Robert D. Teetz
Vice President
Environmental Services

nationalgrid

April 25, 2013

Via overnight mail and electronic mail
Christos Tsiamis
Project Manager
United States Environmental Protection Agency
New York Remediation Branch
290 Broadway
20^{th} floor
New York, New York 10007

***Re*: National Grid comments on the United States Environmental Protection Agency Proposed Remedial Action Plan for the Gowanus Canal**

Dear Mr. Tsiamis:

Please find enclosed comments, with appendices, by National Grid on the United States Environmental Protection Agency Proposed Remedial Action Plan for the Gowanus Canal. We thank you for your consideration and look forward to continuing to work with you.

Very truly yours,

Robert D. Teetz
Vice President
Environmental Services

cc.: Brian Carr, Esq.

175 East Old Country Road, Hicksville, NY 11801
T:516/ 545 2577 ■ F:516/ 545 3300 ■ robert.teetz @us.ngrid.com ■ www.nationalgrid.com

national**grid**

Comments on the United States Environmental Protection Agency December 2012 Proposed Remedial Action Plan for the Gowanus Canal Superfund Site

Submitted April 25, 2013

Table of Contents

I. INTRODUCTION

National Grid commends the Environmental Protection Agency (EPA) for its significant efforts in addressing the challenges posed by remediation of the Gowanus Canal. In addition to decades worth of contamination from hundreds of industrial sources, the Canal is impacted by significant contamination from municipal combined sewer overflows (CSOs), storm water outfalls, and other direct outfalls that continue to this day. Addressing the environmental state of the Canal became all the more challenging when the complexity of the waterbody and the community desire for a speedy remediation were added. Commendably, the EPA has worked extremely hard and has strived to satisfy community expectations by expediting the Remedial Investigation (RI) and Feasibility Study (FS), and issuing a Proposed Remedial Action Plan (PRAP) within two years.

For its part, National Grid quickly recognized the challenge posed by the Gowanus Canal and has stepped up to be part of the solution. After it acquired the companies that held responsibility for the manufactured gas plant (MGP) sites in Brooklyn, National Grid moved expeditiously and used significant resources to remediate the legacy MGP sites, which are located along the Canal. National Grid immediately began and continues to participate in community meetings, communicating with citizens groups, and working with community officials and representatives. In addition, National Grid has collaborated closely with the EPA and conducted a number of essential studies, which it has shared with EPA.[1] Lastly, National Grid assembled experienced, nationally recognized experts to assist in reviewing the technical aspects of the FS Addendum and the PRAP, and to offer expert insights to assist the EPA. All of these efforts are aimed at making the remedy one that is appropriate, sustainable and, most important, successful.

The EPA's understandably fast tracking of the RI / FS, however, did not come without consequences. The record pace to select the final remedy this year has left insufficient time to fully understand the Gowanus Canal eco-system and to evaluate how a proposed remedy will perform under future conditions. Indeed, the Contaminated Sediment Technical Advisory Group (CSTAG) recognized this challenge when it warned that the EPA was proceeding without a complete understanding of all of the Canal elements (EPA 2012a). National Grid's experts have echoed this concern and agree that significant design studies, flexibility, and adaptive management are needed to increase the probability of success.

Nonetheless, the PRAP is a bold first step toward proposing a remedy that, if designed based on good science and implemented under a flexible Record of Decision (ROD), can achieve meaningful remediation. Seeking to align the Clean Water Act (CWA) with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund), the EPA has set out a blueprint to address our national problem of ongoing combined and sanitary sewer discharges to urban water systems. The PRAP correctly proposes that the CSOs be addressed now with a combination of interim and long-term controls. The EPA, however, needs to go further because the proposed CSO storage tanks may not capture a sufficient volume of the

---

[1] A list of the studies and other documents that National Grid has submitted to EPA for inclusion in the Gowanus Administrative Record is attached as Appendix A.

contamination, including petrogenic and pyrogenic polycyclic aromatic hydrocarbons (PAHs), metals, pesticides, and other contaminants associated with fine particles discharged from the CSOs during the total duration of CSO events. This issue, plus specific identification of interim controls, must be addressed in the ROD. If they are not addressed and the much needed CSO controls are postponed until after the remainder of the Canal remedy is implemented, recontamination will occur quickly, wasting not only time and resources, but also resulting in an inability to meet water quality objectives and to attain sustained sediment improvements, needless and substantial disruption, and significant disappointment to the community.[2]

That being said, National Grid recognizes CSO control poses a difficult challenge. Like the decades old contamination left over from the industry of another era that poses its own challenges, the CSO system is dated and its infrastructure is complex. Improving the CSO system is not easy and certainly cannot be done overnight. Any improvements will be very expensive and pose unique technical challenges. To the extent complete CSO control proves to be infeasible and continuing discharges of polluted water are not fully addressed, it will be impossible to effectively remediate the Canal. In addition to adequately controlling the inflow of sediments and contaminants from the CSOs and storm water discharges, other industrial sources need to be identified and controlled. Accordingly, the EPA must be prepared to set in the ROD realistic remedial action objectives (RAOs) and performance standards which recognize and are calibrated to the level of control that is achievable in the near term. Due to remaining uncertainties regarding the appropriateness and specific design requirements for remedy components like dredging, capping, and sediment disposal, the ROD should contain language that allows for the application of alternative methods and techniques that are acceptable to EPA.

Equally important to source control, the EPA needs to work with all parties to study and design remedy components like dredging, capping, and sediment disposal, refine the conceptual site model that evaluates all potential current and future exposure pathways, collect additional data to understand sediment and contaminant transport, and then clarify RAOs and performance standards. Along the way, the design process should not be blind to the potential for equally effective and more efficient alternatives. As a result, the ROD should be flexible enough to allow application of such potential alternatives and allow for real-time modification of the remedy even while it is being implemented. Such an adaptive management approach will enable the parties to work together to design an appropriate and sustainable remedy that will need to be done only once.

---

[2] Careful consideration of the remedial evaluation factors set forth in the National Contingency Plan (NCP) is also critical in developing the ROD. Those factors – overall protection of human health and the environment, compliance with Applicable or Relevant and Appropriate Requirements (ARARs), long-term effectiveness and permanence, reduction of toxicity, mobility, or volume, short-term effectiveness, implementability, cost, and state and community acceptance – are markers against which the remedy should be measured. A remedy that allows for recontamination fails to meet those measures.

The comments that follow outline many of the important design tasks in more detail and propose specific and practical recommendations in the Conclusion. National Grid has been and continues to be prepared to do its part in these efforts. For the remedy to succeed, all stakeholders must keep an open mind and accept the realities that the Canal is an extremely difficult setting, there will likely be delays, and there needs to be an honest discussion about real need for CSO control and best practices for dredge and cap design. If we work together and do the right thing, then together we can work to restore the Gowanus Canal and achieve the clean waterway that all stakeholders desire.

II. EXECUTIVE SUMMARY

The PRAP's plan to mesh the requirements of the CWA and CERCLA establishes the Gowanus Canal as a significant opportunity to chart a new course in urban waterway remediation. If design of the remedy is undertaken with appropriate planning, flexibility, and adaptive management, the EPA will not only be in a position to make significant positive strides toward addressing CSOs and perfecting innovative technologies that can have benefit around the nation, but it will have done a great service to the Gowanus community.

In order to reach those accomplishments, the EPA must move from the concepts contained in the PRAP to specifics in the ROD. The EPA must now work with all parties to create a detailed plan that will control sources to the maximum achievable level, while simultaneously maintaining flexibility and employing an adaptive management approach to designing the rest of the remedy. Once the impacts of source controls are known, the EPA and the parties should reevaluate matters in light of this newly developed information and move in the appropriate direction. To the extent sources cannot be controlled fully, the Canal cannot be cleaned to the extent all would like. Hard choices about the use and ecological recovery will need to be made. These choices must be fully vetted during the design process, so that all parties, including the community, know what the future vision of the Canal is. Only with such vision, known and acknowledged by all stakeholders, can a cooperative effort be had that will make this project a success.

The experts brought together by National Grid will benefit the EPA and the community, as their experience-based recommendations will facilitate creation of the needed vision and plan. They stand ready to assist in the significant efforts that lie ahead, and if afforded the needed flexibility, will help fill in data gaps and help design a remedy that will be the most successful and, therefore, only need to be performed once.

The Gowanus Canal system and the performance of the proposed remedy under future conditions remain largely unexplored. Indeed, as made clear in the accompanying comments by Michael Palermo, P.E., Ph.D. and Alex Brunton, Ph.D. of Baird & Associates, the proposed dredge and cap remedy not only requires evaluation of a host of issues that are not considered in the PRAP, but modeling results raise questions about whether the remedy, as proposed, can meet its objectives. For example, once the flushing tunnel is operational, the increased flow will adversely affect the proposed sand benthic layer and possibly wash it downstream. Continued commercial navigation similar to what is conducted now could also compromise any cap due to propeller induced scouring, which alone could negate the benefits intended from all capping. There may also be periods of hypoxia in remediation target area (RTA) 2 due to reduction in flow caused by an increased depth resulting from dredging.

On the other hand, and contrary to the EPA's PRAP assumptions, testing by Danny Reible, Ph.D. has found no evidence that non-aqueous phase liquid (NAPL) will be mobilized by the weight of a sediment cap; Drs. Palermo and Reible advise that soft sediment can be capped successfully; and early field work indicates that In-Situ Stabilization (ISS) may very well be suitable as well.

The following is a summary of key observations that have been raised by experts retained by National Grid, which are attached as Appendices B through G:

- **Professor Danny Reible, Ph.D.** is a nationally recognized expert on capping technologies, including geotechnical issues and constraints for capping, cap design, evaluating recontamination, cap performance, and long term protectiveness. Dr. Reible's observations are provided as Appendix B and include:
    - Capping of soft sediments should not be ruled out as a potential technique for isolating deeper contaminants. Soft sediment capping has been conducted successfully at other contaminated sites.
    - Initial testing has not observed NAPL mobility in the soft sediments, which may simplify capping and may allow capped soft sediments to be left in place to stabilize NAPL in deeper native sediments (Appendix K).
    - Cap requirements will vary along the length of the Canal depending on sediment conditions, presence of NAPL, groundwater expression, ebullition and navigational requirements. The cap should be designed for specific conditions to optimize placement, functionality, and long term operational costs.
- **Michael Palermo, Ph.D., P.E.** was a Director of the United States Army Corps of Engineers Center for Contaminated Sediments and is an expert in evaluating capping and dredging, including among other things, feasibility, planning, overall coordination and sequencing, volume and production rates, costs, and effectiveness. Dr. Palermo's observations are provided as Appendix C and include:
    - Dredging to the native sand layer may needlessly compromise the existing bulkheads along many parts of the Canal, resulting in potential failure of the cap.
    - Capping soft sediments in select areas of the Canal should not be discounted, but rather should be evaluated during the design process.
    - Commercial navigation in the upper portions of the Canal (RTA 1 and RTA 2) will be interrupted during construction of the remedy. After construction, commercial navigation is likely to cause severe stress on any cap. Given the limited water-dependent industry currently in the upper reaches and the

significant interruption of commerce that will occur during construction of the remedy, serious consideration should be given to the extent of commercial tug and barge navigation permanently allowed in these reaches.

  - Significant additional studies will be required to fully define and design the remedy. The full implications of the site conditions, the need for some of the proposed remedy components, the potential negative impacts of some proposed actions, the effectiveness of some components, and the practicability of implementing some of the components must be fully evaluated.

  - Flexibility, within the bounds of meeting remediation goals, is essential for addressing complex sites like the Gowanus Canal.

- **Baird & Associates** are experts in marine engineering, hydrodynamic and sediment transport modeling and water quality modeling and navigation studies. Baird has developed a calibrated model of the Gowanus Canal, and performed a vessel impacts study, numerical modeling, modeling of CSO flow and sediment inputs, historical analysis of Canal sediment and contaminant dynamics, and modeling of water quality and contaminant transport (Appendix D). Dr. Brunton, who performed the modeling, offers the following conclusions:

  - Sediments entering the Canal through the existing CSO discharges are deposited near the CSO outfalls and comprise the existing soft sediment layer. This condition will continue even after the flushing tunnel is reactivated. Sand deposition near the outfalls will continue (depending upon their location in the Canal) under flushing tunnel flow. Fine sediment (silts and clays) will be redistributed through the Canal and end up in deeper areas of the Canal.

  - The elevations selected for the final cap remedy will determine where ongoing solids in the CSO discharges will collect in the Canal. Deep dredging in the upper reaches of the Canal will result in low water velocities and settling of solids onto the bottom of the Canal, as well as lower dissolved oxygen (DO) levels in the water column. The resulting Canal will at times fail to meet CWA requirements, even with the flushing tunnel active, if the design does not account for these considerations.

  - Bed sheer stresses associated with current Canal tug and barge traffic will destroy the benthic zone in areas with shallow (less than 30 feet deep) water. Baird & Associates believes commercial navigation creates formidable challenges to maintaining cap integrity and ecological recovery in RTAs 1, 2, and 3a.

  - Continued accumulation of CSO sediments above the cap is expected to occur under the proposed remedy conditions. This accumulation may compromise ecological recovery.

  - Higher flow velocities are likely to result, at least locally, during the implementation of some components of the remedy. These include use of sheet piling, or silt fences which may restrict flow in the channel, operation of barges and tugs, and normal navigation activities. Any of these operations may result in velocities that scour contaminated sediment from the bottom of the Canal and redistribute it downstream. The remedial design will need to account for potentially damaging flow velocities.

- **Exponent** has performed an analysis of sediment chemistry data and an evaluation of sources, risk, and dredging risks and effects (Appendix E). Paul Boehm, Ph.D. and Tarek Saba, Ph.D., who performed the analysis, offer the following conclusions:

    - Shallow accumulated sediments and associated contaminants in the Canal likely originated from the CSOs and other upland sources of sedimentation. The sources of sediments are ongoing and will continue unless the CSOs, storm sewers and other upland sources are addressed.

    - Following review and analysis of work performed by GEI, Exponent confirmed that accumulated sediments have elevated levels of a variety of pathogens and pharmaceuticals and personal care products (PPCPs) that are similar to those found in CSO discharges. These compounds will continue to accumulate and cause toxicity in the shallow sediments until CSO and other upland discharges are addressed.

    - PAH distribution in the sediments occurs at different depths. The lower depths are largely attributable to, among other things, the MGPs. PAH distribution in the accumulated shallower sediments point to a range of potential sources including petroleum spills, road runoff, and other materials which likely enter the Canal through the CSOs, storm sewers, and direct groundwater discharges. These sources will need to be addressed in addition to the MGPs to lower future PAH levels in post remediation surface sediments.

    - In RTA 3b, elevated contaminants are present in limited areas (“hot spots”) and should be addressed using a targeted approach as opposed to the proposed remedy of dredging the entirety of RTA 3b.

- **Mutch Associates, LLC**. and GEI Consultants, Inc. (GEI) have developed a groundwater model for the Gowanus watershed. The model suggests the following conclusions:

    - Groundwater flows into the Canal, primarily in its upper reaches (RTA 1 and RTA 2). Groundwater flow rates in RTA 3b are significantly lower.

    - Introduction of impermeable barriers along the sides of the Canal will deflect groundwater flow toward New York Harbor. The groundwater table will tend to mound behind impermeable barriers, potentially resulting in localized flooding.

- **Marc Wilkenfeld, M.D.,** a Board Certified Occupational Physician and GEI have analyzed Canal-related pathogen and public health issues. Dr. Wilkenfeld’s curriculum vitae is attached as Appendix F. Dr. Wilkenfeld and GEI have made the following observations:

- The CSOs are releasing a broad range of pathogens and PPCPs. The potential for these compounds, which are not addressed in the FS for the Gowanus Canal, to pose a health threat to those who come into contact with Canal waters should be carefully evaluated by the appropriate public health and environmental regulatory authorities.

- **Woodard & Curran**, an environmental engineering firm with sewer design expertise, has evaluated CSO data and cap recontamination by ongoing sources. Janet Robinson and Vincent Spada, P.E., have evaluated the proposed remedy and the presumed upgrades to the CSOs (Appendix G) and offer the following observations:

  - EPA's observation that the CSOs have been and will continue to be a significant source of sediments and contaminants to the Canal is well founded. The CSOs are widely documented to contribute the levels and types of contaminants seen in the accumulated Canal sediments.

  - The City of New York has indicated that its Waterbody / Watershed Facility Plan (WWFP) is essentially going to be the City's long term control plan (LTCP), which is due in June 2015. The WWFP, as written with the addition of some planned sewer separation and green infrastructure, will not offer the same level of CSO control that is recommended in the PRAP.

  - The PRAP proposed CSO controls of an eight million gallon storage tank and a four million gallon storage tank is an accepted and proven CSO control technology that will provide CSO control for low intensity storm events.

  - EPA suggests that capturing the first 40 percent of the total discharge volume of each storm will likely capture the storms first flush, which is needed to ensure protectiveness of the proposed remedy. There is not sufficient characterization of the Gowanus CSO discharges during storm events to support this conclusion.

  - The EPA's proposed remedy includes storage tanks to capture about 65 percent of the total annual CSO discharge volume to the Canal. To better ensure that the protectiveness of the remedy is maintained, EPA should consider using the CSO presumptive level of 85 percent capture of annual CSO discharge volume as a criterion, the standard set forth in EPA's CSO Policy.

  - Another approach to reducing CSO loading may be to establish a total maximum daily load (TMDL) for total suspended solids (TSS) in the CSO discharge. The CWA requires establishment of TMDLs for water bodies that do not meet water quality standards after application of technology-based effluent limits, which will likely be the case in the Canal post-remedy.

- The proposed CSO control improvements discussed in the PRAP (including installation of tanks to capture first flush) are based on planning level design information (less than two percent complete) and numerous assumptions, including CSO discharge volumes and volume of first flush. Flow monitoring and hydraulic modeling and post construction monitoring must be conducted for the Gowanus system and may result in the requirement of additional CSO controls beyond the proposed storage tanks. Planning and design of the CSO controls must be flexible and include contingencies to expand CSO controls to account for this outcome.

GEI, an environmental engineering firm with remediation expertise, has performed the following studies:

- ISS may be a feasible technology for stabilization of Canal sediments, even though this technology was ruled out as a feasible technology during the FS. More recent bench scale ISS treatability studies conducted by GEI and Geo-Con (Appendix H) indicate that a number of additives and mixtures of soft and native sediments achieved typical performance standards for strength and permeability.

- GEI has performed repeated, seasonal sampling of surface sediments to evaluate toxicity, chemistry, and the benthic community condition throughout the Canal (GEI 2011a, 2012a, 2012b). Results of this sampling provide the following conclusions:

  - Toxicity and poor benthic community conditions are the result of a wide variety of contaminants and non-contaminant stressors. Chemical contaminants contributing to toxicity include PAHs, polychlorinated biphenyls (PCBs), metals, pathogens, and PPCPs. Non-chemical stressors that strongly impair the benthic community include low DO and poor sediment substrate conditions that result from the organic enrichment caused by CSO discharges. Therefore, control of ongoing sources of non-contaminant stressors (e.g., from CSOs and other urban runoff by way of storm water outfalls) will be needed to ensure that a sediment remedy based on reducing toxicity is successful and that full ecological recovery is achieved.

  - After the installation of the cap, exposure to NAPL associated with the former MGPs and other upland sources will be effectively eliminated, and will no longer contribute to toxicity in the Canal. Toxicity will be dominated by a number of other factors, including PAHs, PCBs, and metals derived from the CSOs, storm drains, and road runoff. Performance standards too narrowly focused on existing conditions, specifically on PAH associated with NAPL, may not provide sufficient protection to ensure ecological recovery. While remedy performance initially should be judged based on the physical integrity of the cap, longer term performance should be established following an evaluation of causes and sources of any toxicity that might remain in sediments deposited after completion of the remedy.

- The benthic community in RTA 3b is significantly healthier, and appears to be less impacted by chemical contamination, low DO stress, and poor substrate condition in comparison to the rest of the Canal. In RTA 3b, greater benthic species diversity and density were observed consistently, even to the point of including commercially important species such as blue mussels (*Mytilus edulus*). Combined with only limited hot spot areas in RTA 3b, this argues strongly for a different and less disruptive remedy in this reach. The relative lack of impacts in RTA 3b is wholly inconsistent with a remedy in which nearly 50 percent of all the sediment slated for dredging in the PRAP is found in this area.

III. COMMENTS ON THE GOWANUS CANAL PROPOSED REMEDIAL ACTION PLAN

A. Optimize the Remedy with Vision, Flexibility, and Adaptive Management

National Grid is not just a service provider to the Gowanus Canal communities, but is an active community member and supporter that has embraced the Superfund process. National Grid is well known among community officials, representatives, and groups and participates regularly with the public at Gowanus Superfund meetings. National Grid has offered to fund the Community Advisory Group Facilitator, offered technical support to citizen groups, and has supported EPA jobs programs, among many other actions. We have listened to the community and submit that the Canal remediation is not just about technical processes, studies, and data. Make no mistake, those are critical and will be discussed at length herein, but community concerns must also be considered.

This is all the more important given that implementation of the remedy, no matter what the form, is likely to have significant ramifications such as noise, odor, inconvenience, and disruption to local businesses. With its lack of detail, the PRAP inadvertently presents an overly optimistic picture and schedule. Contrary to some of the language in the PRAP, the large dredging, sheet piling, and removal / treatment components will certainly cause disruption and the enormity of the tasks that lay ahead will require careful collaborative and time consuming logistical planning.

The foregoing issues require realistic thought, serious discussion, and real understanding. Surely, everyone wants a clean Canal, while at the same time minimizing disruption and leaving neighborhoods intact, but the Gowanus remediation is so immense and complex that the EPA, no matter how well intentioned, cannot simply order it to happen. Rather, the EPA must first come to a vision of the future of the Canal. Once that vision is reached, an adaptive management approach that encourages identification and study of innovative solutions, allows for modification of such solutions to fit different areas of the Canal, and facilitates resolution of the technical contradictions in the proposed remedy (i.e., continued commercial navigation versus ecological restoration), must follow.

While National Grid is not supporting any specific future use for the Canal, there are various and competing interests that will need to be resolved in the final design of the remedy.

For example: Will the Canal be remediated for recreation or dredged for commercial navigation? How important is benthic recovery, especially given that the Canal may very well never be swimmable and fishable? What is to be done with the flushing tunnel, the CSOs, and other discharge pipes? Will the CSOs and pipes truly be controlled or is that simply unrealistic given technical limitations, costs, and politics? If they are not controlled fully, real remediation of the Canal will not be achieved. Should this scenario come to pass, background levels of contaminant concentrations that are anticipated post-remedy should be established. The community must then recognize that years of disruption will achieve only a limited improvement in water quality.

National Grid believes strongly that the EPA must supplement technical considerations in the ROD with a mixed dose of reality and "vision" of the future of the Canal. The community must not only know what it will face during the years of construction, but it must understand that due to technical realities, it is simply not possible for the remedy to accomplish all things for all parties. Stakeholders will have to compromise during the design of the remedy. The remedy can neither be dictated as it is in the PRAP, nor should remedial technologies be applied rigidly throughout the Canal length; rather, the approaches need to be tailored to specific reaches. National Grid is committed to a flexible approach and will work in good faith with all stakeholders to tailor the design so that future use of the Canal can be optimized along its entire length.

Analysis of the complex Canal hydrodynamics in conjunction with external factors like the flushing tunnel, sediment disruption by vessels and barges, and CSO flows highlights significant problems with the remedy as presently set forth in the PRAP. For example, in order for the flushing tunnel to move sediment (and contamination) under design conditions, there must be a gradually sloped, relatively shallow bed elevation throughout the Canal. Dredging RTA 2, as called for in the PRAP, will thus hamper the performance of the flushing tunnel and lead to dramatic re-sedimentation in the middle of the Canal (Appendix D) that will require routine maintenance dredging. Sedimentation will also bring additional organic matter which can increase oxygen demand as bacteria and other organisms feed on it, thus starving the water and sediments within the Canal of DO.

At first glance, it would seem that re-thinking the dredge depth in RTA 2 is in order to help achieve the intended workings of the flushing tunnel. That, however, could hamper commercial navigation. To the extent commercial navigation is desired and must be retained, ecological restoration (needed to meet the RAO of reducing risk to the benthic community) will be impeded. Commercial navigation could also frustrate several of the expressed desires of certain stakeholders within the community, including soft siding along the Canal, wetlands mitigation, public access, recreational use, and shallow benches or sponge parks. Continued commercial navigation affects another critical component of the remedy – the cap. Propeller scour will require that much larger stone be used to create the armor layer. Even then, vessel traffic would still destroy the benthic layer.

In RTA 1, where there is no commercial navigation, the flushing tunnel will do exactly what it is intended to do – refresh water quality in an otherwise stagnant water body. This is achieved by flushing sediments (in particular organic sediments) down the Canal and into

Gowanus Bay. This, however, will also push the critical sand benthic layer down the Canal, thus defeating the ecological goal of the remedy.[3]

Flexibility in the ROD that allows the use of a range of demonstrated techniques is the lynchpin that will optimize the remedy throughout the Canal.[4] The geometry of the Canal should be designed according to modeling that suggests shallower depths at the head of the Canal with gradual deepening along the length optimize flow, maximize DO levels, and move sediments out to the Bay. Soft sediment capping in RTA 1 and RTA 2 is another optimization technique because less dredging means less need for bulkhead replacement and sheet piling, less disruption to the community, and a shorter overall implementation schedule.

Capping may also be optimized to provide a substrate for the benthic community, while still containing deeper contaminants. Solidified material, reactive layers, and various armoring layers must all be explored, and even then, they may be appropriate in different amounts and configurations depending upon location within the Canal. Wetlands plantings (requiring shallower channel depths) and public access points could be located in the turning basins where flow velocities will be lower. Soft siding of the Canal would have to be balanced with the need to maintain proper hydraulics.

Within this scheme of optimization, National Grid's experts suggest that deep draft commercial navigation may best be limited to the lower portions of the Canal (RTA 3b). This is the area where most shipping currently occurs and is also the area maintained by the Army Corps as a federal shipping channel. Navigation above RTA 3b could be limited to recreational and shallow draft, low horsepower or mechanically towed vessels that will cause minimal disturbance to the benthic sand cap.

---

[3]Further complicating matters is the lack of available information on the schedule, sequencing, and future operational conditions associated with the flushing tunnel upgrades. The design of the cap and dredge remedy must take the flushing tunnel operation into account to allow both the CWA and CERCLA objectives to be achieved. In view of the fact that the City of New York has agreed to provide its hydraulic model for CSOs on Newtown Creek, similar information should certainly be made available for use during the Gowanus remedy design, including identification and design of both the interim and long term CSO controls described in the PRAP.

[4]The cost estimates contained in the PRAP may very well be underestimated. For example, the FS speaks of an unrealistic seven day per week, 12-hour per day work schedule and too small sheet piles. On the other hand, the FS leaves open the volume of wastes requiring disposal as hazardous waste. This could be a high potential cost differential. Even the cost for long term operation and maintenance of the remedy cited in the FS is an extremely low two million dollars over 30 years (present value). Given the data gaps and implementability issues which have not yet been addressed, it is difficult, if not impossible, to compare the costs of remedial options in the manner required by the NCP.

B. CONTROL ALL SOURCES

The EPA Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites, Principle One is "control sources early." The Principles go on to instruct, "[a]s early in the process as possible, site managers should try to identify all direct and indirect continuing sources of significant contamination to the sediments under investigation."

The historical industrial nature of the Gowanus area and its long and complex history of industrial uses are well known. Those uses have impacted the Canal in a variety of ways, leaving a number of contaminant sources and potential migration pathways that must be addressed. National Grid's MGPs formerly located along the Gowanus Canal are identified in the PRAP as a source and National Grid accepts responsibility for this historical contamination by its predecessor companies. National Grid is committing a substantial investment of time, energy, and financial resources to ensure that all three MGPs are being properly addressed to control potential sources to the Canal. National Grid simply seeks to have other sources treated in the same way.

The key sources of contamination are identified in the PRAP, and each one must be defined and controlled early:

- MGPs and other upland industrial sources
- CSO discharges
- Other pipes discharging to the Canal.

The ultimate remedy for the Canal should address both historical and ongoing sources. Identification and investigation of sources, and the design and installation of a remedy are complex engineering and regulatory challenges. The ROD should establish a sequence of the Canal remedy that controls all ongoing sources first, and then moves on to the active sediment remedy.[5]

(1) MGPs and Other Upland Industrial Sources

National Grid is already working with the New York State Department of Environmental Conservation (DEC) and the EPA to remediate the former MGPs. National Grid recognizes the importance of eliminating past sources of contamination to the Canal first and will continue to do its part. A remedy for the former Citizens Gas Works MGP (a/k/a Carroll Gardens/Public Place) that includes soil removal, a barrier wall and NAPL collection system designed to prevent future potential migration of coal tar has been approved by the DEC. National Grid is moving forward with this upland remedy and is hopeful that potential sources from Citizens will be controlled prior to initiation of remedial construction in RTA 2 on the Gowanus Canal.

[5]Proper sequencing of source control and remedial implementation will also facilitate both short-term and long-term effectiveness of the remedy, primary factors in determining consistency with the NCP. *See* 40 C.F.R. § 300.430(f)(1)(i)(B).

Similarly, at the former Fulton MGP site, National Grid is working on the FS with the DEC. Simultaneously, National Grid is working with the DEC to prioritize as an Interim Remedial Measure a barrier wall and NAPL collection system to effectively prevent future potential migration of NAPL from the site. National Grid anticipates that the barrier system will be completed in conjunction with the schedule proposed by the EPA, so that potential sources from Fulton will be controlled prior to initiation of remedial construction on RTA 1 on the Gowanus Canal.

Finally, at the former Metropolitan MGP site, National Grid is completing the RI report and will be starting on the FS for the site, which will include a source control barrier/collection system. Again, National Grid expects that the Metropolitan barrier system will be constructed in keeping with EPA's schedule so that potential sources from Metropolitan will be controlled prior to initiation of remedial construction on RTA 2 on the Gowanus Canal.

