiveness in their respective test plots, but there are differences in ease of placement and effectiveness of the amendment in reduction of porewater PCB concentrations.

Innovative Reactive Media Sediment Remedies

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Background/Objectives. Reactive media usage in sediment caps has transitioned from an innovative technology to a proven technology over the last decade. As reactive cap technology matures, there continue to be developments in the types of reactive materials, application methods, cap configurations, and contaminants that are addressed. The use of reactive amendments as an in situ amendment for contaminated sediments is still a relatively innovative technology, which has been pilot tested and more recently selected and/or constructed as a remedy component at several contaminated sediments sites.

Approach/Activities. The state of reactive media usage for contaminated sediment sites continues to evolve from the established use of organophilic clay as a reactive cap to control sheens to more innovative applications. These innovative applications include the combination of multiple media in caps; alternate cap configurations such as granular, pelletized, mat, or funnel and gate application; addressing dissolved flux of contaminants; using media to adjust pH; and in situ amendment using activated carbon or organophilic clay. For example, siderite has been studied using batch tests and geochemical kinetic models to evaluate its ability to neutralize elevated pH porewater. Mixtures of Sorbster with organophilic clay have been evaluated to address mercury-impacted sediment. Funnel and gate systems have been evaluated in combination with reactive sediment remedies to divert groundwater flow to reactive zones within sediment to treat groundwater prior to discharge to the sediment surface.

Results/Lessons Learned. An evaluation of the current state of reactive media technologies for contaminated sediments will be presented. This will include evaluation of reactive capping and in situ amendments, and discussion of other innovative and upcoming uses of reactive media at contaminated sediment sites. The presentation will focus on the innovative approaches for the use of reactive media at contaminated sediment sites.

Overcoming Implementation Challenges: Activated Carbon Placement on the Lower Columbia Slough

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Background/Objectives. The Columbia Slough (Slough) comprises a 19-mile main channel that parallels the Columbia River. Much of the land use immediately adjacent to the Slough is industrial and stormwater runoff and historical discharges have contaminated sediment throughout the waterway. Polychlorinated biphenyls (PCBs) are present in the sediments and represent the primary risk driver in the Lower Columbia Slough. One of the PCB hot spots identified in the Lower Columbia Slough consists of contaminated sediment extending over an approximately 60,000 square foot area adjacent to three stormwater outfalls. Because this hot spot area has relatively consistent PCB concentrations and sediment conditions over a large area it provides a uniquely suitable location to compare approaches for reducing the bioavailability of PCBs to aquatic receptors. This pilot study/hot spot cleanup consists of placing two types of activated carbon amendments in separate halves of the study area. Prior to implementation, porewater and bulk sediment sampling was conducted to establish baseline concentrations and monitoring will be conducted annually for several years following application to assess reduction in freely dissolved concentrations of PCBs.

Approach/Activities. Challenges associated with the AC placement at this location are significant, including a very thin design amendment layer thickness, a permit-limited in-water work window, low water conditions during the in-water work window, limited over-water access during low water, daily tidal fluctuations, limited upland access, and bank use restrictions on both sides of the waterway. The low water levels, resulting in the potential for high tide daily water levels of less than two feet within the application area and dry conditions possible during the proposed implementation period presents the most significant challenge. Critical design and implementation components of the project include:

- Distributing two different activated carbon products within the application area at the design-specified thickness, accounting for variable placement conditions and drift during delivery;
- Transporting and assembling necessary in-water placement equipment to an area with limited over-water access.
- Accessing the project area and delivering the activated carbon products without modifying or impacting the Slough bank; and
- Maintaining the dry activated carbon products until placement in the Slough.

Results/Lessons Learned. Multiple project design iterations were necessary prior to successful implementation. Hurdles encountered included limited contractor interest due to unpredictable conditions and financial risk associated with project access uncertainties, as well as challenges in finding an application method that ensured accurate layer thickness. The presentation will discuss the alternative approaches and technical solutions developed to successfully apply the AC at this site and overcome these unique challenges.

Evaluation of Porewater Reductions due to Carbon Placement via Sedimite and Aquagate at a Contaminated Sediment Site

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Background/Objectives. Activated carbon is increasingly used to reduce contaminant bioavailability in sediments as a remedial measure. Activated carbon is often placed as a composite material to aid in settling and retention at the sediment surface. A demonstration of two such composite materials, Sedimite and Aquagate, was conducted in PCB contaminated sediments in open water near Hunters Point, CA. The materials were allowed to settle directly to the sediment surface. Here the changes in porewater concentration in the surface sediments and in deeper layers up to 40 cm below the sediment surface were evaluated by passive sampling using polydimethylsiloxane (PDMS) coated fibers to measure porewater concentrations of PCBs. Our goal was to evaluate and compare changes to in situ hydrophobic organic compound (HOC) porewater concentrations before and after activated carbon placement and between the two different activated carbon placement methods.

Approach/Activities. The pilot study was conducted at Hunters Point Naval Shipyard (HPNS). For passive sampling, SPME fibers (34.5 μm PDMS coating) were preloaded with 7 C_{13} PCB congeners as performance reference compounds (PRCs). PDMS fibers were inserted to unshielded holders, attached to a tripod frame and embedded vertically 30 cm into the sediment for triplicate measurement of porewater concentration at the 20 sampling locations. After 28 days the fibers were retrieved, sectioned into a 1-6, 11-16 and 21-26 cm segments below the sediment surface and analyzed for PRCs and 111 PCB congeners using GCTQMS. Bulk sediment samples were also collected and the concentrations quantified by GCTQMS.

Results/Lessons Learned. Baseline sampling showed uniform porewater concentrations across the site with lower concentrations in the near surface versus the deeper layers due to exchange with the overlying water from the shallower zone. Statistical analysis showed that the porewater samples were well correlated with nearby samples. After AC placement, porewater concentrations decreased from a baseline average of 2.2 ng/L to 0.35 ng/L in the surficial layer. Smaller but significant reductions in porewater concentration was also noted at the deeper depths. AC also influenced the approach to steady state of the passive samplers with more rapid approach to steady state post-placement. The influence of nonlinear sorption on the PRC analysis was also evaluated by modeling and indicated that the presence of activated carbon can cause traditional analyses to overestimate the fractional approach to steady state.

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