The MGPs, however, are by no means the only potential sources of uplands contamination, including coal tar. Various environmental databases and historical records (EDR 2009) have identified thousands of other contaminated or potentially contaminated sites within the Canal sewer shed / water shed that may cause the remedy to fail in achieving sustainable water quality improvement due to direct and / or indirect groundwater discharge to sewers and then to the Canal by the CSOs. Historical operations along the Canal include approximately 80 parcels directly adjacent to the Canal that may be responsible for groundwater impacts (including the former MGP sites along the Canal).

The RI relied heavily on data collected by National Grid from its upland MGP sites to define potential upland sources to the Canal. Additional work performed by the EPA to identify and quantify additional upland sources led to the conclusion that "[w]ith the exception of PCBs, all classes of contaminants that were sampled (for VOCs, SVOCs, PCBs, pesticides and metals) were detected in samples from both the shallow and intermediate groundwater throughout the length of the [C]anal." The PRAP fails to address the identification and interception/remediation of any of the sources (with the exception of the MGPs), except to say that upland sites will be addressed by DEC. All of these sources of contamination must also be identified and controlled first and all parties must cooperate in the same fashion that National Grid is. Failure to address all upland sources will compromise the success of the remedy.

(2) CSOs

(i) Introduction

The CSOs are one of the most, if not the most, vexing problems of the Gowanus project. While the most significant ongoing and future source of sediments and contaminants to the Canal, the CSOs are also the mainstay of the Gowanus water shed / sewer shed system. Having been put in place over a century ago, the CSOs cannot just be replaced, shut down or separated. On the other hand, if the CSOs continue to operate, the Gowanus Canal will continue to receive more than 350 million gallons of raw sewage from CSO discharges every year (New York City Department of Environmental Protection (DEP) 2008) and the soft sediments and their associated contaminants that are attributable to storm water and CSO discharges will continue to accumulate.[6] Under such circumstances, the question is not whether the CSOs should be addressed, but rather, to what extent the CSOs can be addressed given the urban and technical realities.

(ii) Human Health and Success of the Remedy

There is evidence that the most significant source of new contaminants to the soft sediments is in fact the CSOs. Sampling of water discharged from the CSOs during a storm event in September 2012 contained suspended and dissolved solids as well as the range of contamination and foreign constituents found throughout the Canal sediments, including PAHs, PCBs, metals, pathogens, and PPCPs (Appendix J).7 This mix of contaminants threatens the success of any remedy and is set forth in the following table:

---

[6]Geochronology age-dating of the sediments using ^{137}Cesium and ^{210}Lead (performed by Battelle on behalf of NewFields Environmental Forensics Practice) revealed that the top four feet of soft sediments, with accumulated high organic carbon, post-date the 1950s when the MGPs were shut down. The deeper (native) sediments, on the other hand, are much older (NewFields 2007) and reflect contaminants from MGPs and other historical sources. Similarly, comparison of bathymetry data collected from 2010 through 2012 confirm that soft sediment continues to collect in the Canal (GEI 2011a, 2012a, 2012b), while modeling of sediment fate and transport demonstrates that sediments discharged from the CSOs are deposited along the bed of the Canal (Appendix D). Lastly, sampling of the top four feet of the soft sediment layer in the vicinity of the CSOs confirms the presence of CSO derived chemicals throughout the soft sediment. These chemicals include caffeine, hormones, pathogens, and a variety of PPCPs associated with CSO discharges (Appendix I).

[7]Discharge of sedimentation from the CSOs – as opposed to transportation into the Canal from New York Harbor via tidal action – is supported by multiple lines of evidence. The notion that the Harbor is the source of sedimentation is counter-intuitive based on the presence of CSO sediment mounds above low tide elevation. The DEC Consent Order (signed by New York City) that mandates dredging of these mounds to mitigate CSO “nuisance odors” (Gowanus Canal Waterbody / Watershed Facility Plan Report (DEP 2008). If tidal action was truly moving sediments and water up the entire length of the Canal, tidal flushing would be much greater than has been documented. Furthermore, the flushing tunnel, whose very purpose is to flush stagnant sewage from the Canal, would not be needed. Surficial sediment data demonstrate the presence of pathogens (e.g. fecal coliform) and PPCP compounds in the sediments that are only associated with CSO effluent. Indeed, triclosan and estradiol have both been found in shallow sediments in the Canal (GEI 2011a, 2012a, 2012b). Finally, bathymetric surveys illustrate that discharges from the CSO outfalls cause scour immediately in front of the pipes, as well as deposition of sediments just outside of these localized scour zones.

Pathogens	**Endocrine Disrupting Compounds (EDCs) and PPCPs (continued)**	**Metals**
C. perfringens	Methadone	Cobalt
Coliphage, Male Specific	Naproxen	Copper
Coliphage, Somatic	Nonylphenol	Iron
E.Coli	Nonylphenol Diethoxylate	Lead
Enterococci	Nonylphenol Monoethoxylate	Magnesium
Fecal Coliform	Oxybenzone	Manganese
Giardia		Mercury
EDCs and PPCPs	Phenytoin (5,5-Diphenylhydantion/Dilantin)	Nickel
Acetaminophen	Progesterone	Potassium
alpha-Estradiol	Salicylic Acid	Selenium
Androstenedione	Sulfamethoxazole	Silver
Bisphenol A	Testosterone	Sodium
Caffeine	Trimethoprim	Vanadium
Carbamazepine	**Pesticides**	Zinc
Diazepam	gamma-Chlordane	**Other**
Diclofenac	**Herbicides**	VOCs, including BTEX
Estradiol	2,2-Dichloropropionic acid	SVOCs, including PAHs
Estriol	**Metals**	Total Petroleum Hydrocarbons
Estrone	Aluminum	PCBs
Fluoxetine	Antimony	Free Cyanide
Gemfibrozil	Arsenic	Ammonia
Hydrocodone	Barium	Dissolved Organic Carbon

Pathogens	Endocrine Disrupting Compounds (EDCs) and PPCPs (continued)	Metals
Ibuprofen	Cadmium	Total Dissolved Solids
Iopromide	Calcium	Total Suspended Solids
Meprobamate	Chromium	Total Organic Carbon

Needless to say, the continuing discharges from the CSOs pose an ongoing risk to both human health and the environment and must therefore be a primary target of any remedy.[8] The EPA human health risk assessment (EPA, 2011) concluded that there is a significant risk to human health from incidental ingestion of and dermal exposure to carcinogenic PAHs and PCBs in Canal surface sediment. The presence of these contaminants in Canal surface sediment is primarily attributable to storm water and continuing CSO discharges.

National Grid's human health risk assessment also concluded that there is significant risk to human health from exposure to pathogens and PPCPs (GEI; 2011a, 2012a, 2012b), which EPA did not evaluate. Pathogen and PPCP contamination has been detected throughout the Canal surface sediment. Dr. Wilkenfeld has reviewed the status of the Canal and advises that currently there is a risk of disease including gastroenteritis and other infectious disease from exposure to the sewage in the Canal. Other documented health effects from exposure to sewage include irritation (burning eyes, sore throat, cough); an odor response (headache, nausea, vomiting); and toxic effects (skin disorders, fatigue) (Bridges, 2003; Thorn and Kerekes, 2001). Epidemiological studies also indicate an increased risk of cancer and liver disease from exposure to sewage (Thorn and Kerekes, 2001; Wild et al. 2005; Pizzo et al. 2011).

Dr. Wilkenfeld also notes that pathogens and PPCPs, including EDCs such as estrone and beta-estradiol -- which were also detected in Canal surface water and surface sediment -- contribute to significant human health risk. Exposure to these EDCs in Canal surface water and surface sediment can result in increased cancer and non-cancer risks to human health due to their estrogenic mode of action and resulting increased toxicity.

The PRAP identifies the need for CSO controls and assumes that reduction of solids discharge in the range of only 58 to 74 percent will achieve the preliminary remediation goals (PRGs). Given the ongoing and expected future recreation activity in the Canal, and the recent Hurricane Sandy experience where CSO contaminated Canal water actually invaded homes, clearly more control of CSO contaminants are needed if this issue is to truly be addressed.

In addition to protecting health, the CSOs must be controlled lest they defeat any remedy. Analytical data collected near the outfalls (Appendix I) and sediment transport modeling (Appendix D) support the conclusion that at least the upper four feet of accumulated sediment is

---

[8]In fact, the NCP identifies the overall protection of human health and the environment as a threshold criterion in selecting a remedy. *See* 40 C.F.R. § 300.430(f)(1)(i)(A).

comprised of highly organic soft sediments and are not derived from the former MGPs. In other words, the age of the shallow sediments is very recent, substantially post-dating MGP operations. Although the PRAP acknowledges the proposed Gowanus system upgrades by the City of New York will achieve some level of CSO source reduction, it is far short of what is necessary to meet RAOs. The PRAP goes on to state that, "[t]he cumulative impact of these projected flow reductions and flushing improvements on sediment transport and deposition cannot currently be predicted with a high degree of confidence." Still other City proposed improvements are even less certain because they rely on the implementation of LTCP improvements that have not even been conceived.

The PRAP proposed CSO storage tank improvements will yield some improvements to water quality. However, even under the best case scenario – assuming all of the improvements are actually implemented and achieve the desired results – the remaining 26 percent to 42 percent of the load of contaminants from the CSOs as estimated by EPA will continue to enter the Canal.[9] Furthermore, hydrodynamic and transport modeling indicates that this sediment will settle out and re-contaminate the surface of the Canal bed, even with the flushing tunnel operational.

The storage tanks may not have enough storage volume to reduce CSO solids and contaminants to levels necessary to be protective of the remedy. Contrary to the conclusions of Stein (2006), which are relied upon in the FS to calculate tank size, TSS data collected during a CSO discharge event, indicates that TSS is not concentrated during the first flush (Appendix G). Indeed, as Woodard & Curran explain, the potential exists for a continued discharge of contaminants to the Canal during rain events that produce a flow volume in excess of the capacity of both the tanks and the conveyance system (Appendix G).[10] While these data are not conclusive, they make clear that potential frequency and volume of storm water that may be discharged needs to be studied further, especially in light of climate change predictions that storm events will be more frequent and severe.

(iii) If CSO Control is Infeasible, the RAOs Must be Modified and the Canal Conditions Must Become the Background

Failure to stop discharges from the CSOs will have significant ramifications for everything from the most fundamental success / failure of the remedy to accomplishing the RAOs of reducing human health and ecological risks. Current plans by the City of New York

---

[9] Dr. Brunton of Baird notes that the PRAP appears to underestimate the full extent of sediment discharge from the CSOs. A mass balance for the upper Canal suggests that the one to two inches per year of sedimentation noted in the PRAP could be understated by as much as five to ten times.

[10] Woodard & Curran explained, "The scientific literature suggests that the potential for continued discharge of PAHs and metals to the Canal during storm events that produce a flow volume in excess of the capacity of both the tanks and the sewer system, still exists." This is so because "the first flush tends to include a larger proportion of coarse particulate matter. Since PAH concentrations tend to be higher on finer particulates, PAHs in the CSO flow may continue to be discharged to the Canal later in a storm event, after the CSO tanks are full." (Appendix G).

will not stop contamination from the CSOs. To the extent the City cannot reach full CSO control because it is technically infeasible or prohibitively costly or both, then the EPA, and the City should strive to implement the maximum achievable CSO reductions before the remedy is implemented. The extent of CSO reductions should then be carefully evaluated. Only after understanding the continued loadings into the Canal, can a cap be implemented with any chance of success.

Under current circumstances, the initial step of establishing performance standards in the PRAP is premature since the major ongoing source of contamination will not be controlled. To the extent infeasible or cost prohibitive to fully control CSO discharges any ongoing contribution should be considered background for the Canal and the remedy design should factor in those ongoing sources. Once the background loading to the Canal is understood, future uses of the Canal should be tailored to be protective of human health, as determined appropriate by the relevant public health agencies. Depending on the extent and success of CSO controls, future use may still include some public access restrictions.

Finally, and regardless of the remedy that is ultimately decided upon for the CSOs, the EPA should create and implement a program to measure baseline pathogen levels prior to initiation of any remedy, and this program must be ongoing since pathogen levels do not remain static. Samples must be continuously collected over the course of months and testing must follow remediation to confirm a reduction in pathogens. Parameters for pathogen levels protective of all populations, including pathogen RAOs and risk based PRGs that consider water quality criteria for recreation, must all be established and even then, additional studies may be required as action is taken in the Canal.

(3) Non-CSO Pipes

Other sources in addition to the CSOs, such as roadway runoff, petroleum facilities, and the hundreds of non-CSO pipes, likely account for significant PAH and other loadings to the Canal surface sediment. National Grid understands the importance of controlling potential sources and has implemented serious efforts to clean up legacy MGP sites. However, there are other non-CSO sources that require examination. Accidental releases of contaminants around the Canal occur frequently and impact the Canal through sewers, permitted, and non-permitted discharge points. The DEC has extensive documentation of such contaminant releases to the Canal. Some of these accidental spills included diesel fuels and waste oils with sheens visible on Canal surface water. Petroleum products, oils containing PCBs, and dielectric fluids were also found to be impacting manholes around the Canal at numerous locations. Many other spills were reported in the DEC files to be of unknown sources, some of which were reported to be an "ongoing problem" directly impacting the Canal. This is in addition to the hundreds of thousands of gallons of raw sewage that impacted the Canal over the past 20 years from pump and gate failures, as documented by DEC (Appendix E).

The RI documented almost 250 pipes that are discharging to the Canal. The RI did not evaluate wet weather discharges from any of these pipes. As a result, the chemical loading from these unpermitted discharges is unknown. Even though wet weather sampling of these discharges was not undertaken, the RI did evaluate dry-weather discharges from 12 pipes and identified 18 VOCs, 21 SVOCs, and 18 metals, and cyanide in the dry weather unpermitted discharges. The RI report concluded that flow rates of less than one liter per minute were inconsequential and hence were not sampled under dry flow conditions. However, one liter per minute is the equivalent of 0.264 gallons per minute or 380 gallons per day or 138,700 gallons per year. Furthermore, that is for only a single pipe. Thus, loading from the over 200 unpermitted pipes could be a significant factor in evaluation of a site remedy. At the very least, good science requires that it be explored.

Approximately 14 of the pipes have state pollutant discharge elimination system permits. These include both industrial discharges and storm sewer discharges. All of these sources must be identified, quantified, and controlled before implementing the sediment remedy. Seventy-four million gallons of storm water and roadway runoff are discharged to the Canal each year through storm sewers and overland runoff (DEP 2008). The PRAP characterizes these pipes as "insignificant" and the cost to address them as "minimal" with little, if any, support and without any regard to how the pipes will be addressed by DEC or how making required adjustments will affect permit holders. Exponent has noted that the EPA's investigations of unpermitted pipes is more of a "snapshot" and does not provide the entire story because they were not conducted concurrent with releases of contaminants from upland sources. "Surface sediments adjacent to these pipe outfalls are far more representative of cumulative and time-integrated inputs of contaminants from the upland sources." (Appendix E).

(4) Conclusion: Control All Sources First

Since data from the Canal sediments makes clear that CSO and other outfall inputs of contaminants are continuing, the EPA, consistent with the CSTAG recommendations, must make controlling all contamination sources around the Canal a priority in the ROD. Otherwise, any dredging will be a wasteful use of resources and the Canal sediment will be recontaminated.[11] Only then, when all sources of contamination to the Canal are addressed to the degree practicable using sound science and engineering, proven technologies, a background level of ongoing

---

[11] In 2007, the Sediment Management Work Group presented to the Battelle Conference the results of, "[a] survey of recently completed contaminated sediment remedial actions [which] identified a total of twenty sites in which sediment had become recontaminated" (Nadeau and Skaggs). All had become recontaminated largely because of no assessment or incomplete assessment prior to remedy selection of the risk of recontamination by continuing sources. CSOs and storm sewer outfalls were listed among the "dominant" sources that may lead to the recontamination. At one site, the Anacostia River, sediments covered the cap near to and downstream of an active CSO. Monitoring results after only 18 months indicated that the cap was containing the targeted contaminated sediments, but new sediments containing elevated PAHs from urban sources were accumulating on top of the cap. Sites like Anacostia, and by implication the Gowanus Canal, are important because they make clear that when sediment response actions are planned in areas receiving urban discharges, steps to ensure source control prior to implementing sediment cleanups must be taken. To avoid recontamination, careful study is necessary and source control must be of an equal or greater priority than the sediment response action itself.

contribution is established, and a control plan with specific steps and schedules is in place – can the parties begin their work to implement a successful and sustainable remedy.

C. The Canal Must be Thoroughly Characterized Before any Effective Remedy can be Designed

The PRAP is largely focused on a one-size-fits all remedy of dredge and cap across the entire Canal. This approach is based on assumptions and does not take into account the myriad of variation in conditions along and within the Canal. Successful design and completion of the work requires that all of the variations be considered in the remedy selection process.

(1) Sediment Variation

Sampling results for sediments along the Canal show variation in characteristics, including contaminant levels, chemical properties, geotechnical properties, and mobility (Appendix K). Design of the remedy must accommodate the variations in sediment characteristics to protect existing bulkheads and provide future stability for the cap.

(2) Operational Variation

The PRAP views the Canal as static and thus does not fully consider how the Canal will operate in the future. As a result, the remedy is focused on containment of historical releases. Although important, controlling such releases is only one part of a very complex system. The ROD must consider the impacts and need to control all significant releases, future operations, and the full range of complicating variables.

The PRAP acknowledges that the conditions in the Canal are likely to change as a result of upgrades to the CSO system related to the New York City WWFP. There will be additional changes in the future as a result of the yet-to-be-written New York City LTCP. These changes can have significant implications for the design and performance of the remedy. Furthermore, climate change, and the potential for sea level rise, present issues that were not discussed in the PRAP and will pose challenges during the design. As stated by the New York City Panel on Climate Change (New York City 2010), "[c]limate change poses challenges to planning for coastal waterfront development in New York City, given the uncertain but significant risks of progressive sea level rise and enhanced flooding of low-lying neighborhoods and infrastructure, increased transportation disruptions, increased structural damage, impaired operations, increased beach and shorefront erosion, and loss of wetlands." All of these risks apply to the Gowanus Canal, the Harbor, and surrounding neighborhoods. The final remedy must consider the hydrodynamics of the Canal given rising sea levels and potential for greater storm surges. The design should evaluate the potential for continued and possibly more frequent flooding in the surrounding neighborhoods. The proposed work on the CSO and storm sewer systems must consider the potential for larger and more frequent discharges to the Canal. Finally, these considerations underscore the need for the remedy that will need to be adaptable as conditions change into the future.

There is also the flushing tunnel, which is set to be re-activated in 2014. In an effort to assess the effects of the City's actions, National Grid undertook sediment transport and hydrodynamic modeling of the Canal. These studies demonstrate that increased flow from the flushing tunnel will have a variety of effects on future conditions in the Canal including, bed shear and sediment transport, scour of finer bottom material, and changes in water chemistry and biological conditions such as the reintroduction of marine borers affecting the integrity of timber bulkheads / pilings.

As explained by Drs. Palermo and Brunton, when moored barges and sheet pile enclosures are coupled with the flushing tunnel, flow velocities in the Canal will increase even more, which will increase scour (Appendices C and D). All of this must be carefully evaluated as a part of the remedial design effort.

DO must be maintained to support benthic invertebrate communities and other aquatic life. In accordance with the New York State Water Quality Standards, as a Class SD saline waterbody, the DO in the Canal should never be less than the acute criterion of 3.0 mg/L. However, during the summer of 2012, DO concentrations were less than 3.0 at 28 of 29 sampling stations in RTA 1 and RTA 2 (GEI 2012a). Although the flushing tunnel was not operational during that sampling event, the aeration system in RTA 1 was operating. Testing has shown it was insufficient to maintain DO levels to support aquatic life. Furthermore, 11 of the 29 stations in RTA 1 and RTA 2 had zero benthic invertebrates and most other stations had fewer than 100 organisms per square meter. During other sampling events (GEI 2011a, 2012b), all but two of these sampling stations had hundreds to thousands of invertebrates per square meter. This is strong evidence that lack of DO, even more so than chemical concentrations, will limit the benthic community in the Canal. For the remedy to be successful, and for the Canal to support a healthy benthic community, DO must be addressed as the primary consideration in the RAOs and performance metrics, rather than simply focusing on mitigation of chemical toxicity as do the current RAOs. Modeling of DO levels in the Canal with the flushing tunnel reactivated projects that DO levels are not expected to meet CWA requirements in RTA 2 (Appendix D). The Baird results for DO have identified periods of hypoxia in RTA 2 following large CSO events.

Lastly, even if the volume of solids entering the Canal is reduced, the deposition of potentially toxic sediments from ongoing point sources is not expected to stop. National Grid's hydrodynamic model indicates that solids will continue to settle out in the Canal even with the proposed increased flow generated by the flushing tunnel. According to EPA's proposed remedy, routine maintenance dredging of solids will be required for the life of the Canal. In addition, the full impact of the flushing tunnel still remains unknown. Sediment transport and hydrodynamic modeling has revealed that sediments are likely to come out of suspension in areas of the Canal where there is a significant decrease in velocities. Deeper dredging in RTA 1 and RTA 2 could thus result in settling of sediments with the return of sediment mounds and associated odor and contamination over the long term (Appendix D). Modeling has also identified parameters that have yet to be addressed, including flow conditions, flux of suspended sediment and contaminants, bed shear, and sediment transport and fate.

In summary, the success of the remedy depends primarily on short and long term CSO controls. The FS and PRAP do not include sufficient evaluation of the effects of these controls on the remedy. The evaluation performed by National Grid raises a wide variety of issues concerning the implementability and long term performance of the remedy under the proposed conditions.

(3) Groundwater Flow Variation

Transport mechanisms, including movement of NAPL and dissolved phase constituents in groundwater (leading to discharge of NAPL and groundwater to the Canal), need to be better understood in order to achieve a successful remedial design.

Groundwater modeling and NAPL mobility testing performed by National Grid indicate that contaminant fate and transport vary along the Canal and may require different controls in different reaches and sub-reaches (GEI 2011b and Appendix B). This is especially important given that the majority of the Canal bulkheads are highly permeable timber cribbing structures that allow groundwater to migrate into the Canal. The proposed remedy, however, may require impermeable bulkheads (like those being designed by National Grid for the MGP sites), to stop groundwater migration and thus mitigate the discharge of contaminants to the Canal from other responsible party sites. Groundwater modeling shows that impervious bulkheads will cause groundwater to deflect in different directions and to mound behind the bulkheads. To resolve this issue at the MGP sites, where barrier walls are planned, National Grid is exploring installing liners throughout the sites to minimize infiltration and consequently mounding behind the barrier walls. Under drain systems to collect ground water may also be needed should it rise above an unacceptable level.

There is a high potential for deflection and mounding to flood basements and properties. The effects of the remedy on groundwater flow thus may require responsible parties to explore groundwater controls. This should include a comprehensive groundwater modeling review of each system and how each interrelates. This would be performed in conjunction with the design of the remedy.

Modeling also demonstrates that the majority of groundwater discharge to the Canal (approximately 70 percent) in RTA 1 comes through the Canal floor (GEI 2011b). Design of the cap in this area in particular will require significant pre-design studies, including studies to identify discharge areas and to estimate flow rates.

D. Construction, Engineering, and Future Use Considerations

(1) Dredging and Capping

As explained by Dr. Palermo, all dredging projects are unique because each must address specific site conditions and objectives, not to mention deal with specific unforeseen conditions. There is no doubt that the Gowanus Canal will offer up its own challenges that will result in delays and setbacks. The PRAP does not appear to consider this or the varying site conditions and sediment characteristics throughout the Canal. Matters are further complicated in the Canal because of components, like the CSO system, that are in motion and ongoing and subject to change when the flushing tunnel is reactivated. Armed with experience, Dr. Palermo has recognized these unknown variables and how they reduce the dredge remedy proposed in the PRAP to "little more than a concept." (Appendix C).

Given the conceptual nature of the PRAP, much time must be afforded for extensive study and work to design the dredging portion of the remedy. Basic physical characteristics of the Canal such as water depths, bathymetry, currents, wave energies, the presence and nature of infrastructure and debris, and geotechnical conditions must all be considered. After evaluating the physical setting, dredging allowances, sediment re-suspension, and total volume must be calculated. Finally, the limited access to the Canal, lack of open space for staging, loading / off-loading, and treatment, and tight clearances and space for work within the waterbody must be resolved.[12]

With all of the unknowns outlined above, the very specific remedy components that are set forth in the PRAP are ill-advised and could be counter-productive. This approach cannot be justified given the present preliminary knowledge about the site and sediment conditions and the limited state of technical evaluations conducted to date. Once again, flexibility and adaptive management are essential to design this part of the remedy and to ensure its success. To that end, Drs. Palermo and Reible have identified several studies that, if performed, would help in remedy design:

- **Remedial Design Field Investigations**. Data gaps regarding sediment transport; hydrodynamics associated with ever changing Canal conditions due to the CSOs, the flushing tunnel, other pipes, and flow variations during construction; groundwater flows (lateral and vertical); geotechnical conditions of the soft and native sediments; and bulkhead conditions, and near shore building foundation conditions should receive additional study.

- **Cap Design and Performance Studies**. This would include evaluation of the basic issues such as the need for an armor layer, performance of armoring layers, and in situ stabilization (ISS) to stabilize both soft and native sediments.

- **Performance Standards Evaluation**. Performance standards are a touchstone of the remedial design and are needed for sediment re-suspension, contaminant release to water and air, and dredging production and timeline for completion of dredging.

- **Dredging Production and Throughput Evaluation**. An evaluation of dredging production and sediment throughput from dredging to final disposal should be conducted.

---

[12]These challenges all affect the implementability and cost of the remedy, important factors identified by the NCP. *See* 40 C.F.R. § 300.430(f)(1)(i)(B).

- **Contaminant Release Studies**. Sediment characteristics coupled with high concentrations of contaminants and the presence of NAPL in some areas raise the potential for contaminant release. A study of sediment re-suspension potential, contaminant release potential to water and air, and residual sediments due to dredging should be conducted.

- **Sediment Re-suspension and Contaminant Release Control Evaluations**. The PRAP calls for the most stringent and aggressive form of engineered re-suspension control -- a sheet pile enclosure. More technical evaluation is needed to determine either the need for such control or the potential impact of such control on sediment erosion and the contaminant releases that will follow. Use of hard enclosures may actually result in higher contaminant releases to the Bay as compared to dredging without enclosures.

- **Operations Plan**. The PRAP includes a proposed sequence of work. However, a more comprehensive evaluation of operational aspects is needed to fully assess the practicality and community impacts associated with implementing the remedy. By way of example, the PRAP does not address the feasibility of removing the significant amount of buried debris in the Canal which in itself is an enormous and complex undertaking.

- **Monitoring and Management Plan**. Similarly, a more comprehensive evaluation of monitoring aspects is needed to more fully assess the effectiveness of the remedy.

- **Field Pilot Studies**. Field pilot studies will also be needed to confirm the effectiveness of some remedy components. Pilot studies may include dredging an area to assess sediment re-suspension, contaminant release, and source strengths; as well as cap placement to verify the ability to place caps in both the soft and native sediment layers.

- **Re-handling and Transport Study**. Careful planning of re-handling and transport of sediments is the key to compatibility. Areas for staging and offloading, and sediment treatment must be identified.

- **Sediment Treatability Studies**. The FS and the PRAP identify either stabilization and / or thermal desorption as the treatment and disposal options. Additional treatment studies would help uncover additional options and find a disposal approach.

- **Beneficial Use Studies**. The PRAP identifies beneficial use as the option for all dredged sediment. This may be difficult to implement given the volumes of sediments involved and the lack of a market for sediments with properties as found in the Canal.

- **Landfill Investigation**. Although the PRAP calls for beneficial use of all the dredged sediments, placement in landfills should also be investigated. Evaluations should be conducted to determine required pre-treatment or treatment, logistics of re-handling and transport to the landfills, capacity of landfills that may be considered and the acceptability of the Canal sediments for placement at those landfills from the standpoint of dewatering and workability.

- **Confined Disposal Investigation**. The PRAP includes potential use of a combined disposal facility (CDF) for sediment disposal. Acknowledging the apparent opposition to a CDF and taking no position on it, National Grid submits that if the EPA decides to move forward, more comprehensive studies are needed. Indeed, perhaps a contained aquatic disposal site is an option or a CDF outside the project footprint which could offer true community benefit such as waterfront park land. Initial investigation should focus on possible sites within the basins and Gowanus Bay, and consider volume, site bathymetry, and compatibility for future landside development. Engineering, contaminant pathway, and pathway control should also be evaluated.

The expedited schedule has made it challenging to get to the full range of studies National Grid believes are important (including the list above). Many of these studies would support the development of a more robust conceptual site model that fully identifies sources of contamination and describes fate and transport mechanisms. Such a model is a cornerstone of the CERCLA process and is integral to designing a remedy. As a result, for the remedy concepts outlined in the PRAP to be successful, National Grid believes the ROD should provide for additional time and flexibility for all of the required work to be planned, coordinated, and performed. Data will have to be analyzed, changes in courses of action may have to be made, and new steps may have to be planned. All the while, residents, public officials, and community groups will need to be kept informed.

(2) Navigation

Although the Canal is no longer the heavily trafficked industrial channel it once was, current commercial navigation has a significant impact on remedy design for the Gowanus Canal. The Baird Vessel Impact Study (VIS) Report, submitted to EPA on December 14, 2012 and summarized in Appendix D, found continued deep draft commercial navigation on the Canal could present a serious challenge to the restoration of a benthic habitat layer atop the cap as proposed in the PRAP. If allowed to continue post-remedy, impacts from commercial vessels (notably tugs and barges) that currently mobilize, transport, and redistribute sediments and contaminants in RTA 2 and other shallow portions of the Canal, would likely destroy any habitat.

The Baird VIS provided an analysis of propeller wash calculations to determine the potential for bed sediment mobilization. This coupled with three-dimensional numerical modeling (including flow around moored barges and propeller scour of the Canal bed by vessels underway) from the Baird Sediment Transport Modeling Study, highlights the extensive work and analysis that is required before a final remedy is chosen.

The Baird VIS report documented that despite the continued decline in commercial navigation, vessels and barges nevertheless impact the Canal bed in the following ways:

- Changes to local flow patterns;

- Tugs and barges are a direct and significant influence on flow velocities (and therefore sediment movement) in the Canal;

- Flow velocities increased by at least 600-800 percent ; and
- Vessel contact (or "grounding") with the Canal bed in RTA 2.

A detailed vessel traffic analysis using Automated Identification System (AIS) vessel tracking data identified five active docks located in the Canal between 3rd Street and the Gowanus Expressway. The present-day operations include tug and barge activities for two steel recyclers, two aggregate importers, and one fuel oil importer. Tugs make up over 99 percent of the vessel trips. Over half of all the trips are to the Bayside Fuel Oil Depot located next to Smith Street (at the lower reach of RTA 2).

While the trips to destinations above 9th Street are fewer than trips to the lower Canal, they may be more significant for sediment mobilization due to shallower water depths in the middle and upper Canal. The shallow sediments in RTA 2 show direct evidence of repeated barge groundings. Multi-beam bathymetric surveys very clearly show sediment bed scour caused by barges.

The barge and tug transits not only occur at high water as suggested in the FS (CH2M Hill 2011), but at all stages of tide (including low waters), demonstrating that the FS may have underestimated the potential for commercial vessel traffic to mobilize Canal sediments and contaminants as well as the potential to impact the viability of the future remedy. It is clear that the current vessel traffic in the Canal not only mobilizes and redistributes sediment and contaminants, but propeller wash can mobilize sediments as large as cobbles and boulders – materials much larger than those observed in the Canal bed or proposed for the benthic layer of the cap. Given this fact, it is reasonable to conclude that bed sediments are regularly mobilized into the water column by vessel activity.

For the remedy to succeed, National Grid's experts suggest that allowing commercial navigation in the Canal in RTA 1 and RTA 2 should be carefully considered. While one answer would be to dredge deeper, this will create a different set of problems. The increased depths proposed in the PRAP will decrease water velocity and DO levels in the Canal. This will compromise the ability of the flushing tunnel upgrades to achieve DO standards that satisfy CWA requirements. In addition lower velocities will lead to deposition of CSO solids and sediment on the cap, in turn further reducing DO concentrations and compromising the integrity of the remedy.

Because there is no current commercial navigation in RTA 1, alternative dredging depths should be explored. It is important to note that none of these options would preclude recreational boating from shallow draft boats that are regularly used in the Canal.

Navigation depths proposed for RTA 2 that would leave the cap surface only 16 feet below the water surface at slack tide are a concern. At this depth, the benthic sand cover would likely be continuously disturbed by tug prop wash and scour. This problem and the fact that access to dock facilities in RTA 2 will be lost for extended periods of time during construction of the remedy, speak in favor of additional discussion about supporting commercial navigation in RTA 2.

In RTA 3, sediment depths at the mouth of the Canal reflect current navigational activities. Dredging to greater depths will potentially interrupt navigation dependent businesses and likely result in slower velocities and deposition of fine sediments coming from the Canal, compromising the integrity of the remedy.

E. THE FULL RANGE OF POTENTIAL TECHNOLOGIES SHOULD BE AVAILABLE FOR USE IN THE REMEDY

The FS evaluated a broad range of proven and potential technologies for use in the Canal. Yet, many were eliminated by the EPA during the screening process. Studies performed by National Grid indicate that a variety of techniques eliminated during screening may actually be useful in the final Canal remedy. The ROD should allow further testing and possible use of any viable technique for dredging and/or isolation of sediments.

It is National Grid's belief that sediment removal requirements set in the PRAP still need further evaluation. There is a much wider range of potential technologies that could be employed to achieve RAOs than those included in the PRAP. Maximum flexibility is needed to optimize the use of any or all of these technologies during the design process. Processes like ISS, capping soft sediments without pre-dredging, capping-only remedies, in-situ amendments to reduce bioavailability of contaminants, and alternate approaches in RTA 3 should all be explored. Treatment and disposal also need to be given a hard look.

(1) ISS

The PRAP does identify ISS as a means to mitigate NAPL release in native sediment. However, it does not recommend ISS of soft sediment because the FS considered it technically infeasible, though no performance studies were undertaken. National Grid has undertaken bench scale ISS testing of Canal soft sediment, and the data suggests it may very well be a viable approach (Appendix H). Soft sediment samples from RTA 2 and Turning Basin 1 were successfully solidified in a preliminary round of testing. This work was performed on "worst-case scenario" samples of 100 percent soft sediment. A second round of testing investigated the benefits of mixing the soft sediment with native sediment during solidification. This mimics the blending that could occur as the mixing auger moves up and down the soft and native sediment column to incorporate cement grout. Mixtures of native and soft sediments solidify with less cement than if they are treated separately because of the higher sand and gravel content and lower moisture content of the native sediment.

The effect on groundwater flow patterns resulting from sediment ISS was also noted as a concern. Rather than discounting ISS's potential use as a blanket approach, it would be preferable to better understand groundwater flow dynamics and design accordingly. For example, a portion of the Canal could be solidified, and an adjacent portion left unsolidified as a hydraulic release point topped with a permeable reactive cap like that proposed in the PRAP. Including soft sediment solidification as an option in the ROD will preserve flexibility to combine several appropriate technologies to create a complete and sustainable remedy.

The FS noted potential issues with ebullition and methane upwelling resulting in potential cap uplift. Solidification of the soft sediments and the NAPL-impacted native sediments could inhibit these phenomena. Solidified sediments could also improve bulkhead toe stability and potentially eliminate or reduce the loading to support sheeting, simplifying the design.

In summary, while the PRAP acknowledges ISS may be a useful technology for treating NAPL in native sediments, testing performed by National Grid indicates that both native and soft sediments are promising candidates for solidification. Depending on the final design of the remedy, solidification could be used to help control NAPL in deeper sediments, assist in stabilizing soft sediments to shore up bulkheads (in lieu of or in conjunction with using sheet piles), as a treatment to improve the handling characteristics of sediments used to form the base for soft siding, or to improve the handling of sediments prior to transport offsite or placement in a CDF. While any of these uses may be applicable, the actual use of ISS should be determined based on performance and cost evaluations during the design process. Bench scale tests performed to date (Attachment H) show sufficient promise to include ISS as a potential component of any remedy developed for the Canal.

(2) Capping soft sediments without pre-dredging

The soft sediment layers are heterogeneous throughout the Canal. As summarized in Table 2 of the PRAP, the soft sediments average 54 percent solids with a 35 percent sand fraction. As noted by Drs. Palermo and Reible, caps have been installed successfully at sites with softer and more challenging sediments. Based on field observations of sediment cores, the sand fraction of the soft sediments in some areas of the Canal increases with depth (GEI 2009 and Appendix I). Accordingly, partial dredging of the soft sediments may be best in some areas because it will expose material even better suited for supporting a cap.

To the extent there is concern that soft sediments and any NAPL held therein might be destabilized by uneven placement of cap material, the cap may be placed in thin lifts to avoid point loading. Field observations of sediment cores and the data summarized in the sediment physical characteristics table (PRAP Table 2) suggest that the soft sediments in some reaches of the Canal may have sufficient bearing capacity that could very well do away with special cap placement techniques.

With regard to releasing NAPL, Dr. Reible points out that residual NAPL is unlikely to be mobilized by the weight of a sediment cap. Preliminary testing of sediment samples near the soft-native interface and with vertical loading equivalent to 10 feet of sand showed only trace amounts of NAPL expressed (Appendix B). Finally, NAPL impacts in soft sediment are generally lower than in native sediment (Appendix B). Removal of the soft sediment could actually promote upward migration from the native sediment.

In summary, the EPA should weigh the benefits of removing categories of contaminants (e.g., PCBs and metals) via complete removal of soft sediments against the cost of complete soft sediment removal, the likelihood of cap failure (low), and the fact that native sediments contain higher concentrations of some contaminants than do soft sediments (Appendix B). Flexibility is critical to designing and implementing a successful and sustainable remedy.

(3) RTA 3 Should be Approached Differently

RTA 3b is dissimilar from the other RTAs in terms of size, depth, navigational requirements, hydrology, benthic community characteristics, and level of impacts. Whereas RTAs 1 and 2 are narrow and relatively uniform in width, RTA 3 widens and is more irregular in shape and is also deeper. In fact, RTA 3b is three to five times as wide and, generally one and a half to two times as deep as the rest of the Canal. Also, RTA 3b has the most commercial navigation, but the least concentrations of constituents within soft sediments, including NAPL (saturated impacts are limited to one, western area).

The shape, location and dimensional differences affect a number of other characteristics which can have significant influence on the remedy from upwelling rates of groundwater to sediment flux. Yet, despite these significant differences, the PRAP selects virtually the same remedial approach for RTA 3b as the remainder of the Canal. The Draft FS (CH2M Hill, 2012) appears to over-generalize the nature and extent of impacts within the Canal soft sediments, when in fact this RTA warrants a different approach.

As it stands now, the proposed remedy will result in high costs, level of effort, and disruption to navigation and business that are out of proportion with the low levels of reduction (if any) of risk to human health and the environment that would be gained. A remedial approach that is modified to meet the specific characteristics of RTA 3b makes much more sense. Such an approach could not only decrease the overall level of complexity in the implementation of the remedy, but it could decrease the level of business interruption to nearby commercial facilities, lower resource consumption and decrease the overall cost of construction while still achieving the RAOs outlined in the PRAP.

(i) The Hydrology and NAPL Impacts are Different

Section 4.3.1 of the FS discusses screening of dredging and capping as a remedial technology. This section states "although little NAPL is present in RTA 3, groundwater upwelling through PAH-contaminated sediments in some portions of RTA 3 may pose a concern" (CH2M Hill, 2011). Groundwater modeling demonstrates that the preferential pathways for upwelling follow the alignment of the original Gowanus Creek, with most upwelling occurring further up the Canal in RTAs 1 and 2. The amount of upwelling in RTA 3 (3a and 3b combined) represents only 12 percent of the total groundwater upwelling spread over half of the area of the Canal. This discharge represents roughly 12 percent of the total groundwater upwelling in the Canal (GEI 2011b). This relatively small flux indicates that groundwater velocities are much lower in RTA 3 (and especially the much wider RTA 3b) than RTAs 1 and 2. The results of the quantitative analyses of groundwater (GEI 2011b) should quell the theoretical concern that NAPL could migrate upward in RTA 3b due to groundwater velocity.

Alternative 5 (as opposed to Alternative 7 which was selected for the remainder of the Canal (EPA, 2012b)), was selected for RTA 3b in part because "NAPL impacts in the southern portion of the project area are much less significant and less pervasive than those observed in the upper reaches of the canal" (CH2M Hill, 2011). Further investigation should be undertaken to identify impacted portions of RTA 3b that may then be specifically targeted for remediation. Such a more targeted approach makes much more sense than simply applying Alternative 5 to the entire area.

(ii) The Sediment Chemistry is Different

Although fewer sediment samples have been collected in RTA 3b than in the rest of the Canal (GEI 2009, 2011a, 2012a, 2012b; EPA 2011), it is nonetheless clear that sediments in RTA 3b contain lower concentrations of potentially toxic chemicals than much of the rest of the Canal. Statistical analyses, conducted to evaluate differences in chemical concentrations among and between RTAs (shown graphically in Figures 1 through 6 of Appendix L), indicated that for each of the chemical constituents and constituent groups discussed below, there are relatively lower risks of effects from other chemical contaminants in the soft sediments of RTA 3b.

Total PAH16 in surficial (zero to six inch depth) sediments, measured as the sum of the 16 EPA priority pollutant PAHs, was greatest in RTA 2 and the least in RTA 1 and RTA 3b (Figure 1 of Appendix L). Statistical analysis indicated significant pairwise differences between RTA 3b and all other areas, though RTA 3b is most similar to RTA 1. Concentrations ranges of total PAH16 in subsurface samples in each RTA generally overlap with those of surficial concentrations (Figure 2 of Appendix L). However, the noticeably lower concentrations of total PAH16 within RTA 3b surficial sediment may be the result of natural recovery processes.

Total PAH34 in surface sediment pore water (i.e. interstitial water), measured as the sum of parent and alkylated PAHs using solid phase micro-extraction (SPME), was consistent with bulk surface sediment PAH16 results: Concentration was greatest in RTA 2 and the least in RTA 1 and RTA 3b (Figure 3 of Appendix L). The median PAH34 concentration in pore water was the least in RTA 3b, which may at least partially explain the benthic community results discussed in the next section.

Estimation of PAH pore water toxic units (IWTU) from PAH concentrations measured in pore water using SPME is the most reliable method to estimate the toxicity of PAHs to benthic invertebrates in sediments (EPA 2003, Hawthorne et al, 2005, 2007). IWTU in surficial samples in RTA 3b were less than 10, indicating toxicity resulting from PAHs would likely be minimal. This is in contrast to RTA 2, in which the median IWTU was greater than 10 (Figure 4 of Appendix L). Statistical test results for IWTU were similar to those described for PAH34 in pore water.

Total PCBs concentrations, measured as the sum of PCB aroclors, in Canal sediments followed a very similar spatial pattern to that of PAH16, with surface concentrations in RTA 3b being similar to RTA 1 and significantly less than RTA 2 (Figure 5 of Appendix L). Patterns in subsurface PCB concentrations were similar but less distinct than the surficial concentrations.

Concentrations of lead in surficial samples in RTA 3b were significantly less than those in RTA 1, 2, and 3a (Figure 6 of Appendix L). Consistent with other analytes, subsurface patterns were similar to surficial patterns, but variability was greater.

What is more, the highest PAH concentrations in RTA 3b are localized in sediment abutting the boundaries of this RTA. In contrast, the top four feet of soft sediment in the remainder of RTA 3b contains much lower PAH concentrations. Figure 7 of Appendix L shows this pattern of PAH concentrations in sediment cores located within RTA 3b. The "Alternative Remedial Approaches" section below describes in more detail how the distinctive sediment impacts at the edges of RTA 3b ("hot spots") influence the mean concentrations of impacts when the location of the impacts is taken into account.

(iii) Sediment Toxicity and Benthic Community Health are Different

GEI performed three rounds of benthic sampling concurrent with chemistry and toxicity samples in the Canal between January 2011 and May 2012. Sediment toxicity was variable within each RTA, indicating that location-specific factors are important. However, in general median survival in laboratory toxicity tests was greater in RTA 3b than in RTA 2 and 3a (Figure 8 of Appendix L). These results support the concept that only impacted portions of RTA 3b need be identified and specifically targeted for remediation.

In general, the benthic invertebrate community observed in the Canal represents an estuarine community adapted to soft substrate habitat and that is highly tolerant to disturbed conditions including organic enrichment and low DO (GEI 2011a, 2012a, 2012b). Stress-tolerant annelid worms, specifically of the classes *Polychaeta* and *Oligochaeta*, are the dominant invertebrates, representing greater that 50 percent of the benthic invertebrate community.

Despite the relatively homogenous invertebrate community throughout the Canal, several patterns in the benthic invertebrate community in RTA 3b are clear that further distinguish this RTA from the rest of the Canal:

- The greatest number of taxa was observed within RTA 3b where the Canal opens into Gowanus Bay (Figure 9 of Appendix L). Fifty-six of the 86 taxa (70 percent) identified in all the sampling events were observed in RTA 3b.

- RTAs 3a and 3b were the only areas where Mollusca were observed consistently in samples collected during all events (winter, summer, and spring). Additionally *Mytilus edulus* (blue mussel), a commercially important invertebrate species with known sensitivity to environmental stressors, were observed at two locations in RTA 3b during the spring sampling event.

- RTA 3b maintained a more consistent and stable benthic community across two years and three seasons of sampling. Patterns of number of taxa (Figure 9 of Appendix L), benthic density (Figure 10 of Appendix L), and benthic species diversity (Figure 11 of Appendix L) measured between seasonal events, indicate that the severe benthic community stress that occurred during the summer in most of the Canal had little effect in RTA 3b.

In summary, more hospitable conditions exist for the benthic community in RTA 3b. While toxicity was observed in some locations, the toxicity was not uniform throughout RTA 3b. The physical habitat conditions and DO stress that, in combination with chemical toxicity, severely limit the benthic community in most of the Canal, appear to be significantly improved in RTA 3b, facilitating the observed significant improvement in benthic community health and stability.

(iv) Issues with the Proposed Alternative for RTA 3b

According to Table F-3 of the FS, the combined estimated dredging volumes of RTAs 1 and 2 is 307,000 cubic yards (CY). The estimated volume of RTA 3b alone is 257,000 CY. Thus, under the currently selected alternative, slightly less than half of the dredging work for the entire remediation will be performed in what is accepted to be the least impacted portion of the Canal. Dredging all of the soft sediment in RTA 3b, as called for in the PRAP, will bring disruptions, expense, worker and public risk, resuspension of contaminants within the water column, increased levels of dissolved contaminants, and an extended period of construction,[13] while obtaining minimal, if any, improvements in risk reduction.

As noted in the FS, RTA 3b is used for commercial navigation. Removing all of the soft sediment from EPA will no doubt disrupt those businesses. RTA 3b is also larger and deeper and would invariably take longer to remediate as compared to the narrower areas of the Canal, further protracting business interruptions. Additionally, due to the width, barge traffic would be crossing the channel frequently to unload the dredged sediment for dewatering. There would also be disruption to benthic community.

(v) Alternative Remedial Approaches for RTA 3b

Based on the available information, the proposed remedy for RTA 3b could be altered to reduce construction time, business interruption, and costs, while at the same time comply with all RAOs. This can be done by combining multiple approaches, including dredging only those areas of RTA 3b that contain the most significant impacts (i.e. "hot spots"), allowing natural recovery processes currently taking place to continue, and employing adaptive management as new data becomes available.

To illustrate the importance of addressing sediment hot spots, as opposed to dredging the entire soft sediment, the Table 1 in Appendix L compares the average PAH16 concentrations in the hot spots versus the remainder of RTA 3b. Identification of the hot spots in RTA 3b is presented in Figure 7 of Appendix L. PAH16 concentration in the top two feet of hot spots is an average of 808 mg/kg, as compared to 31 mg/kg in other locations. For the two to four feet range in the soft sediment, the PAH16 concentrations averaged 828 mg/kg for the hot spots, versus 23 mg/kg in other locations. This contrast in concentrations calls for defining and addressing hot spots, as opposed to dredging the entire soft sediment.

In areas outside the hotspots, the accumulation of sediment with relatively low PAH concentrations has been occurring (e.g., core 142 has 9.4 and 6.7 mg/kg PAH16 in the 0-2' and 2-3.8' of sediment, respectively). Certainly, PAH levels at this location suggest that this and other similar locations do not need to be dredged.

[13] Production rate estimates for remedial dredging from contractors for recent similar projects indicate that removal of the large amount of sediment targeted for RTA 3b could take as long as two years.

Based on these results, the RTA 3b remedial action should include identifying the extent of hotspots in RTA 3b and addressing them, as opposed to dredging the entire area in which large volumes of clean sediment has been accumulating. Indeed, this approach has been adopted in other Superfund Sites (e.g., the Hylebos waterway), and has been effective in addressing risks.

Over time, natural recovery processes will also improve the quality of the sediment. A sediment transport and deposition model would provide a quantitative basis and provide certainty in the effectiveness of the natural recovery processes to address contamination in-situ. Areas where the soft sediments are removed could be capped with the treatment, isolation, and armor layered cap as outlined in the PRAP, while areas dredged for navigation could be left at depth with no cap. To the extent there is concern that NAPL in adjacent soft sediments may be destabilized, as noted above, the level of NAPL impacts in RTA 3b are minimal with the only NAPL saturation limited to a single location.

The required exploration and analytical data needed to define remedial action levels and the RTA 3b hot spot areas to be dredged would be collected as part of the predesign investigation. Although there is currently not enough data to compare dredging volumes of the currently selected remedial alternative and alternative proposed herein, given the size of RTA 3b, the reduction in total dredging volume by targeting hot spots could be significant.

Additionally, adaptive management should be considered for any remedy selected. Additional data will be collected from RTA 3b for remedial design, and the selected remedy should be flexible enough to incorporate the more refined understanding of the soft sediment present that the additional data will provide.

Finally, as discussed in the hydrology section of this report, the available data indicates that a comparatively small amount of groundwater is upwelling in RTA 3b, which may negate the need for the treatment layer as currently proposed.

(vi) Conclusion

RTA 3b is a unique portion of the Canal that requires consideration of a different remedial approach. Disproportionate levels of dredging within RTA 3b (slightly less than half of all soft sediments are contained within this RTA), the level of construction, sediment handling, and disruption all contrast starkly with the localized nature of the impacts. The alternative currently proposed in the PRAP does not perform as well for the nine NCP factors (listed in footnote two) when compared to other targeted remedial approaches leading to the need for reexamination of the approach in RTA3. A different, more targeted approach would be as effective, more implementable, result in significant savings in time and cost, minimize resusupension and minimize impact to the community (e.g., less sediment handling, traffic, and odor). The NCP requires that EPA weigh all of these factors when selecting a remedy.

(4) Tailored Design for Optimal Cap Performance

The quality of the sediments, potential for groundwater discharge, current bulkhead conditions, and navigational requirements vary significantly along the length of the Canal. Additional modeling, design studies, and pilot tests are needed to evaluate optimal cap configuration and NAPL control measures. The ROD should acknowledge the need for such additional studies, allow for flexibility in design of the cap to meet RAOs, and provide a full palette of potential capping technologies for use in constructing the final remedy.

A cap with treatment, isolation, and armor layers, like that proposed in the PRAP, may be appropriate for some portions of the Canal. However, the dimensions and compositions of these layers will require a substantial design effort, and therefore should not be prescribed in the ROD. Also, different areas of the Canal will require different cap configurations. At least three categories of caps, consisting of variations of treatment, isolation, armor, sand, and impermeable layers, may be required to optimize the final remedy. The type of cap required will also vary with underlying sediment characteristics, potential for groundwater discharge, amount of NAPL present, potential for methane gas production and ebullition, Canal depth, and navigational requirements.

The PRAP specified a single cap design of a one and a half foot armor layer of stone, a one foot isolation layer of sand and gravel, and a six inch to one foot treatment layer of clay. As noted, the cap design will need to be variable based on specific needs within each reach of the Canal. For example, oil-absorbing material like oleophilic clay, should be targeted where it provides the greatest benefit, can be monitored, and can be replaced at the end of its design life. If relatively impermeable zones of solidified sediment are to be created, oleophilic clay should be deployed elsewhere and only in zones where groundwater communicates freely with surface water. A broadly applied single-design cap of the type designated in the PRAP will be difficult to monitor and evaluate.

A treatment layer of oleophilic clay like that proposed in the PRAP is likely not needed over solidified sediment since the solidification process dramatically reduces contaminant mobility, the very thing that a reactive cap is intended to treat. These technologies are simply redundant. An armor layer is also likely not needed over solidified sediments since the sediments are less susceptible to scour. A benthic habitat layer could be installed over the ISS matrix to facilitate habitat restoration.

A thinner benthic cap offers the advantage of reducing dredge volumes and thereby minimizing waste. Prop wash calculations are needed to determine sizing and thickness of the benthic supporting sand and gravel layer. The calculations would evaluate the type of vessel and draft for the specific portion of the Canal to provide the grain size (armor) and thickness of benthic cover to protect against prop wash. This was similarly completed in Appendix D of the FS and in models completed more recently for the Canal (Appendix D).

Finally, an impermeable cap may be useful for portions of the Canal in conjunction with adjacent areas of benthic or treatment (PRAP-style) caps. Impermeable cap areas (and solidified sediments) will force ground water to discharge through permeable cap areas, where treatment layers could be employed to intercept contaminants. This would be similar to a “funnel and gate” system and may provide a more practicable approach than a treatment layer across the entire Canal. It would also better facilitate monitoring for cap effectiveness. If replacement of a treatment zone is required, it could be more targeted and would not require a widespread dredge effort.

The FS expressed concern that methane gas "may be generated beneath the cap, causing potential uplift and deformation without special design considerations" (CH2M Hill, 2011). National Grid believes it is premature to eliminate the option of a low permeable cap before the design process identifies potentially appropriate technologies to address this concern. Gas venting can be managed, and the generation of gas in a low oxygen environment at the base of the cap may not be as severe as anticipated (Appendix B).

Additional modeling, design studies, and pilot tests are needed to evaluate optimal cap configuration and NAPL control measures. Therefore, the type of cap(s) to be installed should be determined during the design process, which requires flexibility to accomplish this in the ROD.

(5) PRGs and Performance Goals

The remedy will be manageable only if reasonable performance standards are put in place. As such, a proper understanding of the final remedial conditions and the future operating conditions in the Canal must be considered in light of establishing measurable and meaningful performance standards. The following discusses the issues involved.

The PRAP specifies that PRGs for protection of the ecological community be used as performance standards to evaluate the effectiveness of the post-remedy "clean surface." The PRAP identifies three PRGs / performance standards: PAHs (20 mg/kg), Copper (80 mg/kg), and lead (94 mg/kg) [EPA 2012b]. These PRGs were developed to support RAOs to reduce risks to benthic organisms and herbivorous birds in the Canal from direct contact with PAHs, PCBs, and metals in the sediments as well as from dietary exposure, respectively.

National Grid agrees that establishing a "clean surface" cap following remedial construction will accomplish the RAOs of reducing risk to benthic organisms and herbivorous birds because any remaining sediment contaminants will be isolated from exposure to post-remedy benthic organisms and birds. However, the PRAP approach toward establishing performance standards is not sustainable. While the remedy recommended in the PRAP will result in a "clean surface," the PRAP specifically acknowledges that additional ongoing sources of contamination will continue to discharge to the Canal. In other words, PAHs, copper, lead, and other contaminants will all continue to be transported to the Canal via storm water discharges, CSO overflow events, and via the other 200+ outfalls that have not yet been quantified from a contaminant of concern (COC) loading perspective.[14] Given these other ongoing sources from CSO discharges and various other undefined upland discharges, the

[14] PAHs in particular have a multitude of origins that will be carried via storm and sanitary discharges to the Canal including roadway runoff, rooftop drainages, and overland flow from paved surfaces. It has been extensively documented (Menzie 2002) that roadway runoff contains PAHs originating from crankcase motor oils, asphalt particulates, abraded tire particulates, and combustion fallout (e.g. diesel soot). These ubiquitous urban sources of PAHs along with roofing tar PAH sources have chemical forensic fingerprint signatures (pyrogenic) that are similar to other sources of PAHs related to tar that would be isolated beneath the proposed cap (Boehm 2006, Yang 2010, Valle 2007, and Yunker 2002).

concept of a "clean surface" in the Canal is not likely to persist for very long following implementation of the sediment remedy.

Further, the DEP has stated that as part of its LTCP for the Canal, it intends to implement a high-level sewer separation for some of the largest CSO outfalls on the Canal. The intent is to further reduce future sanitary discharges, but with that comes the unintended consequence of bringing roadway runoff contaminants directly into the Canal. This runoff also contains significant loads of COCs, and thus likely will increase the likelihood that the sediment remedy will fail to meet the PRGs due to recontamination.

(6) Background Reference Conditions are Not Currently Defined

The PRAP states that background concentrations of COCs in the Canal, "after all of the major canal-related sources of contamination have been reduced or controlled is likely to be at the upper end of the range of reference concentrations in the Upper New York Bay sediments, i.e., 14 mg/kg PAHs, because of ongoing contributions from uncontrolled surface water runoff and storm water discharges" [EPA 2012b]. The basis for this statement is that,

> [t]he canal . . . is a water body contained in a constructed confined space of relatively regular geometry and shallow depth. Its only natural surface water inputs are from the New York Harbor through tidal exchanges from the south end of the canal and through Flushing Tunnel flow at the northern end. Deposition of solids in the canal from these two main sources and small amounts of exposed soil, historic fill, and rooftop and surface drainage would constitute the background level (i.e. regional) level of contamination[.]

This characterization of the Canal, although accurate, does not fully acknowledge that the post-remedy environment of the Canal will continue to concentrate and receive storm water and overland flow discharges from the heavily urbanized and industrialized properties and uses that surround the Canal and that the high-level sewer separation will in fact increase roadway runoff into the Canal. In addition, the CSO controls that will be implemented likely will not completely stop ongoing discharges of raw sewage into the Canal, and the residual amount that cannot be controlled must be factored into any assessment of future background conditions. Lastly, the conclusion that background levels would be reflective of the reference concentrations in Upper New York Bay sediments (14 mg/kg PAHs) is not accurate. There is no physical mechanism that would account for the Upper Bay sediments to have similar background concentrations to the future sediments in the confined Gowanus that will continue to receive discharges from the surrounding industrial areas.

(7) Selection of Appropriate Performance Measures and Monitoring Programs

Given the containment type remedy using a combination of cap and cutoff measures proposed in the PRAP, ecological risk will primarily be reduced by minimizing migration of COCs through the cap into the surface sediments where the benthic community will re-establish itself. However, as discussed above, the ongoing source discharges to the top of the "clean surface" cap will make it difficult to determine whether the constructed remedy is effective at achieving this objective. Therefore, effective performance monitoring must be able to differentiate contaminants that are migrating through the cap and / or associated sidewall containment systems, from the contaminants being discharged on top of the cap from ongoing sources.

The PRAP makes reference to chemical analyses of PAHs to evaluate the origins of the PAHs that will find their way atop the cap, post-remedy. Presumably, the intent is to distinguish petrogenic (petroleum related) PAHs from pyrogenic PAHs, such as MGP tars. However, there are many current-day sources of pyrogenic PAHs that will continue to be discharged to the Canal (crank-case oils, combustion particulate fallout, boiler exhaust soots, roofing tars, road sealants, etc.) making the sources of PAHs from ongoing storm and CSO discharge difficult to distinguish from sources of legacy PAHs that may migrate up through the cap.

Therefore, until such time as the ongoing discharges from CSOs, storm water outfalls, roadway, parking lot, and roof drain runoff are controlled, National Grid believes that the performance standards proposed in the PRAP cannot differentiate between performance of the remedy and ongoing source loading to the Canal.

With regard to monitoring the effectiveness of the constructed remedy both in the near-term (prior to comprehensive source controls in place) and in the long-term (after source controls are in place), an adaptive management approach is suggested to address the performance of the remedy. This means that performance standards should be developed for the monitoring of cap integrity and a separate plan should be developed for monitoring ongoing discharges to the Canal and the effect of any COC loading to the surface of the cap. To accomplish this:

- A physical cap integrity standard should be implemented by monitoring for the observation of sheen and or NAPL migration through the cap. The details of the monitoring program can be worked out in the design of the actual remedy. However, a simple approach (that has been implemented at other sediment cap sites) would be to periodically use a probe in a regular grid pattern to check for potential sheen generation through the upper armoring and sand layers of the cap.

- Depending on the specific construction of the cap, monitoring for COC migration through the cap should be specified in the cap monitoring plan. Such monitoring could be achieved through the use of probes, coring or passive sampling devices. Final selection of a cap monitoring approach should be based on the final design of the cap.

- During the design of the remedy, data also should be collected on the range and rate of discharge of various COCs and other stressors associated with ongoing CSO and storm sewer discharges. These data should be used to establish an interim baseline condition for expected background levels of COC concentrations that would provide a more realistic sense of what levels of contamination are anticipated post-remedy.

- Finally, similar to recommendations made in the PRAP, toxicity to benthic organisms in the Canal will need to be evaluated post-remedy to confirm that benthic toxicity is indeed being reduced as intended in the RAOs. The goals for this post-remedy evaluation of benthic toxicity should be twofold: First, it is important to determine whether ongoing sources of COC recontamination of the “clean surface” will cause the remedy to fail by introducing toxic concentrations of COCs. Second, the numeric PRGs selected in the PRAP are likely to need adjustments post-remedy because they are based on current numeric relationships between sediment COC concentrations and toxicity. Because such correlations will change substantially following the generation of the “clean surface,” strict adherence to the existing PRGs post-remedy cannot help determine whether RAOs are being achieved.

- During the interim period between the construction of the cap and the elimination of ongoing discharges, the cap monitoring program and the benthic toxicity evaluation should be implemented to assess the performance of the remedy.

Following implementation of the CSO and other direct discharge effluent controls, National Grid recommends that the performance standards should be re-evaluated to determine appropriate toxicity-based performance standards that would be protective of the benthic community. Under this adaptive management approach, following comprehensive source controls, a thorough evaluation of the remaining urban background toxicity to benthic organisms should be performed.

This adaptive management approach to modify the standards and monitoring programs as conditions change in the Canal is warranted for evaluating the performance of the remedy.

IV. CONCLUSION

As is common during this type of complex remediation project, there are many open questions that have yet to be answered. All of them, however, are manageable so long as the EPA works with the responsible parties to provide the additional time and flexibility to do all the required work that remains outstanding. That being said, there is one thing that is immediately critical to the ultimate success of any remedy: First, all sources must be controlled to the maximum extent practicable. National Grid is actively addressing its MGP sites along the Canal. This first and most basic principle of remediation requires that the CSOs, all other discharge pipes, and all uplands sources be identified and characterized and that a long-term plan be put in place that will finally end these sources of contamination.

To succeed, these controls must be implemented before any remedy construction work begins. The critical source control plan must be designed around control measures that have been demonstrated to be effective. To the extent interim controls are required, they too must be identified and their efficacy clearly documented. If the EPA and the City of New York determine that CSO discharges cannot be fully controlled, then we must understand the extent to which these discharges will continue as ongoing sources of contamination. The remedy must be designed to accommodate those influences and the performance standards measuring success of the remedy must realistically account for these ongoing sources. Lastly, the final depths of the Canal needs to be optimized to the ultimate operation and flow rates of the flushing tunnel to ensure both cap stability and to maximize the ability of the flushing tunnel to remove sediments and maintain acceptable DO levels.

Once source control is accomplished, sediment remediation work can go forward: In those areas requiring a bank to bank dredge, private parties who own bulkheads and who allowed them to decay must bring their property up to code; the various sediments and areas of the Canal with their differing characteristics, must all be evaluated and accounted for; and future use of the Canal must be considered and perhaps re-visited. As discussed previously, the final design of the cap will need to balance a number of competing priorities including optimal geometry to avoid sediment deposition and recontamination of the cap, operation of the flushing tunnel to avoid destruction of the benthic sand layer and t commercial navigation in the upper reaches of the Canal.

Finally, there are the "nuts and bolts." The remedy, in whatever form it eventually takes, is going to be a challenge for this community for years with, among other things, dislocation, odors, and noise. Controls for these challenges need to be worked into the final remedy. Basic construction components must also be more fully fleshed out. National Grid's experts explain that sheet pile enclosures, underwater debris removal, groundwater deflection and mounding, dredge production and throughput, treatment, and disposal all pose serious challenges that need better planning and coordination. Given the highly congested, urban environment, even things like simple physical access to the Canal and the availability of nearby land for staging and treatment still need to be evaluated carefully.

All of the issues outlined in these comments must be the subject of many good faith conversations among all of the stakeholders and parties. National Grid started the conversation long ago by cooperating with EPA and other authorities to address its upland MGPs (currently a work in progress) and to undertake informative studies. National Grid is continuing the conversation with these comments and with the expert comments that are attached. It is our hope that EPA will reply with a concerted effort to control all sources, a planning approach that allows sufficient flexibility and timing to allow National Grid and other responsible parties to continue the needed work, and with an open mind to let available experts assist in designing the remedy.

To that end, National Grid requests that EPA incorporate the following concepts into the ROD:

- The ROD should acknowledge that the operational status of the Canal will change dramatically over the next decade in ways that are not fully predictable, and allow flexibility in the design and implementation of the remedy to accommodate these changes.

- The ROD should require an assessment of navigational uses of the Canal with the aim of striking the proper balance between commercial traffic and restoration of ecological conditions. Baird & Associates believes deep draft commercial navigation creates formidable challenges to maintaining cap integrity and ecological recovery in RTAs 1, 2, and 3a.

- The ROD should allow flexibility to incorporate soft sediment capping, ISS of soft and native sediments, different types of capping in different areas of the Canal, and other similar technologies, all based on evaluations during the remedy design.

- The ROD should provide a framework and reasonable schedule for coordinating the regulatory programs responsible for upland site remediation with the CERCLA remedy proposed for the Canal to ensure that, to the maximum extent practicable, upland sources are controlled before construction begins on the remedy.

- The ROD should provide a framework and approach to mitigate and control potential contaminant discharge to the Canal of all permitted and unpermitted pipe discharges including storm sewers to avoid failure of the remedy to achieve sustainable water quality improvement.

- Since remedy success is dependent on the implementation of CSO controls, the ROD should clearly show how a reduction in volume and toxicity from the CSO discharges will be achieved. The ROD should present clear calculations on the future projected volume of contaminants entering the Canal, address the uncertainty associated with the "presumed" future scenarios, and provide estimates of contaminant loading under interim and long term sediment control measures.

- Control of all sources, including the CSOs, should be implemented to the maximum extent practicable prior to the Canal-wide remedy, to prevent recontamination of the "clean surface."

- The ROD should acknowledge the use of modeling – both hydrodynamic and groundwater – during the design to optimize the remedy based on variations in different segments of the Canal and flow conditions after the re-start of the flushing tunnel.

- The ROD should acknowledge the chemical, structural and ecological differences in RTA 3b. The remedy for RTA 3b should be re-evaluated and less-intrusive alternative approaches including hot spot removal and monitored natural attenuation should be considered, especially given that RTA 3b represents nearly 50 percent of all sediments slated for removal in the PRAP.

- The ROD should specify that the performance of the remedy will be based on the post-remedy operation of the Canal. Post-remedy ongoing discharges of pollutants must be realistically accounted for. Performance standards for the remedy should be developed for both the remedial systems designed to control and isolate releases from historical sources, and the impacts from ongoing discharges associated with CSOs and storm sewers. Performance standards should be adapted as conditions in the Canal change.

The Gowanus Canal remedy presents an opportunity to address an age-old problem of our urban waterways. The EPA has seized this opportunity with the Gowanus PRAP and started the much needed dialogue. Now, the EPA must start the hard work that could very well shape a new direction for sediment sites. Given the significance of the Gowanus, EPA and the parties must work together to control sources, plan, and study. This work, however, must be grounded in sound science and engineering practicality and follow a common vision with stakeholders finding areas of compromise to achieve a successful result.

In addition, if all sources are able to be controlled in true working fashion, the EPA should pursue all means to make that happen and National Grid will certainly do its part. If, however, full source control is not practical, alternative means must be taken to arrive at the best solution possible. Under either scenario, the ROD must employ an adaptive management approach that will identify interim and long range controls that are realistic, allow sufficient time and flexibility to analyze the effects of such controls while at the same time planning out the rest of the remedy, and encourage equally effective and more efficient alternatives in order to optimize the remedy that is ultimately selected.

National Grid thanks the EPA for their consideration.

LIST OF ACRONYMS

AIS	Automated Identification System
ARAR	Applicable or Relevant and Appropriate Requirements
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CDF	Combined Disposal Facility
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC	Contaminant of Concern
CSO	Combined Sewer Overflow
CSTAG	Contaminated Sediment Technical Advisory Group
CWA	Clean Water Act
CY	Cubic yards
DEC	New York State Department of Environmental Conservation
DEP	New York City Department of Environmental Protection
DO	Dissolved oxygen
EDC	Endocrine Disrupting Compounds
EPA	United States Environmental Protection Agency
FS	Feasibility Study
GEI	GEI Consultants, Inc.
ISS	In-Situ Stabilization
IWTU	Pore Water Toxic Units
LTCP	New York City's Long Term Control Plan
mg/kg	milligram per kilogram
mg/L	milligram per Liter
MGP	Manufactured Gas Plant
NAPL	Non-Aqueous Phase Liquid
NCP	National Contingency Plan
PAH	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PPCPs	Pharmaceuticals and Personal Care Products
PRAP	Proposed Remedial Action Plan
PRG	Preliminary Remediation Goal
RAO	Remedial Action Objectives
RI	Remedial Investigation
ROD	Record of Decision
RTA	Remedial Target Area
SPME	Solid Phase Micro-Extraction
SVOCs	Semi-Volatile Organic Compounds
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
VIS	Vessel Impact Study
VOCs	Volatile Organic Compounds
WWFP	Waterbody/Watershed Facility Plan

REFERENCES

Baird Inc. (2012). Vessel Impact Study Report, Gowanus Canal. Prepared for National Grid. December 2012.

Boehm, P.D. (2006). Polycyclic Aromatic Hydrocarbons. Chapter 15 in Environmental Forensics – A contaminant-specific approach, R. Morrison and B. Murphy, Eds. Elsevier, New York.

Bridges, O. (2003). Double trouble: health risks of accidental sewage release. Chemosphere 52:1373-1379.

CH2M Hill (2011). Feasibility Study, Gowanus Canal. Prepared for the U.S. Environmental Protection Agency. December 2011.

CH2M Hill (2012). Feasibility Study Report Addendum, Gowanus Canal. Prepared for U.S. Environmental Protection Agency, EPA. December 2012.

Climate Change Adaption in New York City. Building a Risk Management Response. New York City Panel on Climate Change 2010 Report. Annals of the New York Academy of Sciences, Volume 1196.

DEP (2008). Gowanus Canal Waterbody/Watershed Facility Plan Report. NYCDEP, Bureau of Engineering Design & Construction. City-Wide Long Term CSO Control Planning Project. August 2008.

Environmental Data Resources, Inc. (EDR) (2009). EDR: Gowanus Canal, Kings County NY Report, September 14, 2009, Inquiry # 02588067.1r

EPA (2003). Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures. EPA/600/R-02/013. November.

EPA (2011). Draft Gowanus Canal Remedial Investigation Report. Prepared by Henningson, Durham & Richardson Architecture & Engineering, P.C., in association with HDR Engineering, Inc. (HDR) and CH2M HILL. January.

EPA (2012a). CSTAG Recommendations on the Gowanus Canal Superfund Site. January.

EPA (2012b). Superfund Proposed Plan, Gowanus Canal Superfund Site, Kings County, New York. December.

GEI (2009). Remedial Investigation Technical Report Gowanus Canal, Brooklyn, New York AOC Index No. A2-0523-0705. Submitted to: DEC on behalf of National Grid.

GEI (2011a). Sediment and Surface Water Sampling Winter Summary Report: Gowanus Canal Superfund Site. October 2011.

REFERENCES (continued)

GEI (2011b). Groundwater Model Report, Gowanus Canal Superfund Site, Brooklyn, New York, EPA ID# NYN000206222, GEI Consultants, Inc., December 2011.

GEI (2012a). Sediment and Surface Water Sampling Summer Summary Report: Gowanus Canal Superfund Site. July 2012.

GEI (2012b). Sediment and Surface Water Sampling Spring Summary Report: Gowanus Canal Superfund Site. December 2012.

Hawthorne, SB, Grabanski CB, Miller DJ, Kreitinger JP (2005). "Solid-Phase Microextraction Measurement of Parent and Alkyl Polycyclic Aromatic Hydrocarbons in Milliliter Sediment Pore Water Samples and Determination of KDOC Values." Environ. Sci. Technol. 39: 2795-2803.

Hawthorne, SB, Azzolina NA, Neauhauser EF, Kreitinger JP (2007). "Predicting Bioavailability of Sediment Polycyclic Aromatic Hydrocarbons to Hyalella azteca using Equilibrium Partitioning, Supercritical Fluid Extraction, and Pore Water Concentrations." Environ. Sci. Technol. 41: 6297-6304.

Menzie, C.A., Hoeppner, S.S., Cura, J.J., Freshman, J.S., and Lafrey, E.N. (2002). Urban and Suburban Stormwater Runoff as a source of Polycyclic Aromatic Hydrocarbons (PAHs) to Massachusetts Estuarine and Coastal Environments. Estuaries. Vol. 25, No. 2, p. 165- 176, April.

Nadeau, S., Skaggs, Jr., M. (2007). Analysis of Recontamination of Completed Sediment Remedial Projects. Proceedings of the Fourth International Conference on Remediation of Contaminated Sediments, Savannah, Georgia. ISBN 978-1-57477-159-6, published by Battelle Press, Columbus, OH. January 2007.

Newfields (2007). Environmental Forensic Investigation, Gowanus Canal. Prepared for National Grid (formerly KeySpan Corporation). March 2007.

New York City (2010). Climate Change Adaptation in New York City. Building a Risk Management Response. New York City Panel on Climate Change 2009 Report. Annals of the New York Academy of Sciences, Volume 1196.

Pizzo, A., Chellini, E., Costantini, A. 2011. Lung cancer risk and residence in the neighborhood of a sewage plant in Italy. A case-control study. Tumori 97:9-13.

Stein, Eric D. et al. (2006). Watershed-Based Sources of Polycyclic Aromatic Hydrocarbons in Urban Storm Water. Environmental Toxicology and Chemistry, Vol. 25, No. 2, pp. 373–385.

Thorn, J., Kerekes, E. (2001). Health effects among employees in sewage treatment plants: a literature survey. American Journal of Industrial Medicine 40:170-179.

REFERENCES (continued)

Valle, S., Panero, M.A., and Shor, L. (2007). Pollution prevention and management strategies for polycyclic aromatic hydrocarbons in the New York/New Jersey Harbor. New York Academy of Science, New York, New York. September.

Wild, P., Ambroise, D., Benbrik, E., Tiberguent, A., Massin, N. 2005. Mortality among Paris sewage workers. Occupational and Environmental Medicine 63:168-172.

Yang, Y., Van Metre, P.C., Mahler, B.J., Wilson, J.T., Ligouis, B., Razzaque, M, M., Schaeffer, D.J., and Werth, C.J. (2010). Influence of coal-tar sealcoat and other carbonaceous materials on polycyclic aromatic hydrocarbon loading in an urban watershed. Environmental Science and Technology, 44, 1217 – 1233.

Yunker, M.B., Macdonald, R.W., Vingarzan, R., Mitchell, R.H., Goyette, D., and Sylvester, S. (2002). PAHs in the Fraser River basin: a critical appraisal of PAH ratios as indicators of PAH sources and composition. Organic Geochemistry 33, 489 – 515.

Appendix A

List of submittals for the Gowanus Canal Administrative Record

Appendix A

List of submittals for the Gowanus Canal Administrative Record

Document Title	Date	Sent To	Sent By
Investigation Report	12/29/2009	Hank Willems NYSDEC	GEI on behalf of T. Bell National Grid
Email – Revised Scope of Work for Monitoring Well Work plan	5/18/2010	Christos Tsiamis USEPA	T. Bell National Grid
Email – Gowanus – Draft EPA Monitoring Well Work Plan FSP/QAPP/HASP Documents for Review	5/18/2010	Christos Tsiamis USEPA	T. Bell National Grid
Email – Gowanus – Draft EPA Monitoring Well Work Plan & Transmittal Letters	5/18/2010	Christos Tsiamis USEPA	T. Bell National Grid
Phase 3 Remedial Investigation Technical Approach - comment letter to USEPA	5/19/2010	Christos Tsiamis USEPA	T. Bell National Grid
Email – Monitoring Well installation Work Plan, Gowanus Canal Superfund Site	6/17/2010	Christos Tsiamis USEPA	B. Conte GEI on behalf of National Grid
Monitoring Well Installation Work Plan	6/17/2010	Christos Tsiamis USEPA	D. Terry GEI on behalf of National Grid
Email – Updated monitoring Well Installation Work Plan, Gowanus Canal Superfund Site	6/22/2010	Christos Tsiamis USEPA	B. Conte GEI on behalf of National Grid
CSO/Gowanus Canal Pathogen Sampling Scope of Work	7/8/2010	Christos Tsiamis USEPA	M. Felter GEI on behalf of National Grid
Groundwater Model Work Plan - letter	9/13/2010	Christos Tsiamis USEPA	T. Bell National Grid
Surface Sediment Sampling Plan - letter	9/13/2010	Christos Tsiamis USEPA	T. Bell National Grid
Email – Gowanus Canal electronic submittal of groundwater and soil chemistry data	10/14/2010	Christos Tsiamis USEPA	T. Bell National Grid
Email – Gowanus pharmaceutical Electronic Data Deliverables	10/21/2010	Christos Tsiamis USEPA Andrew Judd CH2MHill	J. Wargo GEI
Health and Safety Plan (HASP) Gowanus Canal	11/23/2010	Christos Tsiamis USEPA	D. Terry GEI on behalf of National Grid
Monitoring Well Installation and Sampling Report	11/23/2010	Christos Tsiamis USEPA	D. Terry and M. Felter GEI on behalf of National Grid
Email – signature page Gowanus Canal HASP	11/24/2010	Christos Tsiamis USEPA	M. Felter GEI on behalf of National Grid
Email – Surface water and sediment sampling location map and Sampling Schedule	1/10/2011	Christos Tsiamis USEPA	M. Felter GEI on behalf of National Grid

Appendix A

List of submittals for the Gowanus Canal Administrative Record

Document Title	Date	Sent To	Sent By
Baird Modeling Report	4/10/2011	Christos Tsiamis USEPA	W.F. Baird & Associates
CSO/Gowanus Canal Sampling and Screening-Level Risk Assessment Report - letter	4/28/2011	Christos Tsiamis USEPA	D. Terry and M. Felter GEI on behalf of National Grid
Concept for Combined Dredging/Capping Remedy Memo	7/25/2011	Christos Tsiamis USEPA	M. Palermo - Palermo Consulting
Memorandum: Revisions to the Gowanus Canal Superfund Site Surface Water and Sediment Sampling Schedule and QAPP Revision 2	8/11/2011	Christos Tsiamis USEPA Andrew Judd CH2MHill	D. Terry GEI on behalf of National Grid
Flow, Sediment Transport and Groundwater Modeling During the Remedial Design Process	09/11	USEPA	W.F. Baird & Associates
Email – access to Gowanus Canal Property GIS Database	9/16/2011	Christos Tsiamis, Brian Carr USEAP	D. Terry GEI on behalf of National Grid
Gowanus Canal Superfund Site Numerical Surface Water Modeling	10/4/2011	Christos Tsiamis USEPA	Prepared by W.F. Baird; transmitted by GEI on behalf of National Grid
Gowanus Canal Superfund Site - letter	10/4/2011	Christos Tsiamis USEPA	T. Bell National Grid
December 2010 Bathymetry Data - letter	10/19/2011	Christos Tsiamis USEPA	D. Terry and M. Felter on behalf of National Grid
CSTAG Review - letter	10/20/2011	Christos Tsiamis USEPA	C. Willard - National Grid
Sediment and Surface Water Sampling Winter Summary Report	10/28/2011	Christos Tsiamis USEPA	M. Felter GEI on behalf of National Grid
Gowanus Canal RI/FS Process Presentation to EPA CSTAG	11/3/2011	USEPA	National Grid
Groundwater Model Report	12/22/2011	Christos Tsiamis USEPA	D. Terry and M. Felter on behalf of National Grid
National Grid - NYCDEP CSO Flow and Sediment Data Request	4/20/2012	Christos Tsiamis USEPA	T. Bell National Grid
CSO Sediment Lines of Evidence	4/21/2012	Christos Tsiamis USEPA	T. Bell National Grid
Gowanus Canal - Letter	4/24/2012	Walter Mugdan USEPA	R. Teetz National Grid
Geotechnical Investigation Work Plan for Cap Design	4/24/2012	Walter Mugdan USEPA	R. Teetz National Grid
In-Situ Solidification Treatability Study Work Plan	4/24/2012	Walter Mugdan USEPA	R. Teetz National Grid
QAPP Rev 0 Gowanus Canal Superfund Site	4/24/2012	Walter Mugdan USEPA	R. Teetz National Grid

Appendix A

List of submittals for the Gowanus Canal Administrative Record

Document Title	Date	Sent To	Sent By
Geotechnical Investigation Work Plan for Dredging and Cap Design	5/9/2012	Christos Tsiamis USEPA	A. Prophete National Grid
Presentation - Gowanus Canal - PAH Discussion	5/9/2012	USEPA	GEI and Exponent
National Remedy Review Board Site Review - letter to Amy Legare	6/1/2012	Amy Legare USEPA	R. Teetz National Grid
Email – CSO investigation work plan – response to comments	6/5/2012	Christos Tsiamis USEPA	T. Bell National Grid
Email – CSO Investigation Work Plan Gowanus Canal Superfund Site	6/5/2012	Christos Tsiamis USEPA	T. Bell National Grid
Gowanus CSO Sampling QAPP Rev 0	6/6/2012	Christos Tsiamis USEPA	M. Felter GEI on behalf of National Grid
Email – Sed Flume Results (Appendix A of pending Baird Hydrodynamic model report)	6/7/2012	Christos Tsiamis USEPA	T. Bell National Grid
List of Data Requests from National Grid to NYCDEP	6/22/2012	Christos Tsiamis USEPA	T. Bell National Grid
NYSDEC comments to National Remedy Review Board Site Review - letter to Amy Legare	6/28/2012	Amy Legare USEPA	R. Teetz National Grid
Sediment and Surface Water Sampling Summer Summary Report	7/25/2012	Christos Tsiamis USEPA	M. Felter GEI on behalf of National Grid
Gowanus CSO Sampling QAPP Rev 1	7/5/2012	Christos Tsiamis USEPA	M. Felter GEI on behalf of National Grid
Information request letter to Walter Mugdan	7/6/2012	Walter Mugdan USEPA	R. Teetz National Grid
Revised CSO Investigation Work Plan	9/10/2012	Christos Tsiamis USEPA	V. Spada Woodard & Curran
Email – response to comments on additional data collection for Hydrodynamic Model	10/19/2012	Christos Tsiamis USEPA	T. Bell National Grid
Gowanus Canal Numerical Surface Water Modeling Phase 1 Report	10/22/2012	Christos Tsiamis USEPA	Prepared by W.F. Baird; transmitted by T. Bell National Grid
Email – Additional data collection for hydrodynamic model	11/2/2012	Christos Tsiamis USEPA	T. Bell National Grid
Email – two technical memoranda from Baird and Mutch Associates responding to the Louis Berger Group's presentations to EPA regarding origin of sediments in the Gowanus Canal	11/7/2012	Christos Tsiamis USEPA	D. Terry GEI on behalf of T. Bell National Grid
Baird Vessel Impact Study	12/14/2012	Christos Tsiamis USEPA	T. Bell National Grid
Gowanus Spring Sediment and Surface Water Sampling Summary Report	12/21/2012	Christos Tsiamis USEPA	K. Bradley GEI on behalf of National Grid

Appendix B

Draft Comments on Gowanus PRAP and Geotechnical Investigation of Gowanus Canal Sediments: NAPL Expression, prepared for National Grid, by Dr. Danny Reible.

Correspondence

Danny Reible
10300 Indigo Broom Loop
Austin, TX 78733

Date: April 23, 2013

Re: **Gowanus Canal Superfund Site Proposed Remedial Action Plan**

I submit the following comments on the United States Environmental Protection Agency (EPA) Proposed Remedial Action Plan (PRAP) for the Gowanus Canal.

I am a Board Certified Environmental Engineer with a Bachelor of Science in Chemical Engineering from Lamar University, and a Master of Science and Doctorate in Chemical Engineering from the California Institute of Technology. I am a Fellow of the American Institute of Chemical Engineers and the American Association for the Advancement of Science. In 2005, I was elected to the National Academy of Engineering for "the development of widely used means of managing contaminated sediments"

I am the Bettie Margaret Smith Chair of Environmental Health Engineering in the Department of Civil, Architectural and Environmental Engineering and Director of the Center for Research in Water Resources at the University of Texas.

I have coauthored four National Research Council committee reports on risk assessment and remediation of contaminated sites and have written two textbooks, Fundamentals of Environmental Engineering and Diffusion Models of Environmental Transport, and edited four other texts including one focused specifically on the management of contaminated sediments. I have published more than 150 journal papers and chapters in books.

Within the area of contaminated sediments I am most recognized for my work on the design and assessment of sediment capping alternatives.

I have reviewed the PRAP and agree with my colleague, Dr. Michael Palermo, that more study and work remains to be done before a final alternative is selected. Based on my experience, capping options exist (i.e., capping soft sediment) that have not been adequately considered by the EPA.

(1) Alternatives were ruled out prematurely

Although the PRAP proposes seven alternative remedial plans, only two, alternatives five and seven, were retained. Alternatives two and three involved partial sediment removal and a conventional cap (alternative two) or a treatment layer with a conventional cap (alternative three). Alternatives four and six involved dredging of the entire soft sediment column and conventional capping (alternative four) or stabilization (alternative six). Alternatives two and three were rejected because of concerns about the technical challenges of capping over low strength sediments, and possible destabilization of non-aqueous phase liquid (NAPL). Alternatives four and six were rejected because they did not include a treatment layer.

I believe these alternatives were screened out prematurely. Capping is the primary means of achieving remediation of the Canal, but the specific form of capping that is most appropriate and effective is not yet clear based on the currently available site data. Accordingly, those options that have been screened out should not have been. For example, in portions of the Canal it is likely that even alternative two (conventional capping) will be effective. It is also unclear if any of the remedial alternatives that focused solely on the sediment will achieve the desired risk reduction in the Canal. Passive or active management of groundwater contamination may be required to achieve a lasting sediment remedy. More site-specific information needs to be obtained and more analysis needs to be performed before creating and selecting among the various alternatives.

Lastly, to the extent the PRAP cities my own work (Reible, 2005) as a basis for screening out alternatives, I respectfully submit that my work suggests only that the alternatives that were screened out might require additional assessment and/or modified construction methods for successful implementation.

Although the PRAP is correct that the low bearing capacity of soft, fine-grained sediment with high water content makes capping difficult, it by no means makes it impossible. The soft sediments in the Gowanus Canal that we have examined often contain significant quantities of sand and exhibit water contents of less than 50% (total sample basis). This does not suggest that the sediments are particularly soft and unlikely to be successfully capped. Caps have been placed on sediments with essentially no sand content and far higher moisture contents. Conventional techniques (bucket placement) were used on soft sediments in the Anacostia River (Reible, Lampert et al. 2006). Slurry placement has also been used at a number of sites where soft sediments were of concern (e.g. Silver Lake, Massachusetts; Soda Lake, Wyoming; Roxana Marsh, Indiana; Onondaga Lake, New York). Special techniques have also been adapted for sediments that have had no measurable shear stress or bearing capacity. Low density material and placement using minimum disturbance approaches were used in Welch Creek in North Carolina over exceedingly soft and weak contaminated sediments.

To the extent there is concern that capping the soft sediment could destabilize NAPL present in the sediment, such concern is over-emphasized. Past experience at a variety of contaminated sediment sites suggests that NAPL has often weathered prior to remedial evaluation such that it is largely immobile due to loss of more mobile, lower viscosity constituents as well as loss of any NAPL greater than residual saturations. "Could destabilize” is not “will destabilize" and NAPL mobility and expression as a result of capping should have been assessed.

To the extent that alternatives two, four, and six were rejected because “an armored sand cap is not sufficient to control the long-term flux of NAPL and dissolved-phase contaminants,” alternative six includes stabilization of the top three to five feet of native sediment. Such treatment has the potential to eliminate long-term flux of NAPL and substantially reduce the flux of dissolved-phase contaminants. Furthermore, I am unaware of any definitive analysis that suggests that such a cap would not work in at least portions of the Gowanus Canal. To the contrary, in the Pine Street Canal (Burlington, Vermont) a sand cap was placed over very soft NAPL contaminated sludges and with the exception of a single location where the sludges were the weakest and thickest, the cap has been effective. As an added precaution, organophilic clay was added to contain the NAPL where the sand cap was not effective. At the Gowanus Canal, it is certainly possible, if not likely, that an armored sand cap may be effective over at least portions of the Canal and that amendments to manage NAPL or dissolved contaminant flux may be needed only in portions of the Canal. This was apparently not quantitatively assessed prior to the screening out of such remedies from the Canal. A proper evaluation of NAPL mobility via in situ and laboratory testing in conjunction with groundwater modeling will be required to make informed decisions on cap components.

(2) Cap integrity

Ensuring cap integrity is a key component of cap design and construction. Without detailed assessment of the potential risks of cap failure and the resulting contaminant exposure, it is difficult to evaluate the different alternatives. Again, the decision to rule out alternatives appears to have been made prematurely without assessment of the variations in effects along the length of the Canal of reactivation of the flushing tunnel, combined sewer overflows, and continued navigation in the Canal. Stormwater flows may cause sediment resuspension and the contaminant loads associated with such flows may lead to substantial recontamination of sediments. Current commercial navigation in portions of the Canal likely cause substantial sediment and contaminant resuspension. It is unclear if continued commercial navigation in the upper 2/3 of the Canal is consistent with long-term sediment remedial goals under any of the PRAP alternatives. The flushing tunnel will also likely necessitate substantive differences in remedial design in the upper reaches of the Canal compared to the rest of the Canal.

(3) Required studies and work

The following data collection approaches, which are well known and have become standard since 1998 when they were outlined in the EPA Capping Guidance (Palermo, Maynord et al. 1998), are critical to selection, design, and implementation of any capping remedy, and should be followed here:

(a) Identify the remedial objective. The Canal faces multiple inputs including uncontrolled groundwater, combined sewer overflows, stormwater, and releases from sediment. Moreover, current plans for the Canal include reactivation of the flushing tunnel and continued navigation that could lead to erosion and thus undermine the remedy. Evaluation of the hydrodynamics of the Canal under future use and operating scenarios (e.g. flushing tunnel and commercial navigation) is needed to effectively address these questions.

(b) Identify the geotechnical characteristics of the sediment layer to be capped. The degree to which the soft sediments can form a foundation for a cap, the ability to stabilize and solidify these sediments in-place, and their stability under flushing tunnel and commercial navigation operations, is unknown. Variation in these properties over the length of the Canal and how that variation might affect remedial designs is also unknown. Among the testing required to address these questions are geotechnical testing (strength, consolidation, NAPL and contaminant expression) (Erten, Gilbert et al. 2011) over the length of the Canal and solidification testing of particular Canal sediments for strength and contaminant control.

(c) Identify contaminant physical characteristics, concentrations, and fluxes. Although sampling to date has identified contaminant concentrations in sediments and confirmed the presence of NAPL, additional testing is needed to evaluate mobile phases (dissolved or NAPL), mobile phase concentration (porewater or mobile NAPL concentration), and fluxes (groundwater and contaminant fluxes). Since the phase of concern and fluxes are expected to vary widely over the length of the Canal and with depth into the sediments, characterization is critical at those portions of the Canal and at depth horizons that might contribute to surface fluxes after partial implementation of a remedy. Until studied and known, these issues pose significant uncertainties for cap design and could ultimately determine whether sediment remediation in any form should be pursued,

(d) Identify potential capping materials and their characteristics, including any amendments that might be necessary to effectively contain contaminants. The characteristics of a cap (stability, chemical containment) are a strong function of the available capping materials. The need for any amendment material to enhance performance of a cap also depends upon the foundation cap materials and their characteristics. Lastly, the performance of many specific cap amendments, including organophilic clay for NAPL containment and carbon (manufactured or natural carbons) for dissolved contaminant mitigation are strongly site dependent and require site specific testing to evaluate their expected performance and feasibility.

(e) Design cap thickness and composition. The information outlined above will help inform a cap design. The selection of cap materials and conceptual design, however, also require modeling of consolidation and NAPL expression during cap loading and modeling of chemical migration through specific cap compositions to identify potentially effective caps and their viability in the Canal. Key questions that remain are whether a cap can be effective in the environment of the Canal or whether any sediment remedy may achieve remedial goals given ongoing sources and the potential for recontamination.

(f) Evaluate potential erosive forces that might impact a cap and the resulting impacts on cap design. A critical component of the design of a cap in the Gowanus Canal is the integration into future uses and operation of the Canal. The ability to cap the Canal is dependent upon the erosive forces generated by future commercial navigation and the operation of the flushing tunnel and is a strong function of water depth. It is far from clear that the proposed sediment remedy can work in conjunction with the current plans for the flushing tunnel and continued navigation. The evaluation of future use and operating scenarios must be coupled with analysis of potential cap designs.

(g) Evaluate appropriate equipment and placement techniques. The Canal currently poses significant logistical challenges to a large-scale sediment remedial project. All of the challenges identified, such as access, open space for staging, and clearances and space for work, will also make it difficult to cap as desired.

(h) Iterate as necessary to finalize the design. It is to be expected that the analysis outlined above, will result in design requirements that are incompatible with the proposed plan, and thus iteration will be required, which will require more analysis, and which will require more time.

(i) Implement the design. Regardless of repeated iteration and analysis, significant uncertainties will remain that can only be managed during implementation so long as flexibility and adaptive management are allowed.

(j) Monitor performance and apply adaptive management as necessary to achieve remedial goals. Given the uncertain status and effects of components like control of ongoing sources, reactivation of the flushing tunnel, and future navigation within the Canal, adaptive management becomes even more critical to evaluate cap performance. In general, the focus should be on measures of available and mobile contaminants rather than bulk solids, which is not particularly useful to address cap performance (e.g .Lampert, Lu et al. 2013).

Conclusions

My review of the PRAP and my knowledge and experience with contaminated sediment management suggests the following

- The PRAP prematurely rejects capping upon soft sediments and sediments containing NAPL, and arbitrarily removes from consideration alternatives that involve capping directly on soft sediments or after partial dredging of the soft sediments.
- The PRAP focuses on the sediments rather than on potential sources of recontamination such as combined sewer overflows, stormwater, groundwater, and sediment resuspension due to commercial navigation and the flushing tunnel. Failure to consider these effects may limit the ultimate success of any remedial alternative. The PRAP does not recognize the critical importance of groundwater on long-term effectiveness of any sediment remedy and the need to integrate groundwater management with in-Canal remedies.
- The PRAP does not recognize that there exists a variety of different conditions within the Canal that may encourage selection of one or more of the alternatives screened out.
- Further assessment and evaluation is required before I could recommend any particular remedial approach and have any confidence in its appropriateness and effectiveness.

References

Erten, M. B., R. B. Gilbert, C. S. El Mohtar and D. D. Reible (2011). "Development of a laboratory procedure to evaluate the consolidation potential of soft contaminated sediments." ASTM geotechnical testing journal 34(5): 467-475.

Lampert, D. J., X. Lu and D. D. Reible (2013). "Long-term PAH monitoring results from the Anacostia River active capping demonstration using polydimethylsiloxane (PDMS) fibers." Environmental Science: Processes & Impacts.

Palermo, M., S. Maynord, J. Miller and D. Reible (1998). "Guidance for in6situ subaqueous capping of contaminated sediments." EPA 9056B966004.

Reible, D., D. Lampert, D. Constant, R. D. Mutch Jr and Y. Zhu (2006). "Active capping demonstration in the Anacostia River, Washington, DC." Remediation Journal 17(1): 39-53.

Danny Reible, PhD, PE, BCEE, NAE

April 1, 2013

From: Danny D. Reible, Chadi El Mohtar, Mintae Kim, Alexandre Martinez

To: GEI Consultants, Inc.
400 Unicorn Park Drive
Woburn, MA 01801

Re: **Geotechnical Investigation of Gowanus Canal Sediments: NAPL Expression**

Summary

Selected sediments samples from the Gowanus Canal were subjected to geotechnical testing for potential NAPL expression. The testing followed the methodology of Erten et al. (2011)[1]. The samples were selected on the basis of measurable NAPL content (based upon PID readings from sonic cores in the same interval) and location near the interface of the "soft" and "native" sediments in the Canal. The sediments that may be exposed after dredging and that will require capping to contain sediment contaminants. The purpose of the testing was to determine the potential for NAPL expression.

Of the three samples, two samples were fine-grained material containing 9-15% hexane extractible material (HEM, EPA Method 9071B) divided by total sample weight) or 20-32% HEM per dry solids, and one was more sandy material containing approximately 3% HEM (total basis), 4% HEM (dry solids basis). HEM is used here as a surrogate for NAPL content although HEM may overpredict NAPL content if there is significant extractible organic material in the samples. All samples were subjected to loadings equivalent to up to 10 feet of sand in five stages. No samples released meaningful quantities of NAPL as a result of this loading. One sample with a higher content of NAPL did release a non-measurable trace quantity of NAPL during loading. Significantly, no substantial NAPL was expressed even though the samples were subjected to volumetric strains (volume reduction during consolidation) of 16-18% of the fine-grained samples and 2.5-5% of the coarser samples.

This testing indicates that the methodology of Erten et al. (2011) may be used for NAPL expression testing in these sediments and that the NAPL present in the sediment samples is at a residual saturation that is unlikely to be mobilized by loading with the weight of a sediment cap. The trace amounts of NAPL expressed in one sample suggests that disturbance can release small amounts of material that could ultimately lead to sheens. Further testing is required to confirm whether these conclusions are generally applicable in the Canal.

[1] Erten, M.B., R. Gilbert, C.S. El Mohtar, D.D. Reible, Development of a laboratory procedure to evaluate the consolidation potential of soft contaminated sediments, *Geotechnical Testing Journal, 34*, 5, September (2011)

Methodology and Results

Selected sediments samples from the Gowanus Canal were subjected to geotechnical testing for potential NAPL expression. The testing followed the methodology of Erten et al. (2011)[1] which is designed to evaluate the potential for NAPL expression under loadings typical of placement of a sediment cap. Three samples were taken and designated:

- GC-B-002
- GC-B-004
- GC-B-005

These samples were selected based on testing of samples with tar impacts or elevated PID readings in sonic cores over the same tube sample interval and location near the interface of accumulated “soft” sediments and alluvial/sand “native” deposits.

Three eight-inch-long sections were cut from the bottom of each sample core and tested at the University of Texas at Austin. Four triaxial consolidation tests were performed on samples obtained from the three Shelby tubes. Iit should be noted that the tubes were subjected to some disturbance during shipping as a result of shipping while horizontal. As a result, the samples were likely to be less consolidated and the NAPL more mobile than in undisturbed cores.

Characterization of the samples included

- Density and estimated mass of dry solids based on NAPL and Water content
- NAPL, mobile organic contaminant content- Measured via EPA 9071B, Hexane Extractible Material
- Water Content- Measured by drying overnight at 105 C

Measurements were conducted on pre-consolidated samples as well as at the top, middle and bottom of consolidated cores. All measurements were conducted in triplicate although occasional samples were lost or invalidated.

Typically a Ko consolidation test is run to simulate field conditions. In a Ko consolidation test, the vertical and horizontal principle effective stresses are not equal and the ratio between the two is chosen to insure that the specimen consolidates only vertically (no lateral strains). For the soft sediments, the vertical effective stresses are usually higher than the normal effective stresses to insure Ko conditions. With only three samples it was not possible to determine the appropriate Ko value and a value of 0.7 (horizontal to vertical effective stress) was used based on previous results on soft sediment testing. This was likely lower than optimum and one sample (GC-B-005) failed horizontally during testing. Volumetric strain and NAPL displacement can still be determined although other consolidation parameters would not be estimated accurately. These parameters were estimated as part of other geotechnical testing and so this was not considered a serious limitation for the current testing.

The samples were first removed from the tube and trimmed down to the testing diameter of two inches. Figure 1 below shows the early stages of trimming on specimen GC-B-004(p1) obtained from tube GC-B-004. Note the limited presence of contaminants in samples from this tube and the heterogeneity of their distribution. Figure 2 shows specimens GCB-004(P1) and GC-B-002 after being trimmed down to testing diameter. The specimens were then placed in a second trimming device to cut off the top and bottom to insure they were parallel and perpendicular to the heigh of the specimen (Figure 3).

After trimming, the specimens were placed in the triaxial setup through a split mold (Figure 4a). Before the cell is assembled and testing begins (Figure 4b), bladder accumulaters were used to collect the effluent. General comments about the specimens and consolidation testing performed are as follows:

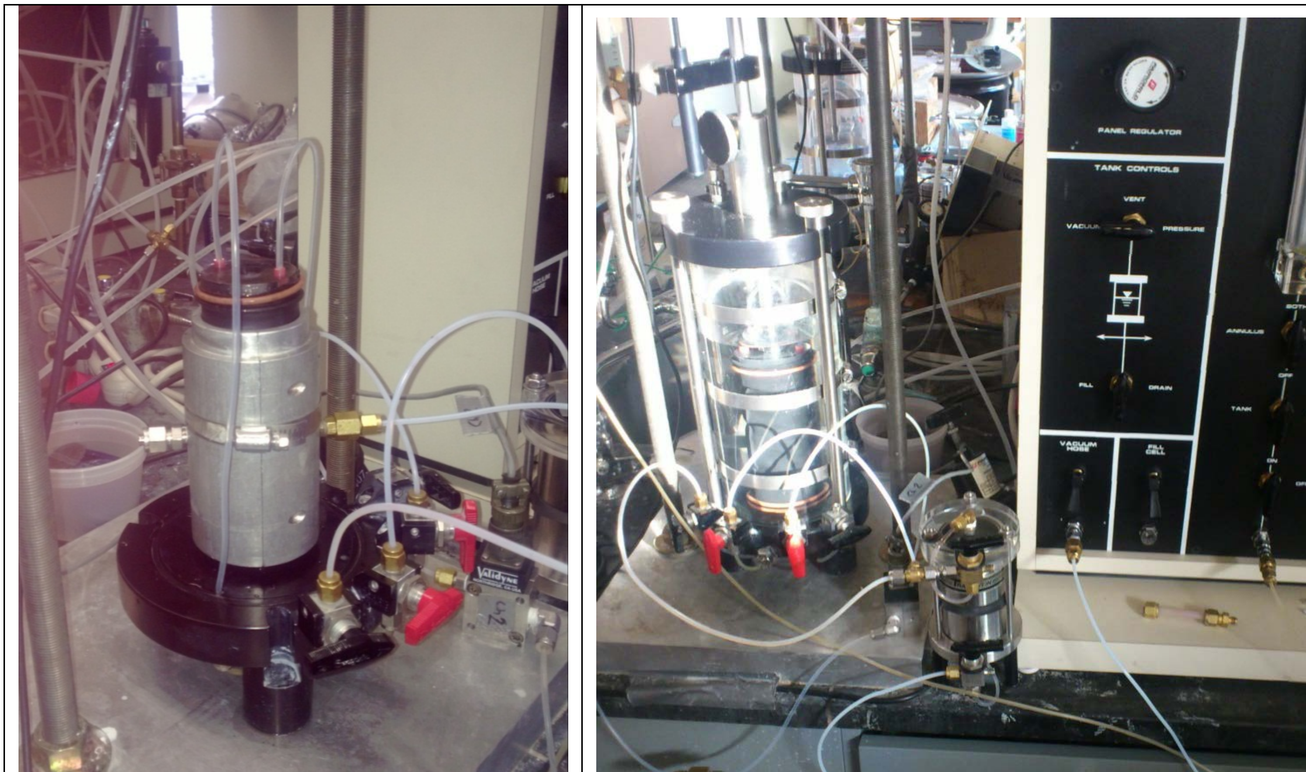
1) The samples cannot be considered undisturbed since they were not stored and shipped properly. Specimen GC-B-002 had traces of contaminents that were already expelled from the specimen due to disturbance during shipping. Since they were not undistubed, there is a higher likelihood that contaminants would be mobile.
2) Samples GC-B-002 and GC-B-005 appeared more contaminated (Figure 2b and 3). Sample GC-B-005 had more “roots” and other debris that made trimming more challenging and eventually resulted in the specimen failing during consolidation.
3) The soil in sample GC-B-004 was light brown with occasional non-uniform pockets of NAPL or other organic rich material (Figure 1). The soil was coarser than that of the other two samples, with a higher sand content.
4) Sample GC-B-002 was tested first. Due to a transducer failure, high precision consolidation information was not recorded although volume changes due to consolidation at regular intervals were recorded manually and analyzed herein.
5) With the limited number of samples, Ko could not be identified and therefore the results reported here should be used with caution as they do not reflect true Ko conditions. Additional tests are needed to determine Ko for these sediments before a true Ko consolidation can be run.

Figure 1: early stages of trimming on specimen GC-B-004(P1)

	
a) GC-B-004(P1)	b) GC-B-002

Figure 2: specimens trimmed to final diameter of 2”

Figure 3: trimming top and bottom of specimen GC-B-002.



a) Within the split mold	b) Triaxial cell assembled

Figure 4: specimen setup in the triaxial cell.

Consolidation was conducted in five stages as shown in Table 1, exposed sediment and then capped with the equivalent of up to 10 feet of sand in 2.5 foot stages. Water depth (to set hydrostatic pressures) was assumed to be 10 ft. Table 1 summarizes the stresses used for the testing and the equivalent field conditions.

Table 1: lab stresses and equivalent field conditions

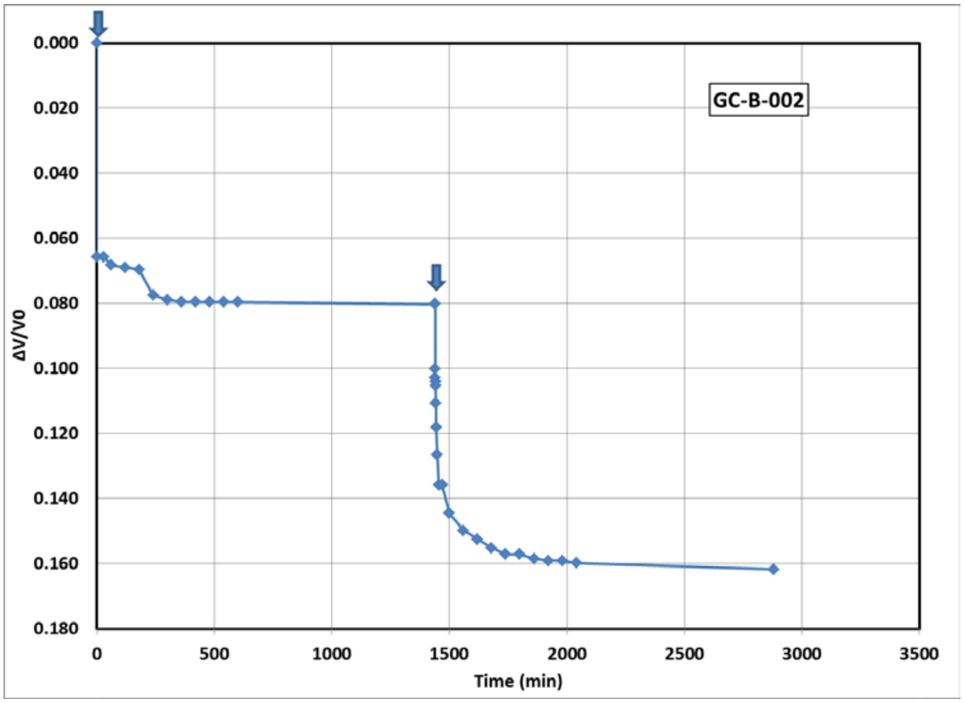
Depth to top of specimen (ft)	Thickness of sand cap (ft)	Depth of water to top of specimen (ft)	Horizontal Effective Stress (psi)	Vertical Effective Stress (psi)	Back Pressure (psi)	Horizontal Total Stress (psi)	Vertical Total Stress (psi)
2.5	-	10	0.47	0.68	5.5	5.97	6.18
2.5	2.5	10	1.31	1.88	5.5	6.81	7.38
2.5	5.0	10	2.16	3.09	5.5	7.66	8.59
2.5	7.5	10	2.95	4.21	5.5	8.45	9.71
2.5	10.0	10	3.82	5.45	5.5	9.32	10.95

The volumetric strains versus time for each of the specimens and estimated NAPL (as measured by HEM) and water contents are shown in Figures 4-7. In each figure the placement of additional load on the sample is shown by the vertical arrows. For Sample GC-B-002, the maximum load was placed in two steps while for other samples, the load was applied in 5 steps. The fine-grained sediment samples GC-B-002 and GC-B-005 showed >20% initial NAPL contents and water contents in the 70-100% range (mass NAPL or water per mass dry solids). The coarse grained sediment sample GC-B-004-1 and GC-B-004-2 showed initial oil contents of less than 5% and a water content of 25%. There was similar variability as measured by absolute standard deviation between replicates of all samples which meant that the lower NAPL content of sample GC-B-004 samples exhibited a relatively high relative standard deviation (+/- ~100%). Samples GC-B-002 and GC-B-005 samples showed similar absolute variability but much lower relative variability due to the higher NAPL/HEM contents. The fine grained samples consolidated approximately 16-18% with the loading of the equivalent of 10 feet of sand. The coarser sample consolidated <5%. None of the samples expressed meaningful amounts of NAPL. Trace observations of expressed NAPL however indicate that the sediments could lead to transient sheens if disturbed.

Post-consolidation sampling showed that some redistribution of NAPL and water had occurred in the samples despite negligible NAPL release. Water mobilized to the near surface and water was expressed from the top of the sediment during the consolidation process. NAPL, however, had apparently replaced water at the bottom of the sample. Samples collected post-consolidation from the top of the specimens showed elevated water contents and depleted NAPL levels (as measured by HEM) while bottom samples showed the reverse trends.

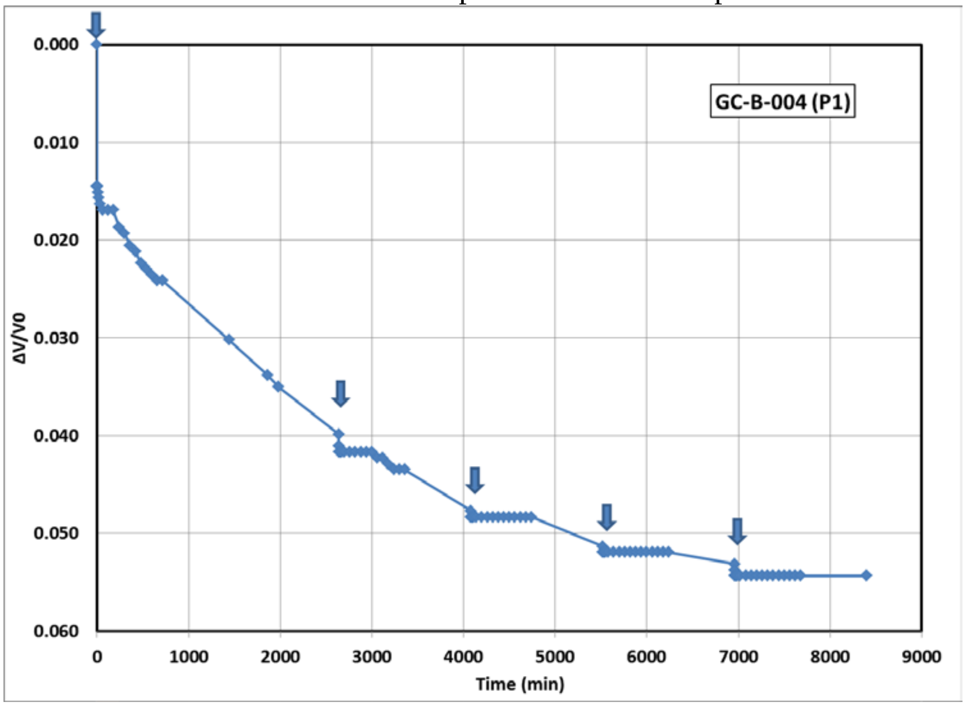
Although this testing was preliminary in nature, it suggests that the NAPL currently present in sediments in the Gowanus Canal is unlikely to be mobilized by capping. Further testing is required to confirm whether these conclusions are generally applicable in the Canal.

Figure 5: Sample GC-B-002 consolidation profile and water/NAPL content statistics pre and post consolidation. The full load of the equivalent of 10 foot of cap was placed in two steps with rapid sample consolidation immediately after application. Total sample strain was 16%. No meaningful NAPL was displaced, only water. NAPL redistributed slightly through the sample with some movement to the bottom of the sample as water was displaced.



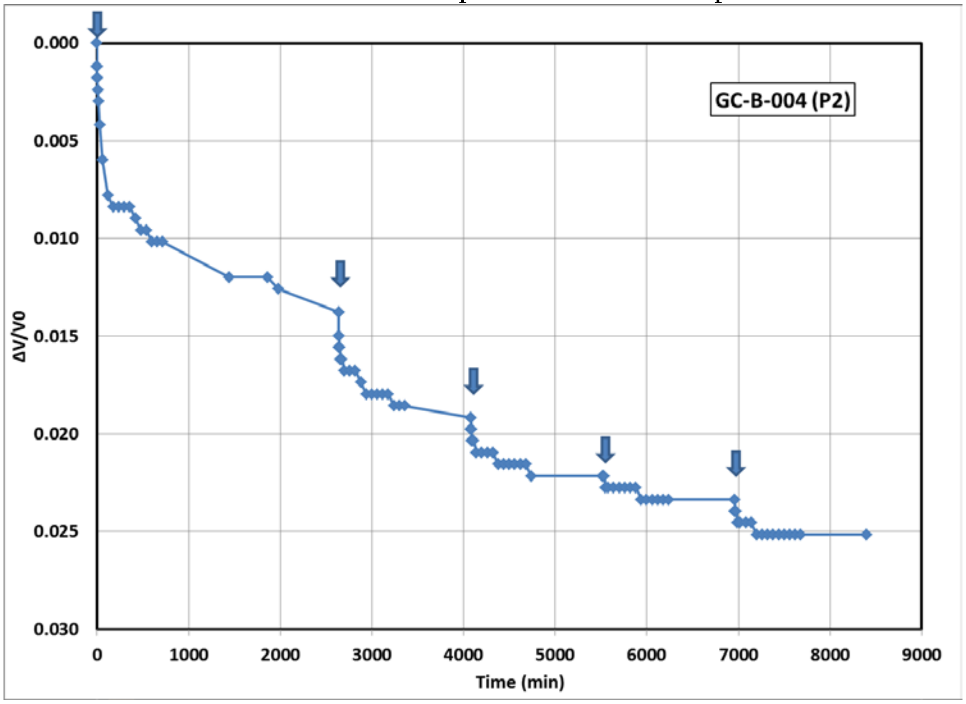
Core GC-B-002			Post Consolidation		
		Undisturbed	Bottom	Middle	Top
Density of sample	(kg/m3)wet sample	1.31	1.33	1.40	1.32
SD	+-	0.10	0.09	0.09	0.04
Water Content	g water/g sample	48.56%	37.79%	38.76%	42.27%
SD	+-	0.65%	6.97%	2.21%	1.29%
% HEM	g HEM/g sample	9.09%	13.55%	11.17%	9.61%
SD	+-	1.99%	1.91%	2.29%	0.28%
Water Content	g water/g dry solid	114.69%	77.67%	77.40%	87.86%
SD	+-	2.19%	10.05%	3.87	1.85
% HEM	g HEM/g dry solid	21.47%	27.86%	22.30%	19.97%
SD	+-	2.88%	7.48%	3.91%	1.36%

Figure 6: Sample GC-B-004-1 consolidation profile and water/NAPL content statistics pre and post consolidation. The full load of the equivalent of 10 foot of cap was placed in five steps with rapid sample consolidation immediately after application. Total sample strain was 5.5% as a result of water displacement. NAPL redistributed slightly through the sample with some movement to the bottom of the sample as water was displaced.



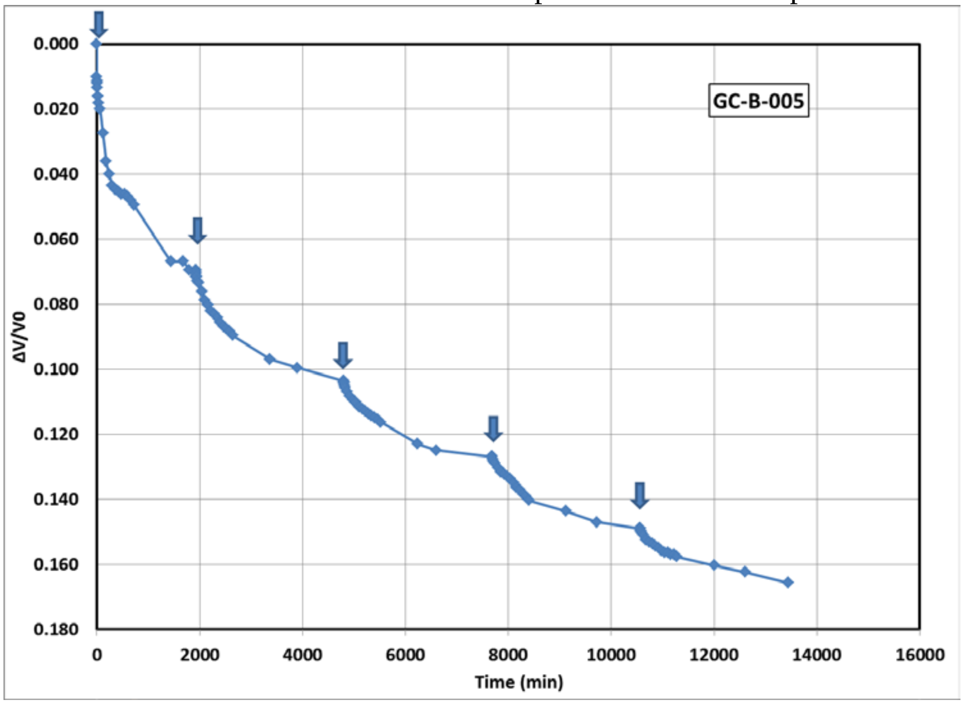
Core II : GC-B-004			Post Consolidation		
		Undisturbed	Bottom	Middle	Top
Density of sample	(kg/m3)wet sample	1.85	1.93	2.23	1.95
SD	+-	0.08	0.03	0.26	0.16
Water Content	g water/g sample	19.82%	10.13%	12.87%	13.90%
SD	+-	0.60%	0.30%	0.69%	0.27%
% HEM	g HEM/g sample	2.81%	4.96%	2.67%	1.64%
SD	+-	3.12%	3.12%	2.36%	0.04%
Water Content	g water/g dry solid	25.61%	11.93%	15.24%	16.46%
SD	+-	3.23%	3.15%	2.56%	0.39%
% HEM	g HEM/g dry solid	3.63%	5.84%	3.16%	1.94%
SD	+-	4.45%	4.42%	3.41%	0.28%

Figure 7: Sample GC-B-004-2 consolidation profile and water/NAPL content statistics pre and post consolidation. The full load of the equivalent of 10 foot of cap was placed in five steps with rapid sample consolidation immediately after application. Total sample strain was 2.5% as a result of water displacement. NAPL redistributed slightly through the sample with some movement to the bottom of the sample as water was displaced.



Core II : GC-B-004			Post Consolidation		
		Undisturbed	Bottom	Middle	Top
Density of sample	(kg/m3)wet sample	1.85	2.03	2.06	2.10
SD	+-	0.08	0.03	0.12	0.06
Water Content	g water/g sample	19.82%	17.95%	16.21%	13.71%
SD	+-	0.60%	0.54%	0.30%	0.09%
% HEM	g HEM/g sample	2.81%	5.65%	2.05%	1.70%
SD	+-	3.12%	1.79%	2.73%	0.75%
Water Content	g water/g dry solid	25.61%	23.49%	19.89%	16.21%
SD	+-	3.23%	1.95%	2.77%	0.76%
% HEM	g HEM/g dry solid	3.63%	7.40%	2.50%	2.02%
SD	+-	4.45%	2.60%	3.88%	1.07%

Figure 8: Sample GC-B-005 consolidation profile and water/NAPL content statistics pre and post consolidation. The full load of the equivalent of 10 foot of cap was placed in five steps with rapid sample consolidation immediately after application. The sample partially collapsed during the test although total sample strain was still measurable. Total sample strain was approximately 16% as a result of water displacement. NAPL redistributed slightly through the sample with some movement to the bottom of the sample as water was displaced.



Core III : GC-B-005			Post Consolidation		
		Undisturbed	Bottom	Middle	Top
Density of sample	(kg/m3)wet sample	1.50	1.18	1.36	1.31
SD	+-	0.05	0.09	0.09	0.03
Water Content	g water/g sample	37.21%	28.90%	33.66%	35.59%
SD	+-	2.74%	3.83%	0.95%	1.98%
% HEM	g HEM/g sample	15.11%*	22.40%	14.77%	15.59%
SD	+-	12.38%*	2.00%	1.79%	2.00%
Water Content	g water/g dry solid	78.08%	59.34%	65.26%	72.88%
SD	+-	12.97%	5.78%	2.24%	3.45%
% HEM	g HEM/g dry solid	31.70%	46.00%	28.63%	31.92%
SD	+-	17.72%	4.76%	2.71%	3.45%

* Pre-consolidation measurements were subject to large variations due to uneven distribution of NAPL, causing equally large variability in water content and HEM/dry solids ratio

Appendix C

Feasibility and Practicality of Dredging in the Gowanus Canal. Prepared for National Grid by Dr. Michael Palermo. April 2013.

Michael R. Palermo, PhD, PE
Mike Palermo Consulting

Feasibility and Practicality of Dredging in the Gowanus Canal

10030 Green Level Church Rd, Ste 802-1280
Cary, NC27519
(601) 831-5412
mike@mikepalermo.com

National Grid has retained Dr. Michael R. Palermo, Mike Palermo Consulting, with expertise in environmental dredging and dredged sediment treatment and disposal, to evaluate the feasibility and practicality of environmental dredging and dredged sediment treatment and disposal as proposed in the United States Environmental Protection Agency (EPA) Proposed Remedial Action Plan (PRAP) for the Gowanus Canal.

I. Qualifications

I have been an engineer concentrating on dredging, dredged material management, and contaminated sediment remediation for almost 40 years, since 1974. I have extensive experience in both design and technical oversight of navigation dredging and contaminated sediment remediation. I have supported government agencies and responsible parties on a number of large-scale sediment remediation projects, including Hudson River (New York), Housatonic River (Massachusetts), Fox River, (Wisconsin), Onondaga Lake (New York), and Portland Harbor (Oregon).

I hold Bachelors and Masters degrees in Civil Engineering from Mississippi State University and a Ph.D. in Environmental and Water Resources Engineering from Vanderbilt University. I have served with the United States Army Corps of Engineers (the Army Corps) as a Research Civil Engineer and Director of the Center for Contaminated Sediments at the Engineer Research and Development Center at the Waterways Experiment Station, where I managed and conducted both research and applied studies for the Army Corps, the EPA, the Department of Justice, the National Oceanic and Atmospheric Administration, and the United States Navy, among others.

In addition to being a member of the Western Dredging Association (WEDA), the International Navigation Association, and the American Society of Civil Engineers, I have served as an Adjunct Professor of Engineering at Texas A&M University and Mississippi State University. I am also an Associate Editor for the WEDA Journal of Dredging Engineering and have served on numerous national and international workgroups and peer-review panels.

I have written a number of articles and guidance documents on dredging, dredged material disposal technology, and contaminated sediments remediation. I have been the lead author of Army Corps, EPA, and international guidance documents pertaining to contaminated sediments, including the Army Corps / EPA 2008 <u>Technical Guidelines for Environmental Dredging of</u>

Contaminated Sediments, the EPA 2005 Contaminated Sediment Remediation Guidance for Hazardous Waste Sites, and the EPA 1998 Guidance for In-Situ Subaqueous Capping of Contaminated Sediment.

II. Introduction

Dredging projects require a specific expertise, and even then, much hands-on experience. These comments are offered in a spirit of cooperation and support to provide recommendations that have been informed by my work on a number of real dredging projects and that will hopefully not just improve the PRAP, but also lead to a workable and successful remedy for the Gowanus Canal.

EPA has completed a Remedial Investigation (RI) and a Feasibility Study (FS) and I have reviewed both, along with numerous other documents, as part of this evaluation. Although my evaluation focuses on dredging, dredged sediment treatment and disposal, and post-dredging cap design and implementation, other components of the PRAP are also considered because they relate to dredging. Compatibility of dredging, in-situ stabilization, capping, and sediment treatment and disposal are extremely important and must be evaluated in order to design any remedy.

The RI identified two major sediment layers in the Canal: A surficial layer of "soft" sediments which have accumulated since the Canal and bulkheads were constructed, and an underlying layer of "native" sediment which dates back to the time when the Canal was in its natural state. Both layers are contaminated, but NAPL impacts are more severe in the native sediment, presenting challenges with respect to dredging in this layer. Further, exposing the native sediment will make it harder for the post-dredging cap to be effective. The two-layer stratigraphy in the Canal therefore plays an important role in defining dredging elevations and has significant effect upon the scale and complexity of the dredging remedy put forward in the PRAP.

The RI also identified three Remediation Target Areas (RTAs) corresponding to the upper (RTA 1), middle (RTA 2), and lower (RTA 3) reaches of the Canal. Conditions and sediment characteristics unique to each RTA have bearing upon how dredging may differ in each RTA. In other words, the one remedy outlined in the PRAP does not necessarily fit all three areas. This then adds yet another dimension to the Canal that must be evaluated.

The FS set forth seven remedial alternatives, ranging from "No Action" to active remediation with dredging the soft and native sediment layers, followed by capping. Only two alternatives were evaluated in detail: Alternative 5 which calls for complete dredging of the soft sediment layer, followed by capping; and Alternative 7 which calls for complete dredging of the soft layer, followed by in situ stabilization (ISS) of the surficial native sediment layer in areas of active NAPL migration, followed by capping.

The PRAP follows closely the findings described in the FS. The PRAP calls for application of Alternative 5 to RTA 3 and application of Alternative 7 to RTA 1 and RTA 2. The PRAP, however, neither builds upon nor explains the descriptions of Alternatives 5 and 7 beyond the limited information presented in Table 4-4 of the FS (for purposes of this memo, the PRAP is assumed to incorporate the concepts provided in Table 4-4).

The comments that follow focus primarily on the steps needed to get from the PRAP to an implementable remedy. Based on my experience, I submit there is still much study and work to be done during the design phase. The Record of Decision for the Canal must provide flexibility to incorporate the results of these important studies and to allow time to shape new plans and work into the ultimate remedy. Based on my experience as well as my work with Dr. Danny Reible, who has also reviewed the PRAP and is commenting on it, I believe that capping soft sediments in select areas of the Canal should not be discounted, but rather should be evaluated during the design process.

III. The ROD Should Include Flexibility and a Realistic Timeline

The PRAP calls for application of remedy components in a very specific manner with little appearance of flexibility. In my experience, flexibility, within the bounds of meeting remediation goals, is essential to address complex sites like the Gowanus Canal. There are numerous components to even the simplest environmental dredging project that require extensive advance study and planning. I have found that as each dredging projects unfolds, unforeseen conditions and events arise that not only create delay, but may mandate overhaul of the entire project. The PRAP appears to make no accounting for this reality. To the contrary, significant components of the PRAP appear to have been based on limited, if any, information and evaluations. As a result, critical issues like the need for some components of the PRAP, the effectiveness of certain proposed actions, the potential negative impacts of other proposed actions, and the ability to implement the proposed plan all remain unknown to a large degree.

With the need for flexibility comes the need for sufficient time, especially with the type of involved dredge and cap remedy called for in the PRAP. The PRAP targets five years for project completion, but offers few details on the sequencing, coordination, and production rates, to name a few of the things required to meet this goal. By way of example, production rates must be calculated at the conceptual level based on conservative assumptions for operating production rates and operational and quality of life constraints. During remedial design, these rates will be refined as the unique constraints presented by the Canal geometry and the requirements for compatibility with transport, re-handling, and disposal become known. Likewise, the type, size and availability of treatment and staging areas will impact the time-line.

In short, based on my experience with these types of dredging projects, and given the need for advance thinking, planning, and coordination, as well as the unforeseen conditions, delays, and setbacks that are always inevitable, setting a target time as the PRAP does, is not prudent. It will only lead to disappointment and, worse, resentment. The ROD should omit the five year target and wait until a more realistic time frame can be set depending upon the outcome of the remedial design efforts.

IV. Capping Soft Sediments Should be Evaluated

Much of the proposed plan appears to have been shaped by the notion that soft sediment cannot support a cap. Apart from the fact that removal of all soft sediments — a mass removal approach — and removal of more sediment "in case of cap failure" are wholly inconsistent with EPA guidance, there is no evidence in the PRAP that supports this notion.

The "golden rule" of capping is to place the cap in thin layers over large areas, gradually building up thickness. If this rule is followed, a cap can be constructed on the Canal soft sediment layer. At Gowanus, the soft sediment layer contains a significant fraction of sand size particles, while the solids content averages 51% by weight, a value higher than the average for many contaminated sediment sites. Plasticity is also low. Also, the cap can be designed more easily if founded on the soft sediment where NAPL migration will not easily occur. The higher PAH concentrations and NAPL with depth strongly favor a combined remedy approach with limited sediment removal followed by engineered capping. This approach will also reduce contaminant releases during implementation and increase long term effectiveness.

Shear strength (the strength of the sediments to resist a bearing or sliding failure) also plays a role in supporting a cap over the soft sediment. Shear strength increases as you move down deeper into a sediment column. This is so because the pressure of the sediment column increases as you move down, thus consolidating (compacting and compressing) the deeper sediment. Under such circumstances, dredging of even a few feet of the soft sediment in the Canal will leave a surface with a higher shear strength than the original soft sediment surface. This new and stronger "pre-consolidated" soft sediment surface may very well support a cap. However, much geotechnical evaluation coupled with time and flexibility to review and digest evaluation data will be necessary to establish whether or not this will be the case.

The geometry of the Canal also lends itself to capping the soft sediment. Mud waves, which are a risk with any soft sediment occur when sediment squeezes out laterally as the cap is placed. This leads to an uneven surface, which makes capping much more complicated and less effective. The Canal bulkheads (and bulkhead reinforcements) provide lateral containment for cap placement, reducing the potential for mud waves. Placing the cap in thin layers across the full width of the Canal to build up the cap will reduce the risk of mud waves. And, the geometry of the Canal is suited for placement of geotextiles, if needed, for increasing the strength of the sediments to support a cap.

Finally and perhaps most important, the EPA's misguided notion that soft sediment cannot be capped is contradicted by the fact that caps have been placed successfully on soft sediment at a number of sites:

- Soda Lake (Wyoming) - Capping materials were mixed with water to form a slurry which was pumped through four inch pipe to a spreader barge, where it was distributed using an eight foot wide diffuser box. The pipeline discharge entered the diffuser box in a way that sprayed the slurry upward against a baffled surface. This surface distributed the slurry in a lateral fashion less than one foot above the water column and promoted uniform distribution. In shallower areas, the cap was placed using an aerial disbursement method.

- •Fox River (Wisconsin) – Cap material was placed using hydraulic slurry conveyed by pipeline to a floating mechanical spreader with a spreader wheel, similar to those that spread salt on roadways.

- •Silver Lake (Massachusetts) - A dissipater/spreader assembly (spreader box) consisting of a 20 foot wide perforated diffuser pipe extended across the top of the spreader box, with an angled steel plate was mounted on a barge. The angled plate dissipated energy while directing and spreading sand. The same equipment was used for a phase of the Fox River project.

- •St. Louis River (Minnesota) - A sand sub-cap was placed hydraulically using a barge with a spreader box fed by a dredge pump. As the barge advanced using a cable system, the spreader box dissipated energy to allow the sand to settle gently as a uniform layer.

- •Mocks Pond (Indiana) – Cap material slurry was pumped to a spreader barge through eight inch pipe, where it was distributed using a 16footwide diffuser plate. The plate distributed the slurry in a lateral fashion less than one foot above the water column and promoted uniform material distribution.

- •Ward Cove (Alaska) –A sand cap was placed by using an eight and one-half cubic yard bucket that was welded to hold an amount of material equivalent to a six inch placement over the 300 square foot arc of the bucket swing. The material was released below the water surface within 10 to 20 feet of the bottom.

- •Onondaga Lake (New York) – A large spreader plate system, similar to the one used at Silver Lake, was used. Cap material slurry was conveyed by pipeline to the spreader using a 12 inch pipeline.

Photos of the equipment used at these projects are attached.

The foregoing shows the wide variety of equipment designs and placement techniques that have been utilized around the nation to resolve the challenge of capping soft sediment. Clearly then, the option of capping the soft sediment layer should not be dismissed out of hand as in the PRAP, but should be evaluated as part of the remedial design.

V. The PRAP Fails to Consider the Practicalities of Dredging

Implementing dredging as part of the remedy for major sites like the Gowanus Canal is a complex undertaking, involving a range of issues. Some issues can be addressed in design, but others relate directly to the practicality of dredging and the ability to effectively implement a remedy. The EPA Office of Emergency Response recognized the complexity of such projects as early as 2002, and engaged the Army Corps to develop guidelines for environmental dredging for sediment remediation. I was the lead author of those guidelines, published by the Corps as the Technical Guidelines for Environmental Dredging of Contaminated Sediments (Palermo et.

al. 2008) (the Guidelines). EPA identified the Guidelines as a supporting document for the EPA Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (EPA 2005), commonly called the "Superfund Sediment Guidance." The Guidelines and the Superfund Sediment Guidance provide the framework for designing, implementing, and monitoring environmental dredging projects.

(a) Dredging Operations

The PRAP does not consider how dredging operations should be conducted in view of the challenges presented by the Canal site conditions. Site conditions and sediment characteristics are of particular importance when planning dredging, treatment, and disposal. These components are challenging at the Gowanus Canal because they vary throughout the water body, are in perpetual motion because of the ongoing nature of sources like the combined sewer overflows (CSOs), and are subject to dramatic change in the near and distant future. One significant change in the Canal will occur when the flushing tunnel is reactivated. Increased flow from the tunnel coupled with CSO inputs and natural tidal and river flow fluctuations will make for a very active system that will mobilize sediment and contamination. Dredging and capping actions, if done strictly in accordance with the PRAP, will further stir things up by exacerbating the flow. This will cause sediment scouring during and immediately following dredging operations. The PRAP addresses none of this, and as a result the dredge and cap remedy as proposed therein is little more than a concept.

In addition, basic physical characteristics of the Canal must be evaluated because any one by itself has the potential to undermine the dredge and cap remedy. As with the active and changing components of the Canal, the PRAP contains little or no discussion of how site conditions such as water depths, bathymetry (especially slopes), currents, wave energies, the presence and nature of major infrastructure (i.e., bulkheads, piers, abandoned pilings, bridges, utility crossings, pipelines), the presence and nature of debris in Canal sediments, and geotechnical conditions (i.e., stratification of underlying sediment layers, depth to bedrock, physical properties of foundation layers) will impact the dredging operations. All of these things must also be considered as part of the remedial design.

Consideration of over dredging allowances, potential for sediment resuspension, and behavior related to removal, post-dredging treatment, and disposal — all very necessary parts of any dredge design — are essentially absent in the PRAP. The remedial design must account for overdredging (additional dredging depth to account for equipment inaccuracies) and must evaluate the allowable tolerances around target elevations. Other operational factors such as ability to dredge along a sloping bottom and limits on precision of removal must also be considered in defining the total volume of material to be dredged. None of these dredging design specifics were considered in the PRAP, and this has resulted in an underestimation of the dredging volumes, operational challenges, and timelines required to implement the PRAP remedy.

Future use of the Canal should also be considered. One of the most basic and important questions asked when designing a remedy is, "What do we want this site to look like post-remedy?" Underlying the answer to this question for the Gowanus Canal are issues like commercial versus recreational navigation use, habitat restoration / enhancement, future shoreline and adjacent upland development, and engineering practicalities associated with shoreline stability. All of these issues must be addressed in the remedial design. Especially critical among these issues is re-thinking of Canal uses that require greater water depth. Given that the Canal has seen limited use (as revealed by the present state of sediment accumulation) and the plans for residential / recreational development along the Canal, it is unlikely that there will be a need for deeper navigation depths. At the very least, it appears that the upper portion of the Canal will eventually be limited to recreational traffic, which reduces any requirement for depth and thus reduces the need for dredging.

Finally, simple access to the waterbody is extremely critical when it comes to dredging. In addition to the need for open space for staging, loading / off-loading, and treatment, clearances and space for work within the waterbody determine equipment and operational approaches for both dredging and capping. For example, in the Gowanus Canal, horizontal clearances at bridges in RTA 3 constrain access from the bay. The narrow channel width of 40 feet between abutments, at several other bridges constrain ability to work in the Canal. Similarly, land-side access is limited by the dense development along both sides of the Canal. As a result, there are few, if any, areas adjacent to the Canal suitable for staging, re-handling, and treatment. These constraints, plus the narrow width of the Canal for most of its length will limit the size and operation of dredge barges, sediment transport barges, and tugs. Not only are none of these things mentioned in the PRAP, but certain components recommended in the PRAP like the enclosures to control resuspension, which will reduce the Canal width by half, actually magnify the already significant constraints that are sure to hamper a dredge operation and increase the time required to complete a remedy.

(b) Impacts of Dredging

In addition to the site characteristics and operational specifics that are not considered in the PRAP, the consequences of the remedial actions proposed are also not included. This is a fundamental mistake that often arises because of single focus on “how to do the dredging.” After the dredging is undertaken, it often becomes clear that insufficient provision was made for how to handle the impacts of the dredging, with disastrous results.

All dredges stir up (resuspend) some sediment into the water column during the dredging operation, and resuspension results in release of contaminants in dissolved form to the water and as a volatile release to the air. Resuspension evaluations with appropriate modeling are needed to predict suspended solids concentrations as a function of distance and time and related potential for contaminant release to water and air. These estimates can be based on field experience or empirical or analytical models (e.g., the Army Corps DREDGE model or more sophisticated numerical sediment transport models). Results are then compared to performance standards for resuspension or water quality standards for suspended sediments or turbidity. The need for control measures (such as restrictions on the rate and timing of operations or deployment of silt curtain or hard containments) can then be determined. No such evaluations were conducted or even considered in developing the PRAP.

At the Gowanus, site-specific estimates of resuspension rates need to be performed before any design is put in place. Estimates should be based on procedures provided in the Army Corps Guidelines, considering the site specific sediment characteristics of the Canal (both for the soft and native sediments) and the anticipated dredge types and sizes. The resuspension estimates will inform the subsequent estimates of contaminant release rates for water and air.

Lastly, the PRAP fails to account for "residual sediments," sediments found at the post-dredge surface either within or adjacent to the dredging footprint that contain contaminants at concentrations above the action level. Residual sediments can be generated and left behind by the digging action of the dredge or can be missed by the dredging operation due to poor characterization of the sediments. Residual sediments pose a significant risk because they result in contaminant releases from the dredged surface prior to cap placement. This was a real problem at the Hudson River Superfund Site, where scour of loose residual sediments at the new, post-dredge surface, resulted in a high degree of contaminant release. This problem may even be worse in the Gowanus Canal due to the higher concentrations of contaminants of concern and the PRAP plan to dredge to the native sediment where NAPL is much more concentrated.

(c) Resuspension Controls

Evaluation results for sediment resuspension, contaminant release, and residual sediments should be compared with performance standards to determine if operational and engineering controls are needed during dredging, and if so, whether they will be effective. Operational controls are those associated with dredging, such as adjustment of dredge type or size, bucket wash tanks, changes in the rate of operation or advancement of the dredge. Engineering controls include structural containments such as sheet pile enclosures or silt curtains to control sediment resuspension. Controls for resuspension also help control contaminant release to water and air.

Operational and engineered controls, however, are not only expensive, but they can significantly limit the amount of material that can be dredged at any one time and therefore reduce efficiency. Further, the improper use of controls can have significant negative impacts like increasing sediment resuspension and / or the time needed to complete the project.

The FS requires that sheetpile enclosures be used. Furthermore, it assumes that all dredging and capping will be conducted within the enclosures, the enclosures will capture all resuspended sediment, and overlying water from the enclosures will be treated prior to opening the enclosures. These assumptions were included in the PRAP without the benefit of any technical evaluations and without consideration of the potential negative impacts of implementing such controls.

Sheetpile enclosures will significantly narrow the Canal. My construction experience shows that once the bulkheads are reinforced, the enclosures could reduce the width of the Canal by more than half. This will increase flow velocities around the enclosure, which will increase shear (force on the bottom sediment), which will increase erosion (movement of the bottom sediment). This will become even worse once the flushing tunnel is turned back on and transport barges appear. Lastly, modeling indicates that moored barges will also cause an increase in scour. Transport barges will have the same effect. It is possible that sediment erosion and related contaminant release could be greater with enclosures, as opposed to dredging without enclosures. These issues were not addressed in the PRAP and directly relate to the ability to implement the remedy.

Sheetpile enclosures, if used, will also concentrate resuspension of sediments within the enclosures. The enclosure will thus turn into a concentrated source for more releases to air, which will mean significant odor throughout the community. Although resuspension within the enclosure may stop once dredging is complete and suspended sediment may settle out, significant dissolved concentrations will remain in the water column. To remedy this unwanted situation, EPA proposes dilution-based flushing by treating two volumes of water from the enclosure prior to opening them. This, however, is a waste of resources because groundwater will continue to discharge laterally and from below into the enclosure, and leakages through the sheetpiles will occur. As a result, EPA's dilution-based flushing will not treat the enclosure water sufficiently, and once the enclosure is opened, a sudden pulse release will occur. Also, treating the water and then discharging it outside the enclosure into the dirtier Canal makes no sense. It may be better to discharge the treated water inside the enclosure, which will reduce contaminant concentrations in the slug of water released when the enclosure is moved.

If the need for enclosures is established in the design, an alternative to the sheetpile enclosure chosen by EPA may be reinforced silt curtains. In fact, this very design worked well at the Bangor (Maine) site, a site along the Penobscot River with significant NAPL, flow variability, and a 14 foot tidal fluctuation. The silt curtains were attached to spaced anchor piles with mesh reinforcement to reduce curtain sailing and tears. A baffle configuration was used to allow for exchange of water from the large tidal fluctuation. The mesh was cyclone fencing material, but other mesh materials such as hardware cloth are also effective. Although the Penobscot River bank had an inset that saved the curtain from being directly exposed to river current / flow, the same could be accomplished in the Gowanus Canal by installing a short sheetpile deflector wall at the upstream end, which would also shield the curtain from direct flow. Construction of this alternative design would take less time, be less intrusive to the community with respect to noise and emissions, and would allow for greater flexibility in alternating the enclosure from side to side and along longitudinal reaches of the Canal.

The foregoing makes clear that the degree of controls needed is site-specific and should only be applied when conditions clearly dictate. They should not be set, as they are in the PRAP, solely because they can be (EPA 2005). Indeed, operational controls such as fixed arm equipment, enclosed buckets, operation of the dredge within a primary oil boom and silt curtain Moon Pool, secondary oil booms, and bucket washing and catch pans may very well be more effective than enclosures in maintaining an acceptable level of releases during dredging and capping in the Canal. A site-specific evaluation should be conducted for the remedial design to first establish the need to control sediment re-suspension, and second if needed, an evaluation should be conducted to evaluate the type of controls that should be used, whether they will be effective, and whether such controls could also have negative impacts.

(d) Material Re-handling

Another key issue not considered in the PRAP is the compatibility of the dredging, treatment, and disposal or reuse of the dredged sediments. Careful planning and design of rehandling and transport is critical because rehandling operations should be limited as much as possible to minimize the risk of spills and releases. Community intrusions (e.g., odor, noise, lighting, traffic and other issues) should also be considered, and health and safety plans should address both workers and community members. In order to reducing bottlenecks and maintaining throughput of material from the dredge to transport to treatment to disposal, transport and rehandling must be associated with dredge operations very closely, generally in the form of a detailed Operations Plan. The PRAP does none of this and all of this will take time.

With mechanical dredging, multiple re-handling steps between the dredge and disposal of sediments are usually required. Material is usually placed directly into barges for transport to an offloading or staging area where the dredged sediments undergo dewatering and / or treatment. The dewatered / treated sediments are then rehandled to trucks or barges for transport to the disposal site. Neither the FS nor the PRAP discuss this in any detail. Rather, EPA simply says all treatment / disposal options will include barging dredged sediment to a "local on-site dewatering and transfer facility." Again, the PRAP does not account for inevitable delays due to things like public concern and releases, not to mention the very real challenges to re-handling and transport posed by the limited access to the Canal, the Canal geometry, and the lack of space for staging and operations. Accordingly, refined studies and evaluations are required for purposes of remedial design and siting specific areas for staging and offloading, and sediment treatment.

(e) Transport and treatment of Dredged Sediments

The narrow width of the Canal will hamper placement of dredged sediments into transport barges. As explained above, bulkhead reinforcement and construction coupled with the use of control enclosures, will cut the width of the Canal by more than half. Such narrow confines will limit barge traffic to one way only, will not allow for barge turning, and will slow ingress / egress for barge rotations. Further, the small width will effectively eliminate navigation upstream of the active working area and will likely limit the project to use of a single operating dredge. These issues need to be evaluated in light of the required dredge sizes and dredging barge dimensions as well as the likely dimensions of transport barges.

The PRAP suggests that dewatering be done at an on-site staging area, followed by treatment of the water. It is quite possible that no acceptable offloading or treatment / re-handling sites can be located along the Canal because such arrangement requires not only space on land for a treatment plant, but also space in the Canal to moor multiple barges and to allow time for settling and generation of free decant water.

Location of such a transfer / dewatering facility may not even be the best approach from a public acceptance standpoint. Such a facility will be another source for emissions and noise and light. Such a facility will also create an offloading / re-handling step that may not be necessary.

Finally, an on-site area with limited space is not likely to allow for docking or offloading of multiple barges, which will possibly cause delays.

To the extent facilities off-site will be considered, that will affect the dredging operations in proportion to the distance away from the Canal. Transit times will directly influence the required number of transport barges and the size of the barges so as to avoid dredging delays. Although experience with a number of projects has shown that redundancy in equipment and operations can reduce down time and allow for continuing throughput of materials, this must be studied.

(f) Sediment Treatment and Beneficial Use

The treatment and disposal options in the FS and PRAP involve stabilization and / or thermal desorption, but do not provide any technical evaluations regarding the necessity or effectiveness of this approach. Thermal desorption will not reduce the concentrations of metal contaminants in the sediments. Sediments will therefore still be required to be placed in a landfill. EPA selected these approaches without the benefit of any treatability studies and without considering whether a specific treatment approach is workable or optimal for the Canal sediments.

A major consideration is the need or benefit of a sediment treatment approach. Stabilization may be needed for meeting the “paint filter test” so the material may be accepted for landfill disposal. However, the need for thermal desorption should be fully established. If the material would be acceptable for landfill placement without thermal desorption, there is no justification for requiring that treatment.

Furthermore, most sediment treatment technologies have not seen wide use because of high unit costs and difficulties treating sediments at the rate at which they are removed. Particle size separation and solidification / stabilization have comparatively lower unit costs and are more commonly implemented. Treatment of sediment solids to reduce toxicity or mobility of contaminants may be considered, but are not commonly used because of high cost and the need for permanent disposal of the treated sediment.

Beneficial use of sediments is also limited by the lack of cost-effective uses (EPA 2005). Landfill cover and construction fill are two uses that have worked, but the potential treatment requirements, levels of residual contamination following treatment, and physical nature of the fine-grained sediments normally associated with remediation sites present significant challenges to most beneficial uses. Beneficial use will be especially difficult for Non-NAPL impacted sediments from RTA 1 and for all sediments from RTA 3 because of the volumes of sediments involved and the lack of a market for sediments with the properties found in the Canal.

Several technical / logistical evaluations are needed to determine if beneficial use for Canal sediments is practical. Landfill cover is the best possibility, but agreements will be needed with landfills regarding the rate of throughput that can be accepted and total volume requirements. In general, total volumes of material needed for landfill cover are far less than the capacity of most landfills. Use as construction fill is also a possibility, but specific projects must be identified that will match the timeline for generation of material from the Canal as well as the properties of the material generated. These issues are real impediments to application of large volumes of material from a remediation project for beneficial use, and they cannot be merely assumed to be workable.

(g) Landfill Disposal

Off-site disposal of sediments in licensed landfills is an option that is common to most remediation projects, and the Gowanus Canal project should be no different. This is so because on-site disposal is limited in the New York City region. However, there are a number of issues that can complicate landfill disposal. These are requirements for pre-treatment or treatment, logistics of rehandling and transport to the landfill, capacity of the landfill, and acceptability of the sediments for the landfill.

The PRAP assumes that sediments will be stabilized to the degree needed to pass the paint filter test, and that the sediments will be transported by truck from the processing facility to a Subtitle D landfill. The PRAP, however, makes no mention of the degree of dewatering needed for landfill placement and the workability of sediments for landfill placement, even if they pass the paint filter test. Indeed, at the Fox River site, some landfills required a higher tipping fee for dewatered sediments that had poor workability. Furthermore, agreements will be needed with specific landfills regarding the rate of throughput that will be accepted and the total capacity for sediments that will be handled over the total timeline of the project.

(h) CDF Option

The PRAP includes a confined disposal facility (CDF) option for one of the turning basins that will contain sediments from RTA 3 only because those sediments are the least contaminated. To the extent the Region pursues a CDF, the more contaminated sediments from RTAs 1 and 2 should not be precluded. There are no technical constraints (or to my knowledge regulatory constraints) limiting use of a CDF based on contaminant concentrations. CDFs can be designed with contaminant pathway controls that are as effective as any in hazardous waste landfills. Similarly, the PRAP requirement that only solidified material may be placed in a CDF is also unfounded. This requirement is not based on any technical evaluation. The CDF option, should it move forward, must, like all other components of the proposed remedy, be better planned and studied and afforded flexibility in design to meet performance standards.

VI. Conclusions

(a) Dredging Feasibility and Practicalities

The conclusions regarding the feasibility and practicality of the dredging and sediment treatment / disposal remedy set forth in the Gowanus Canal PRAP are summarized as follows:

- The PRAP calls for application of remedy components in a very specific manner with little or no flexibility. This approach is neither supported by the present level of knowledge about the site and sediment conditions, nor is it supported by the level of technical evaluations conducted to date. Experience has shown that flexibility, within the bounds of meeting remediation goals, is essential for addressing complex sites like the Gowanus Canal.

- The feasibility of implementing several of the specific components of the proposed plan as described in the PRAP is questionable, considering the site conditions, physical constraints, the nature of the sediments, and the potential for stringent performance standards. The limited geometries of the Canal, potential for bulkhead instability and need for reinforcements, future operation of the flushing tunnel, presence of significant debris, and the presence of NAPL and contaminants of concern at high concentrations, all point to difficulties with dredging.

- Many components of the proposed plan were based on limited information and evaluations. Many technical evaluations and studies are needed to determine the full implications of the site conditions, the need for some of the proposed components, the potential negative impacts of some proposed actions, the effectiveness of some components, and the practicability of implementing some of the components.

(b) Summary of Required Evaluations and Studies

A significant technical effort will be required to fully determine feasibility, practicality, and effectiveness of the remedy and then to optimize the remedy ultimately chosen. This effort should include laboratory testing studies, hydrodynamic / sediment transport modeling studies, groundwater modeling, bench treatability studies, contaminant pathway testing, field investigations, and pilot studies. Such a comprehensive and complex effort will require close coordination among the various parties and significant time.

Required evaluations and studies pertaining to the dredging component are as follows:

- **Remedial Design Field Investigations.** Important data gaps exist for basic processes such as sediment transport, hydrodynamics resulting from changing conditions, groundwater flow conditions, geotechnical conditions, and bulkhead condition mapping and sampling. These aspects have not been characterized to the extent necessary for comparison of the remedial options and for remedial design. The gaps should be addressed with a coordinated series of remedial design field investigations.

- **Navigation Study.** Future navigation needs as well as future maintenance should be assessed. This assessment should include both commercial and residential / recreational potential.

- **Performance Standards Evaluation.** Performance standards (numeric limits or criteria related to the dredging operation) are a touchstone of remedial design. Categories of performance standards may include those related to sediment resuspension, water quality or air quality standards for contaminant release to water and air, and dredging production and timeline for completion of dredging. The specifics of meeting ARARs should be established using an effects-based approach and should consider the background concentrations and potential for recontamination of the Canal. Similar considerations apply to performance standards for the capping and sediment treatment and disposal components. Evaluations of performance standards should be discussed with the agencies in the early stages of the remedial design, not later.

- **Dredging Production and Throughput Evaluation.** An evaluation of dredging production and sediment throughput from dredging to final disposal should be conducted. Mechanical dredging is the approach most suited for the Canal, but specifics like the size and numbers of dredges as well as redundancy and flexibility of use of equipment to avoid delays and bottlenecks must be determined. This will inform the desired timeline for completion of the remedy, which at this juncture is unrealistic. A production and throughput evaluation should also be performed to identify potential constraints resulting from control measures and the interface between the dredging and subsequent transport and rehandling components of the remedy.

- **Contaminant Release Studies.** Sediment characteristics for the Canal, high concentrations of contaminants, including NAPL in some areas and sediment layers, create a potential for contaminant release. A study of sediment resuspension potential, contaminant release potential to water and air, and residual sediments should be conducted. This effort would include laboratory testing for source strengths, and near field and far field modeling of release behaviors. This study is critical in determining the potential short-term effectiveness and long-term effectiveness of environmental dredging for the site, and the potential need for control measures. The potential contaminant releases due to a dredging operation should be compared with releases due to sediment erosion in the Canal with and without the use of controls such as sheetpile enclosures.

- **Sediment Resuspension and Contaminant Release Control Evaluations.** The PRAP calls for the most stringent and intrusive form of engineered resuspension control -- a sheetpile enclosure. No technical evaluations were conducted to determine either the need for such control or the potential impact of such control on sediment erosion and contaminant release. Considering the geometry of the Canal and the potential influence of the flushing tunnel, the use of hard enclosures may actually result in higher contaminant releases as compared to dredging without enclosures. A site-specific evaluation should be conducted to establish the need for engineered controls. If controls are needed, options must be evaluated to determine the most appropriate and effective control for the Canal, as well as the potential for negative impacts.

- **Operations Plan.** The PRAP's limited sequence of work is inadequate and a more comprehensive evaluation of operational aspects is needed to assess more fully the practicality of implementing the remedy. Among other things, an Operations Plan with detailed dredging prisms; delineation of dredging management units; description of dredge cuts, layback slopes, and box cuts; a sequence of operations; detailed mobilization and demobilization and construction timelines, complete descriptions of all equipment to be used; design and use of control measures; and methods for monitoring progress must be developed. This, however, can only be developed after all of the studies outlined in these comments are completed.

- **Monitoring and Management Plan.** Although these comments focus on dredging planning, design, and implementation, it cannot be forgotten that monitoring will be required to ensure the various performance standards are met. A Monitoring Plan should be developed during the remedial design and agreed to by all parties. This plan should include the monitoring equipment and techniques to be used (e.g. specific instruments, sampling devices, coring equipment); the protocols for sampling, handling and testing of samples (e.g. numbers and locations for sampling, compositing schemes, and testing procedures); and a description of how the monitoring data will be interpreted. Monitoring baseline conditions is critical during the remedial design phase for purposes of comparing conditions prior to, and immediately following, reactivation of the flushing tunnel.

- **Field Pilot Studies.** Field pilot studies will be needed to demonstrate the effectiveness at full scale for some remedy components. The pilot studies could include full scale dredging to assess sediment resuspension and contaminant release source strengths as well as full scale cap placement operations to field verify the ability to place caps on both the soft and native sediment. Specific objectives of the pilot studies will require an assessment of the needs based on the results of earlier investigations.

Required evaluations and studies pertaining to the sediment treatment/ disposal components of the Canal remedy are:

- **Rehandling and Transport Study.** Careful planning and design of the rehandling and transport components of the remedy is the key to compatibility. Areas for staging, offloading, and sediment treatment must be identified; and dredge to transport barge issues need to be evaluated in light of the required dredge sizes and dredging barge dimensions as well as the likely dimensions of transport barges. In-barge stabilization, including both treatability and operations, should be evaluated as part of the remedial design studies.

- **Sediment Treatability Studies.** EPA has identified treatment and disposal options in the FS and PRAP that involve either stabilization and / or thermal desorption. However, it appears EPA selected these approaches without the benefit of any treatability studies and without considering whether a specific treatment approach is workable or optimal for Canal sediments. A full bench-scale treatability study should be conducted to evaluate solidification / stabilization, thermal desorption, ISS, and treatment related to potential beneficial uses and potential landfill placement. The testing for ISS should be conducted on both the soft and native sediments.

- **Beneficial Use Studies.** Beneficial use will be difficult to implement considering the volumes of sediments involved and the market for sediments with the properties found in the Canal. A marketing study, aimed at identifying the potential demand for use of the Canal sediments, should be conducted to determine if there is any real potential for this option.

- **Landfill Investigation.** Although the proposed plan calls for beneficial use of all dredged sediments, placement in landfills should be investigated as one aspect of remedy optimization. Evaluations should be conducted to determine required pre-treatment or treatment, logistics of rehandling and transport, capacity of landfills that will be under consideration, and the acceptability of sediments from the Canal for placement in those landfills from the standpoint of dewatering and workability.

- **Confined Disposal Investigation.** To the extent EPA pursues use of a CDF, more comprehensive studies should be conducted. In addition to a CDF, a Contained Aquatic Disposal (CAD) may be considered. The initial investigation should focus on possible sites within the basins and Gowanus Bay, considering volumes, site bathymetry, and compatibility for future landside development. The more comprehensive studies would include the engineering design aspects as well as contaminant pathway testing and pathway control evaluations.

VII. References

References cited in these comments are as follows:

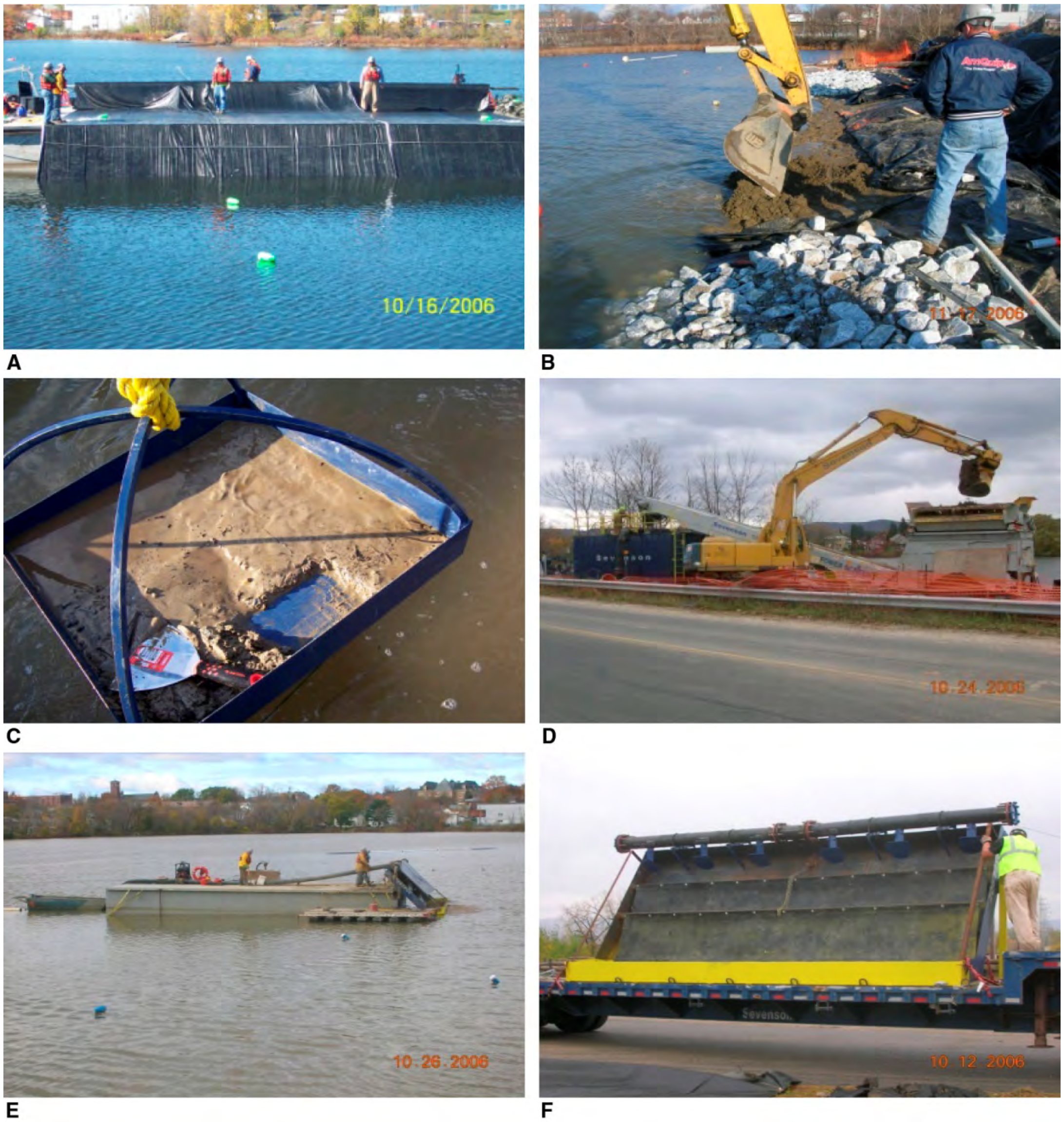
Environmental Protection Agency. 2005. Contaminated Sediment Remediation Guidance for Hazardous Waste Sites. OSWER 9355.0-85, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.
http://www.epa.gov/superfund/health/conmedia/sediment/guidance.htm

Palermo, M., P. Schroeder, T. Estes, and N. Francingues. 2008. Technical Guidelines for Environmental Dredging of Contaminated Sediments. Technical Report ERDC/EL TR-08-29, U.S. Army Engineer Research and Development Center, Vicksburg, MS.
http://el.erdc.usace.army.mil/elpubs/pdf/trel08-29.pdf

If there are any questions, please call at (601) 831-5412 or email at mike@mikepalermo.com.

Sincerely,

Michael R. Palermo, PhD, PE
Consulting Engineer
NC PE Lic.039511 NC Corp. Cert. C-3886



Geotextile and Hydraulic Placement in Silver Lake Capping Pilot Study, Pittsfield, MA (larger scale version of this equipment was also used at Onondaga Lake, NY.).

(Photos courtesy of EPA Region 1.)

Cap Placement at St. Louis River Interlake Duluth Tar Site, Duluth, MN

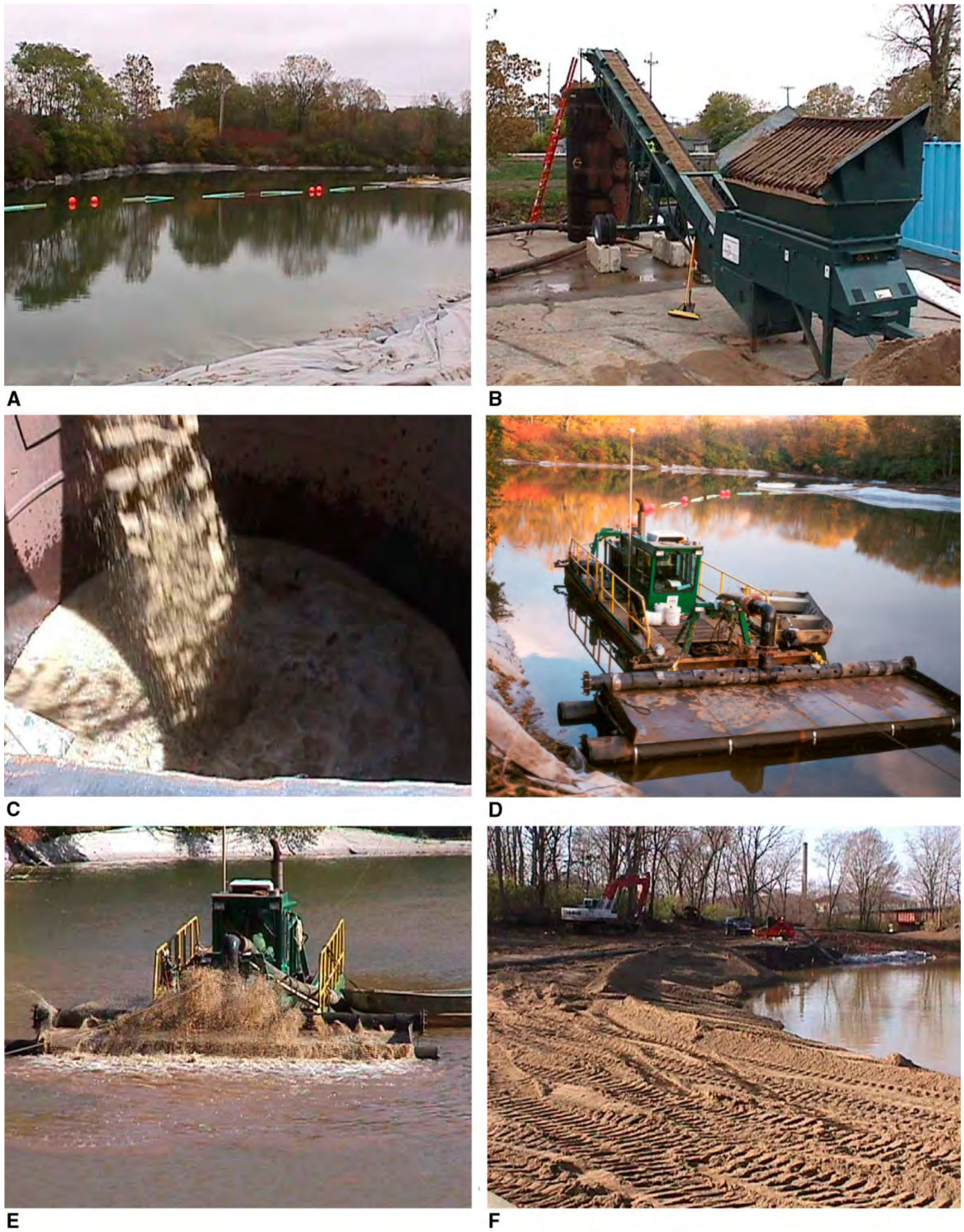
(Photos from Bell and Tracy 2007; Hedblom, Patch, and Costello 2007.)

A

B

Mechanical Placement at Ward Cove, Ketchikan, AK

(Photos and description courtesy of Greg Hartman, Dalton, Olmsted & Fuglevand, Inc.)



Geotextile and Hydraulic Cap Placement at Mock's Pond, Muncie, IN

(Photos from Thompson *et al.* 2004a.)

Sand and Gravel Spreader Used for Fox River Operable Unit 1, Menasha, WI

(Photos courtesy of Mike Palermo Consulting, Inc.)

Appendix D

Comments on the U.S. Environmental Protection Agency Gowanus Canal Proposed Remedial Action Plan. Prepared for National Grid by Baird Inc. April 2013.

Baird & Associates
1267 Cornwall Road, Suite 100
Oakville, Ontario Canada L6J 7T5
T. 905 845 5385
F. 905 845 0698

Baird

oceans
engineering
lakes
design
rivers
science
watersheds
construction

Hydrodynamic, Sediment and Contaminant Transport Evaluation of the Gowanus Canal Proposed Remedial Action Plan

I. Introduction

Hydrodynamic characteristics, sediment and contaminant transport, re-suspension, and deposition in the Gowanus Canal have not been assessed in sufficient detail in the United States Environmental Protection Agency (EPA) Proposed Remedial Action Plan (PRAP). Consequently, there are several shortcomings of the proposed remedy with respect to long-term sustainability and ecological functionality of the Canal, not to mention basic feasibility of the EPA's proposed plans and actions.

EPA's discussion of sediment and contaminant transport and deposition through the Canal is anecdotal and not quantified. This is not surprising because the patterns of sediment and contaminant movement in the Canal are far more complex than anticipated by EPA and require the use of a numerical model to appreciate the full impacts of all of the processes involved. To that end, flow patterns, sediment and contaminant transport, and water quality issues in the Canal have been evaluated by Baird.

The performance of the EPA proposed remedy was examined with an eye toward four key areas:

- Surface water and sediment contributions to the Canal under existing conditions and under the EPA proposed remedy;
- Performance of the EPA proposed remedy;
- Feasibility of construction; and
- Transport and fate of contaminants of potential concern (COPCs).

The model results presented below demonstrate the complex interaction between factors like the flushing tunnel, vessels and barges, combined sewer outfall (CSO) flows, and tidal-driven currents, which together control flow patterns in the Canal. These in turn affect scour, and transport and deposition of sediments in the Canal.

Baird

II. CSO Contributions

Particle tracking and sediment transport model analysis to assess the potential fate of sediments from CSOs suggests that the particles found in the sediment mounds come from the outfall in the immediate vicinity of the mound. A two-week simulation from 23 August to 6 September 2011 tracked particles from CSOs RH-034, OH-007, and RH-031. The particles tracked were clays, medium silt and sand. This time period was chosen as it represents an extreme condition (it includes the Hurricane Irene surge and rainfall), giving an indication of the farthest distance that sediments may travel when the flushing tunnel is inactive. The model results (Figure 1) show that even under extreme conditions, sands and silts settle in the vicinity of the mounds, with clays being dispersed around the mounds. Under less extreme conditions, sediments are deposited even closer to the CSO outfalls.

Although the PRAP correctly recognizes that discharge from CSO RH-034 is the dominant source of sedimentation in the upper Canal when the flushing tunnel is inactive, the PRAP underestimates the full extent of the problem. So far, long-term sediment discharge from the CSOs has been predicted based only on flows from the New York City InfoWorks model. This model, however, is uncalibrated and unvalidated for sediment discharge from the CSOs. As a result, the PRAP does not account for the actual sediment discharge from the CSOs, which must be greater than is presently estimated. Indeed, although section 2/p. 2 of the Feasibility Study (FS) Addendum notes that CSO loading is estimated by DEP to be 259,000 pounds per year, a mass balance for the upper Canal suggests that this is five to ten times **less** than the amount of sediment that would generate the one to two inches per year of sedimentation noted in the PRAP (column 2, p. 10).

Given the likely underestimation of the amount and type of sediment discharged to the Canal from the CSOs,[1] the CSO storage tanks will need to be much larger to achieve the EPA desired reductions in solids. Absent this, the bed morphology of the restored Canal will need to be optimized to allow for greater throughput of sediment to New York Harbor. Lastly, percentage reductions in target flows for sediment from any remaining outfalls in the remedial design must be replaced by absolute targets so that these volumes can be accounted for in the remedial design.

III. Sediment Transport Analysis Summary

Monitoring of CSO sediment loads is required prior to selection of a final remedial alternative, and the Record of Decision (ROD) must be flexible enough to adapt any remedial design accordingly. Given that data and model predictions of flow and sediment load inputs from the CSOs and other outfalls is limited, longer-term inflows

[1]Given that parts of the Canal are accumulating at rates greater than two inches per year, the underestimation of the CSO sediment loading is in all likelihood even more than a factor of five to ten.

Baird

were derived from a basic watershed hydrologic model. With this in mind, the Delftl3D water quality, sediment and contaminant transport model was set up to evaluate the transport and fate of sediments under different events and Canal configurations. In addition to using the model to examine event-based sediment and contaminant transport, the hydrodynamic and water quality model results were applied along with particle tracking to determine likely pathways of sediments over longer time periods.

When sediments are represented in the Delftl3D morphological model, we find that they enter the Canal from CSO RH-034 and are initially transported by the momentum of the CSO flow. As coarse sediments settle out in the vicinity of the CSO outfall, the finer sediments move downstream by tidal currents (and diffusion). With the flushing tunnel inactive, the finer particles remain within the upper area of the Canal where they mostly settled out within two tidal cycles. A sediment budget for the CSO sediments introduced to the Canal from RH-034 with the flushing tunnel inactive (Figure 2) shows that most of the sediments settle to the bed of the Canal upstream from 3rd Street, and all of the sand settles out above Carroll Street, while the clays and silts are transported further downstream. The sediment budget highlights the ability of the model to reproduce the general patterns of sediment movement in the Canal under existing conditions, which form a baseline against which the performance of a remedial design (or series of designs) can be evaluated.

The PRAP asserts correctly that CSOs dominate sedimentation in the Canal, and that this sedimentation is most apparent in RTA 1 and the "surface" layer (the top two feet) of the soft sediment. The basis for this assertion are the five bullets ("multiple lines of evidence") in column two of the table on page 11 of the PRAP and column one of the table on page 12 of the PRAP, which are repeated below:

- CSO solids have high TOC content. The TOC content of the surface sediment is about 6 percent. Based upon the results of the RI and EPA (1998), the TOC levels in Upper New York Bay sediments are, on average, about 3 percent. Accordingly, if suspended sediments in tidal inflow or Flushing Tunnel flows from Upper New York Bay were contributing the majority of the deposited mass, the TOC of the surface sediment would be closer to 3 percent.
- The concentrations of PAHs, copper and lead in the surface sediment and in the CSO solids are similar. The concentrations of these chemicals are much lower in the reference sediments in the harbor; therefore, deposition of suspended sediments in harbor water (or from the Flushing Tunnel which brings in harbor water) could not be the predominant source of high concentration of PAHs, copper and lead in the Canal surface sediments. Aluminum and iron are not good indicators of CSO solids since they are "crustal" elements, i.e., they are very common in soils and sediments and are not COCs at this site.

- Sewage indicators, such as fecal coliform (GEI, 2011) and steroids (Kruge et al., 2007), are found consistently in the surface sediment in the Canal. The highest concentrations are located in the upper portion of the Canal where most of the CSOs are located.
- EPA's bathymetric study shows that most of the accumulation of sediment coincides with the Canal location (upper reach) where most of the CSOs are located and the highest CSO volumetric discharges take place. It has been reported and visually noted that CSOs discharge heavier mass solids. These heavier solids are typically expected to settle to the bottom of the Canal within a short distance from the point of discharge unless high horizontal velocities disperse the solids downstream.
- Overall, the surface sediments in the upper Canal have higher sand content and lower silt and clay content than the Harbor reference locations. The sediments in the lower Canal, closer to the Harbor, have similar silt and clay content to the reference stations. This indicates that the upper Canal surface sediment is more influenced by the deposition of CSO solids than the area near the mouth of the Canal. This is consistent with NYCDEP's conclusion that CSOs predominately contribute heavy grain sediments, while fine grain sediments are a mixture of CSO discharges and Flushing Tunnel and harbor tidal contributions.

(EPA, 2012)

While these bullets certainly indicate that the CSOs are the primary / dominant source of sediment to the Canal, the bullets by no means indicate that the role of the CSOs stops there. There is no evidence that discharges from the CSOs are limited to the surface layer and upper part of the Canal. We contend that the limits of CSO influence to surface sediments and the upper reach of the Canal are not supported by the sedimentary evidence. The CSO influence is likely to be dominant in all areas of soft sediment accumulation, and not just in the top 2 feet (it is highly unlikely that any other sediment source has been dominant in the past). In areas of propeller scour and remobilization of bed materials (particularly in RTA 2), it is also likely that CSO sediments have become mixed with native materials due to the regular turbation of bed materials. A more thorough analysis of this factor needs to be included in the PRAP design. We recommend that the ROD clarify this:

First, bullet number 1 suggests there is no difference between total organic carbon (TOC) in sediments found in the surface and sediments found lower in the bed. This does not indicate that discharges from the CSOs are limited to the surface layer and upper part of the Canal.

Second, bullet number 3 states that sewage indicators are highest in the upper part of the Canal. Although this is the case, it does not prove that discharges from the CSOs are limited to the surface layer and upper part of the Canal. NYCDEP (2008; Figure 4-18) states soft sediments are found throughout the Canal, suggesting that soft sediments will accumulate wherever CSO sediment inflows occur, and not just in the upper Canal.

Third, bullet number 4 suggests that the location of recent accumulation can be determined by a bathymetric survey. Such survey is by no means representative of long-term depositional patterns throughout the Canal, and regular, repeated bathymetric surveys are required to monitor the depositional characteristics of the Canal. In addition, the notion that CSO sediments are coarser in general is only true in the sense that they feature a sand fraction. They also feature high silt and clay fractions. Consequently the idea that CSO sediments are heavier and settle closer to their discharge point is misleading.

Fourth and last, bullet number 5 identifies that surface sediments in the upper Canal have higher sand content. This suggests that a signature of the CSO solids is sand, which may imply incorrectly that silts and clays are not derived from CSOs. Rather, it is simply unclear.

IV. The Proposed Remedy Will Not Meet Objectives

Model runs of sediment and contaminant transport show that the proposed remedial design is incompatible with the habitat and water quality goals of the project because particle tracking and sediment transport simulations confirm that trapping of sediments will increase, especially in RTA 2. Figure 3 shows a comparison of sediment deposition rates between existing conditions and the EPA remedial design, using the November 2010-November 2011 boundary conditions. Sediment deposition rates increase by up to 300 % in RTA 2, showing that any sediment still entering the Canal will be trapped in the deeper channel in RTA 2.

Background suspended sediments present in Buttermilk Channel will be introduced to the Canal through the flushing tunnel (FT) upon its reactivation. Figure 4 shows when the flushing tunnel is active, with the existing Canal bed configuration, sediments from the tunnel are deposited primarily in the central, deeper section of the Canal (RTA 2). This is so because flow slows down due to the increase in channel depth. Dredging in RTA 2 to an even greater depth, with a target evelation of -16 feet further reduces the ability of the flushing tunnel to move sediments and contaminants through the Canal to the Harbor, as the flow speed in RTA2 decreases due to the proposed increase in depth (Figure 3).

Even with the Flushing Tunnel flow, the USEPA Feasibility Study alternative reduces the ability of the Canal to transport sediment in the section between 3rd Street and the Expressway. In contrast to Existing Conditions with the FT inactive (Figure 2), where most of the sediment is trapped in the upper reach of the Canal, under the Remedial Design conditions the major area of sediment trapping is now the deeper section between 3rd Street and 9th Street. This demonstrates the general incompatibility

Baird

between the effectiveness of the Flushing Tunnel (requiring a relatively uniform bed elevation throughout the Canal), and the deep dredge to accommodate commercial vessel navigation.

The model study has identified other complex interactions that will occur in the Canal and that also need to be considered in order to develop a design that meets the water quality and ecological restoration objectives in a sustainable manner:

- **Reactivation of the flushing tunnel will have significant adverse effects.** The sand "benthic layer" in RTA 1 will require ongoing maintenance as flow from the flushing tunnel pushes the benthic layer downstream. This points to the issue that design of RTA1 will be more complex and challenging than is presented in the PRAP, and that flexibility to alter the design to be resilient to the driving forces in the Canal is imperative.

- **Varying depths in the Canal must be considered.** Figure 5 shows when the flushing tunnel is active, sediments from the flushing tunnel are deposited primarily in the central, deeper section of the Canal (RTA 2). This is so because flow slows down (and it is exclusive of the influence of commercial navigation, which will cause sediments to be regularly resuspended and deposited). Deep dredging in RTA 2, however, will reduce the ability of the flushing tunnel to move sediments and contaminants through the Canal to the Harbor. Similarly, the -16 feet target elevation for RTA 2 is not realistic, given ongoing commercial navigation in this section of the Canal. Propeller scour will require an armor layer consisting of large cobbles to boulders to prevent damage to the cap. Sediments deposited above the armor layer would be subject to regular remobilization and redepostion under the influence of vessel traffic. Lastly, the transition from "shallow" (-9 feet) in RTA 1 to "deep" (-16 feet) in RTA 2 leads to deposition in RTA 2 of CSO sediments and contaminants, sediments from the flushing tunnel, and sediments remobilized from the sand benthic layer in RTA 1. These sediments will be subject to remobilization by vessel activity. If this section of the Canal is made deeper to accommodate commercial vessel navigation, conditions may be significantly worse. Given these scenarios, all commercial navigation should be stopped.

- Even at a Canal depth of 30 feet, which would be necessary for a gravel armor layer to survive the presence of commercial vessel traffic, the sand benthic layer would still be subject to re-suspension by propeller wash. Once re-suspended, there would be a net downstream movement of this sand due to the flow from the flushing tunnel**.**

Baird

- At a proposed elevation of -16 feet, dissolved oxygen levels in the middle reach (RTA 2) of the Canal may border on hypoxic conditions at times of high CSO flow inputs, even with the flushing tunnel active. If this section of the Canal is made deeper to accommodate commercial vessel navigation, conditions may be significantly worse following major CSO flow events, as the flushing tunnel flow becomes less effective at flushing the Canal in deeper scenarios. Sediment transport simulations confirm that the Remedial Design configuration will increase trapping of sediments in the Canal, especially in RTA2. Organic matter and organic substances adsorbed to suspended sediment may also settle in the Canal, which may lead to development of a layer of anoxic sediment in RTA2. Deposition of this organic material could increase the sediment oxygen demand as bacteria and other organisms feed on it, starving the Canal of oxygen. This process would considerably reduce the effectiveness of any remediation measures for the Canal.

V. Evaluation of Water Quality Performance of EPA proposed Remedial Design: Dissolved Oxygen

Delft3D-WAQ is a three dimensional water quality model which solves advection-diffusion-reaction equations for various substances on a predefined computational grid.[2] It is not a hydrodynamic model. It was coupled with the Delftl3D hydrodynamic model to evaluate the impacts of the reactivated flushing tunnel, CSOs, vessel traffic, tidal flushing, hydrodynamics and sediment transport, re-suspension, and sediment-related contaminant transport on the water quality in the Canal under existing and remedial design conditions.[3] None of these issues have been assessed in the FS Report, the FS Addendum or the PRAP. Consequently, the effects of these

[2]Baird simulated the influence of freshwater inputs on water quality and sediment transport processes in the Canal through the inclusion of CSO flows in the model. The water quality model includes tidal flows, CSO flows, flushing tunnel flow (when applicable), temperature and salinity (heat flux model), dissolved oxygen (a function of: biochemical oxygen demand, sediment oxygen demand, and chemical oxygen demand; nitrification and denitrification; photosynthesis and respiration), sedimentation and resuspension, re-aeration of oxygen.

[3]Prior to water quality modeling, the hydrodynamics model was updated to include temperature and salinity processes. The ocean heat flux model, which represents back radiation and heat losses due to evaporation and convection using air temperature, cloud cover, and relative humidity, was used. The model boundary was forced with water level (tide/surge), water temperature, and salinity at the Harbor boundary. Wind measurements, air temperature, relative humidity, and cloud cover were applied over the full model domain.

Baird

processes on Canal water quality have not been fully considered. This is an essential step towards evaluating the existing and historic behavior of contaminants in the Canal, and in determining the likely effectiveness of any remedial activities.

A long-term simulation of dissolved oxygen (DO) levels in the Canal was completed for the time period from 1 November 2010 to 31 October 2011. CSO flows from the watershed hydrologic and sediment supply model were included in the WQ model. Observed and predicted hypoxia and anoxia from the long-term validation runs are shown in Figures 6 and 7. The results show that predicted DO levels agree well with observed values throughout the year, and also spatially throughout the model domain. Throughout the model year, the Canal was repeatedly subjected to hypoxic and anoxic conditions as a result of CSO flows during storm events and the limited flushing capability of the Canal without the flushing tunnel. The DO model results also suggest there may be periods of hypoxia in RTA 2, even when the flushing tunnel is active (Figure 8).

While the flushing tunnel flow is generally effective in improving DO conditions in the Canal, it's effectiveness is reduced in the deep dredge area in RTA 2. The reduced flushing and increased sedimentation in RTA 2 could lead to development of a layer of anoxic sediment. Further, deposition of organic material could increase the sediment oxygen demand as bacteria and other organisms feed on it, starving the Canal of oxygen. Decay of this material also uses up oxygen and generates methane gas. These processes could reduce the effectiveness of any remediation measures for the Canal in considerable fashion.

The results of our initial DO modeling also suggest that water quality goals may not be met with a deep dredge approach. Sediment deposited in the deeper middle section of the Canal is likely to impair water quality, especially when remobilized by vessels and barges. A thorough water quality assessment due to the possibility of developing hypoxic or anoxic conditions in the lower part of the water column in deeper areas is necessary prior to selection of a remedial alternative.

The bottom line of this modeling is that regardless of how much the water quality of CSO discharges is improved, there will likely always be fine organic sediments delivered to the Canal (from storm water, direct surface runoff, flushing tunnel flow), and the ROD should recognized that due to these on-going discharges from the CSO system, the post-remedy ecological diversity and populations likely will not re-establish to the same degree as one may expect devoid of the on-going CSO releases.

We contend that there is an opportunity during the remedial design of the Canal to adjust the Canal bed configuration and flushing tunnel flow so that there is a 'balance' or equilibrium in sediment transport over the long term. However, in the proposed design, the flushing tunnel flow that would prevent sedimentation in the deeper downstream areas may be too high in the shallower upstream area. Accordingly, detailed predictive model transport runs incorporating validated CSO

Baird

flows and sediment and contaminant inputs need to be completed prior to selecting a remedy. In addition, the potential to use the flushing tunnel flow in an adaptive capacity to maximize the water quality in the Canal (such as by increasing flushing flow after a CSO event) should be recognized as a possible way to provide active management of water quality and sediment transport in the proposed remediation scheme.

VI. Evaluation of Water Quality Performance of EPA proposed Remedial Design: Contaminants of Potential Concern

While the PRAP includes provisions for improved source control through the implementation of CSO flow retention tanks, it does not consider the transport and fate of contaminants that may still enter the Canal from the CSOs under the proposed remedial alternative. Baird developed a three-dimensional numerical contaminant transport model for Gowanus Canal using the Delft3D model suite. The Delft3D-WAQ model allows for the tracking of contaminants, their retention time and deposition in the Canal under existing and remedial design configurations. The following four contaminants of potential concern were evaluated:

- Polycyclic Aromatic Hydrocarbons (PAHs)
- Polychlorinated Biphenyls (PCBs)
- Copper (Cu)
- Lead (Pb)

The concentrations of the COPCs entering the Canal through the CSOs were estimated from results of the CSO flow event sampling undertaken during two wet weather events on 18th and 28th September 2012. During the event on September 18th 2012, samples were collected at OH-007, and on September 28th 2012, samples were collected at OH-007, RH-031, RH-034 and RH-035. The average values of these samples were used to define the COPC concentrations from the CSOs for inclusion in the model. Further details on the setup of the COPC model will be made available in the water quality modeling report for this study (in preparation).

The results of the COPC model runs show broadly similar patterns to those of the sediment transport runs. Figures 9 to 12 show the differences in deposition rates between existing conditions and the EPA remedial alternative bed configuration for copper, lead, PAHs (benzo[a]pyrene) and PCB-153. The figures compare the existing conditions with the remedial alternative, assuming the same CSO and tidal flows, based on the 2010-2011 time period. The remedial alternative includes the flushing tunnel flow. The figures show that heavy metals entering the Canal through the CSOs tend to settle in the dredged portion of the Canal, particularly in RTA 2, as this is the main receiving area for material from RH-034 and OH-007. This highlights the incompatibility of deepening the Canal to accommodate commercial navigation, while trying to reduce deposition of sediment and contaminants in the Canal to reach an ecologically-sustainable outcome.

Baird

Further model scenario results for varying depth configurations show that if RTA 2 was to become even deeper to accommodate vessel navigation, more accumulation occurs. This is simply because the deeper water decreases the velocity in the Canal, which allows more sediment and contaminants to drop out of suspension and accumulate in these areas. Sediment and contaminants also tend to accumulate in the quiescent waters of the turning basins.

In order to assess and optimize the remedial design, the accumulation rates for the COPCs should be evaluated in detail to determine whether the ecological goals of the remediation can be met, given that the deeper water in RTA 2 leads to reduced flushing tunnel effectiveness and deposition of contaminants on the benthic layer in this reach. While maintenance dredging will be needed to maintain the required depths in the deep section of the remedial design, it may also be necessary to remove contaminated sediments caused by deposition where depths are necessary to accommodate navigation. This would appear to be contrary to the EPA goals of sustainable benthic habitat in the restored Canal.

VII. Construction

In order to prevent bed sediments from being disturbed during construction, which can lead to remobilization of the contaminants therein, the United States Environmental Protection Agency (EPA) has proposed that dredging be conducted within sheet pile cells (EPA Proposed Remedial Action Plan (PRAP), Table 9; FS Addendum, Table 1), that would be blocked off from the surrounding water body. The dredge cells will span half of the width of the Canal at any given time. This approach, simply cannot be employed while the flushing tunnel is operating. Accordingly, the flushing tunnel will need to be shut down for the entire time that the dredge cells are in the Canal.

Baird simulated hydrodynamic flow patterns and sediment transport potential in the vicinity of a dredge cell using the Delftl3D model.[4] Model results show an increased rate of erosion for the portion of the Canal next to the dredge cell, as a result of reduced cross-sectional area. When the discharge that normally passes through the entire width of the Canal, is forced through an area half as large, flow speeds double and scour of sediment increases accordingly. This presents a problem in terms of implementation: the existing contaminated sediments alongside the dredge cell (not contained within the cell) will be subject to scour and remobilization. In this way, the

[4]Three bed elevation configurations were considered for RTA 1, each representing a range of different dredging scenarios: -7, -12, and -17 feet.

dredge cell system proposed by the EPA, rather than containing contamination, will actually facilitate its redistribution throughout the Canal. It may also damage portions of the newly constructed cap – if one side of the Canal cap is constructed, and the dredge cells are in place on the opposite side of the newly-built cap, damage could result from the increase in velocity and propeller scour caused by the presence of the dredge cell. We therefore agree with Dr. Palermo's assertion that the EPA's dredge cell approach would increase erosion rates in uncontained areas (Palermo, 2013).

Next, Baird looked at a "worst-case" scenario by adding a moored barge alongside the dredge cell. Conditions worsened as the presence of the barge further constricted the area and increased flow velocities five-fold. This in turn increased scour potential of contaminated materials in the uncontained section of the Canal. Similarly, a vessel operating (as opposed to being moored) alongside the dredge cell also increases bed scour. Lastly, the effects of propeller scour increased (Schokking, 2002), to the point where the depth of disturbance may be even higher than the estimated values provided in our Vessel Impacts Analysis (see section VII).

Given the findings outlined above and in the Baird Vessel Impacts Analysis, the work sequence proposed by EPA is unlikely to be practical. If tugs are used to move barges to and from the dredge cell locations, it is likely that previously-remediated downstream sections will be damaged by grounding and propeller scour.

Based on this, we recommend that the ROD require that the flushing tunnel be shut down while (or if) dredge cells are employed; that the related negative impacts to water quality must be accounted for; and that all navigation alongside the dredge cells in RTAs 1 and 2 be stopped for the full period of construction.

VII. Vessel Impacts Analysis

In the PRAP, a navigation depth of -16 feet (NAVD88) was assumed in RTA 2 based on existing commercial navigational needs. Baird tested this with a vessel impact analysis.[5] Modeling revealed that the PRAP does not account for the full range of vessel impacts, such as vessel grounding and propeller scour, which cause remobilization and redistribution of bed sediments. This has significant implications

---

[5]The analysis in Baird's 2012 Vessel Impact Study included: quantification of commercial vessel traffic using Automated Information System vessel tracking data; examination of Acoustic Doppler Current Profiler data collected in the Canal to determine the impacts of vessels underway on flow in the Canal; analysis of multibeam bathymetric data for evidence of propeller scour and vessel grounding; analytical propeller wash calculations to determine the potential for bed sediment mobilization under existing and remedial design conditions; and three-dimensional numerical modeling, including flow around moored barges and prediction of the fate of sediments mobilized by propeller scour of the Canal bed by vessels underway.

Baird

for depth and cap / armor layer designs, namely with the continued presence of commercial navigation in RTA 2, the depths prescribed in the PRAP are not practical. In order for a remedy to continue in place and have positive effects, it must take into account the impacts identified through this study, incorporate them into the ROD, and account for them during the remedial design. The findings that must be considered are as follows:

- Contrary to the EPA's assumption, vessels do not only move at high tide;
- Several instances of propeller wash close to the Canal bed and of vessel groundings (vessel contact with the Canal bed) have been identified and they both disturb and redistribute bed sediments. In fact, vessel traffic cannot only mobilize and redistribute sediments (and thus contaminants), but propeller wash can mobilize sediments as large as cobbles and boulders – materials much larger than those observed in the Canal bed. Given this fact, it can be concluded that bed sediments are regularly mobilized into the water column by vessel activity;
- Flow speeds in the Canal increased by at least 600 to 800 percent as a result of vessel passage and propeller wash;
- Scour of the Canal bed is induced by propeller wash, causing resuspension and redistribution of bed sediments and contaminants;
- A significantly deeper dredge depth will be required to accommodate commercial vessel traffic in RTA 2;
- The cap armor layer material size for the proposed elevation of the bed in RTA 2 is significantly underestimated in the PRAP, and as a result, for example, a single trip by a commercial vessel may be sufficient to irrevocably damage the armor layer and underlying cap;
- A sand benthic layer will be unsustainable under the combined effects of propeller wash and flushing tunnel flow at depths as deep as 30 feet. However, a deeper dredge depth will compromise the ability of the flushing tunnel to prevent water quality issues in the Canal.

As noted above, the sand benthic layer will be disturbed. Published methods were used to determine if a benthic sand layer could be stable given the presence of tug activity in the Canal. Based on the methods provided by Hamill et al. (1999) and Ryan and Hamill (2012), the depth of sand disturbance will be significant. In the case of the -16 foot target elevation in RTA 2, disturbance to a depth of more than five feet in the sand benthic layer is possible assuming a fixed tug with full power. At the 30 foot depth, the predicted disturbance of the sand benthic layer is approximately two to six inches. A confined flow case (such as against a quay wall) will produce higher bed velocities (Schokking, 2002), and the depth of disturbance may be higher than the estimated values provided.

In some sections of the Canal under existing conditions, the bed materials are similar to a sandy benthic layer. Accordingly, the potential for tug-induced disturbance expected in the benthic sand layer was checked against observations made in the Canal. Bathymetry surveys in 2010 and 2011 were completed. During the period between surveys, AIS data suggests that tug / barge activity in towards the Dorann dock (but never beyond or from the opposite direction) disturbed the bed (Baird, 2012). In this area of tug activity and maneuvering, erosion / scour on the order of four to seven feet is observed in the bathymetric data, supporting the view that disturbance of the Canal bed can occur to a significant depth, and that a sand benthic layer will be subject to remobilization and redeposition on a regular basis unless commercial navigation is removed from RTA 2.

The effects of mobilizing sands and silts into the water column in the Canal were evaluated using the numerical flow and sediment transport model (Baird, 2012). Fine sediments and contaminants mobilized through propeller action can migrate away from the point of scour due to tidal and / or flushing tunnel activity. Regular tug activity in the Canal causes fine sediments in the bed to regularly move around and mix throughout the area. The movement of sands and gravels is likely less dramatic within a single event, however repeated erosion and deposition of sandy materials could result in gradual offshore migration through the study area. This also indicates the potential for fine sediments to be “winnowed” out of the bed – that is fine sediments are mobilized while leaving behind the coarse sediments. Since tug operators mostly travel in the Canal during higher tides, there is potential for a net asymmetry in the movement of fine bed sediments as they remain in suspension over the ebb tide. This effect is magnified during operation of the flushing tunnel since flow in the Canal becomes unidirectional towards the outlet at all states of the tide. The significance of this in terms of ongoing maintenance and nourishment of a depleting benthic layer needs to be considered as part of the analysis of the potential impacts of the remedial design.

Given the foregoing issues, the ecological and water quality objectives of the Canal remediation effort are incompatible with ongoing commercial navigation in RTA 2, the ROD should call for an end to commercial navigation in RTA 2. This is especially so in view of the facts that vessel traffic analysis identified a total of only five active docks limited to the southern portion of the Canal between 3rd Street and the Gowanus Expressway, on average there is only a single commercial vessel trip per day, and the typical trip is approximately only a single hour in duration.

VIII. Conclusions

RTA 2 is unlikely to remain stable with ongoing commercial navigation, even at the EPA recommended bed elevation of -16 feet. A deeper bed configuration is similarly ineffective because it will not only increase sediment and contaminant accumulation, but it will also lessen the ability of the flushing tunnel to address water quality issues in this section of the Canal. Given that the environmental goals of the proposed remedy are not achievable with commercial navigation in RTA 2, removing commercial navigation in RTA 2 must be evaluated. This should be done with a numerical flow and sediment transport model prior to development of the final remedy.

In the event that the prudent strategy of eliminating commercial vessel traffic is not pursued as part of remediation of the Canal, there must be flexibility within the PRAP to be able to evaluate bed elevations and the configuration of any proposed cap and armor layer in light of detailed vessel impacts.

The results demonstrate that if RTA 2 is dredged to accommodate navigation by commercial vessels, RTA 2 will suffer ongoing accumulation of sediment and contaminants. This is so even if the CSOs are controlled. In order to meet the primary goal of the restoration of benthic macroinvertebrate communities, a solution that minimizes sedimentation, erosion, and maintenance dredging is required.

References

Baird (2012). Gowanus Canal; Vessel Impacts Study Report. Report prepared by W.F. Baird & Associates Ltd. for National Grid.

Palermo, M. 2013. Feasibility and Practicality of Dredging in the Gowanus Canal. Submitted to USEPA, April 2013.

Schokking, L.A. (2002). Bowthruster-induced Damage. M.Sc. Thesis, Delflushing tunnel University of Technology

Sincerely,

W.F. Baird & Associates Coastal Engineers, Ltd.
Dalston Alex Brunton, Ph.D.

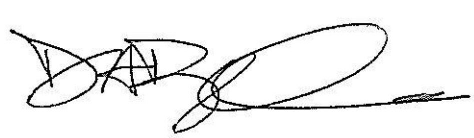


Figure 1. Transport of outfall sediments under surge conditions. Note this represents the more extreme limits of the distance particles may travel from the outfalls before being deposited on the bed. Deposited particles are color coded by size.

Figure 2. Fate of sediments introduced from CSO RH-034 under existing conditions, flushing tunnel inactive

Figure 3. Increase in silt deposition rates in RTA 2 resulting from dredging to -16 feet

Figure 4. Fate of suspended sediments introduced into the Canal via the flushing tunnel; Existing Conditions Bathymetry

Baird

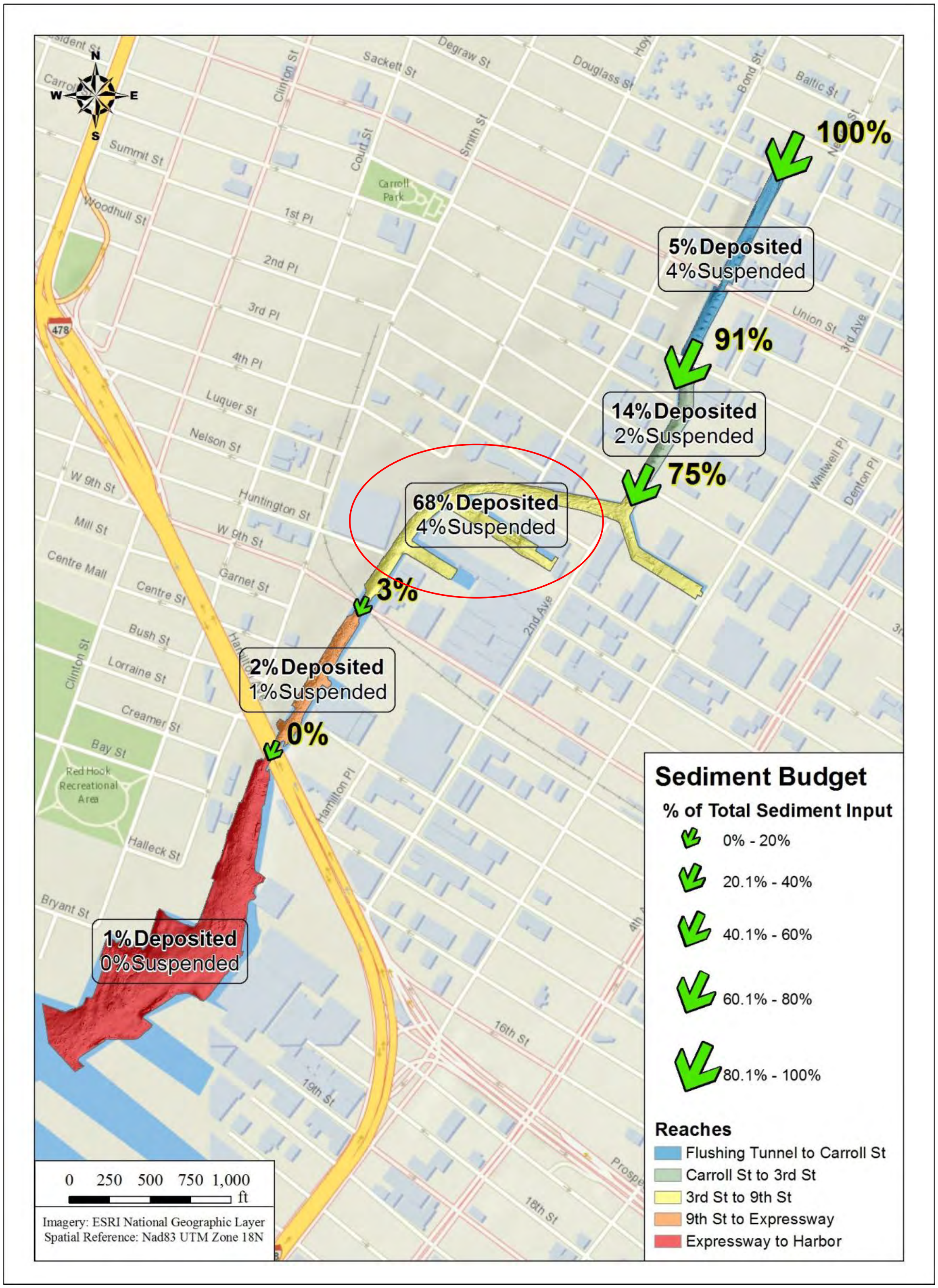


Figure 5. Sediment budget showing fate of flushing tunnel sediments under remedial alternative conditions. Zone of major deposition in RTA2 highlighted in red

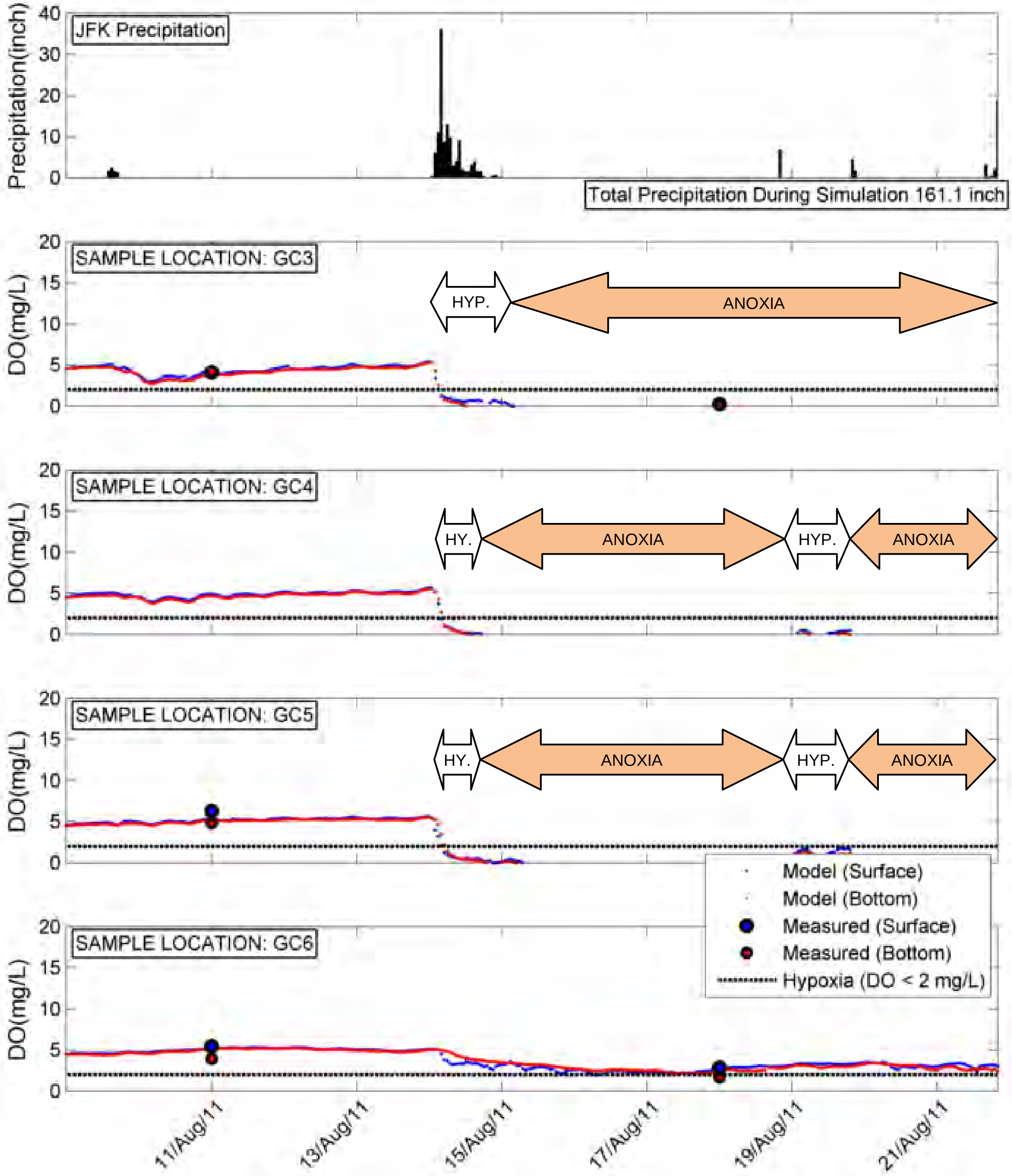


Figure 6. DO model validation showing measured and modeled anoxia and hypoxia in the Canal following a rainfall and CSO flow event on 14th-15th August, 2011. Note that modeled results do not include effects of oxygenation pipe.

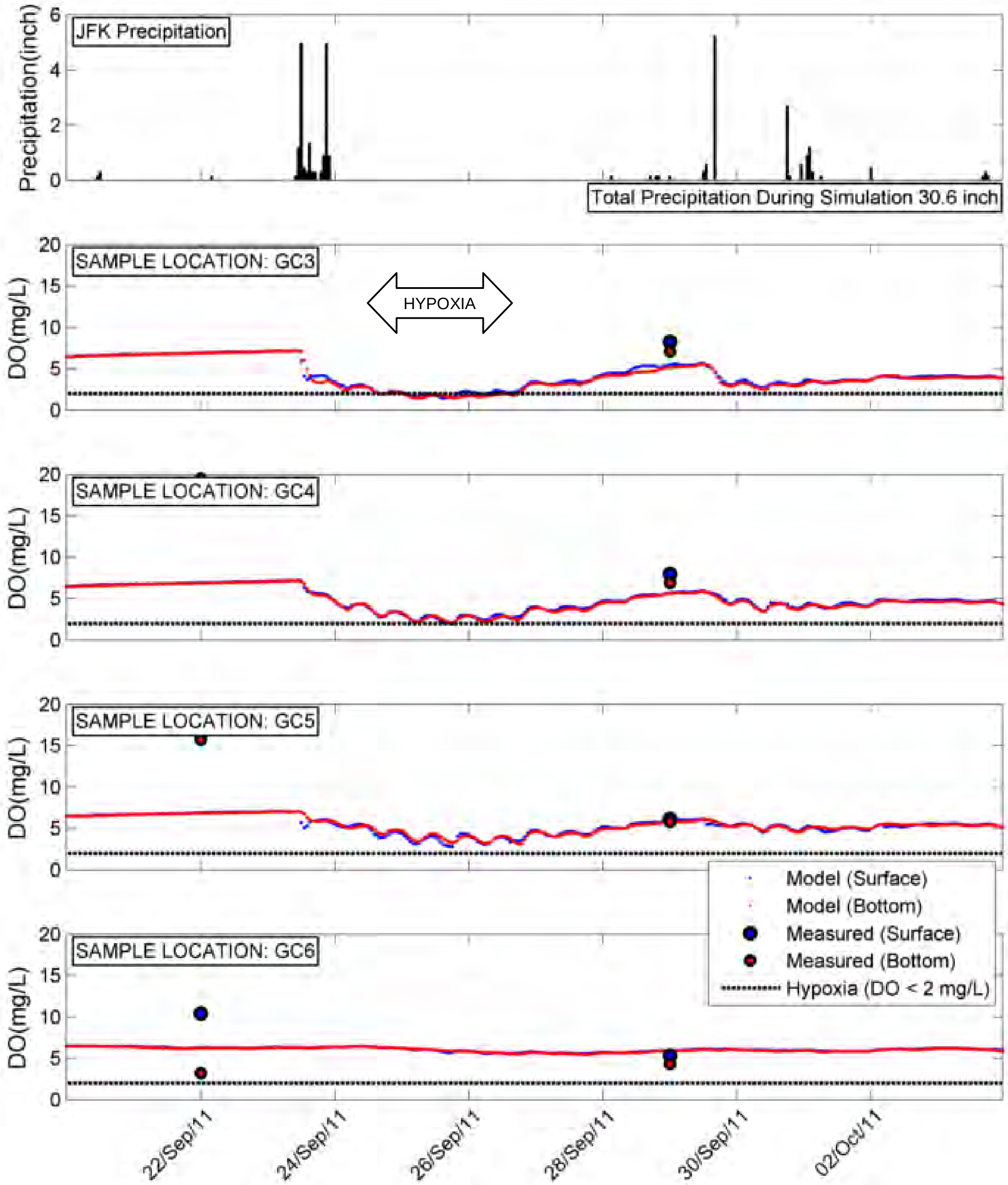


Figure 7. DO model validation showing measured and modeled hypoxia in the Canal following a rainfall and CSO flow events on 25th September, 2011 and 29th September, 2011. Note that modeled results do not include effects of oxygenation pipe.

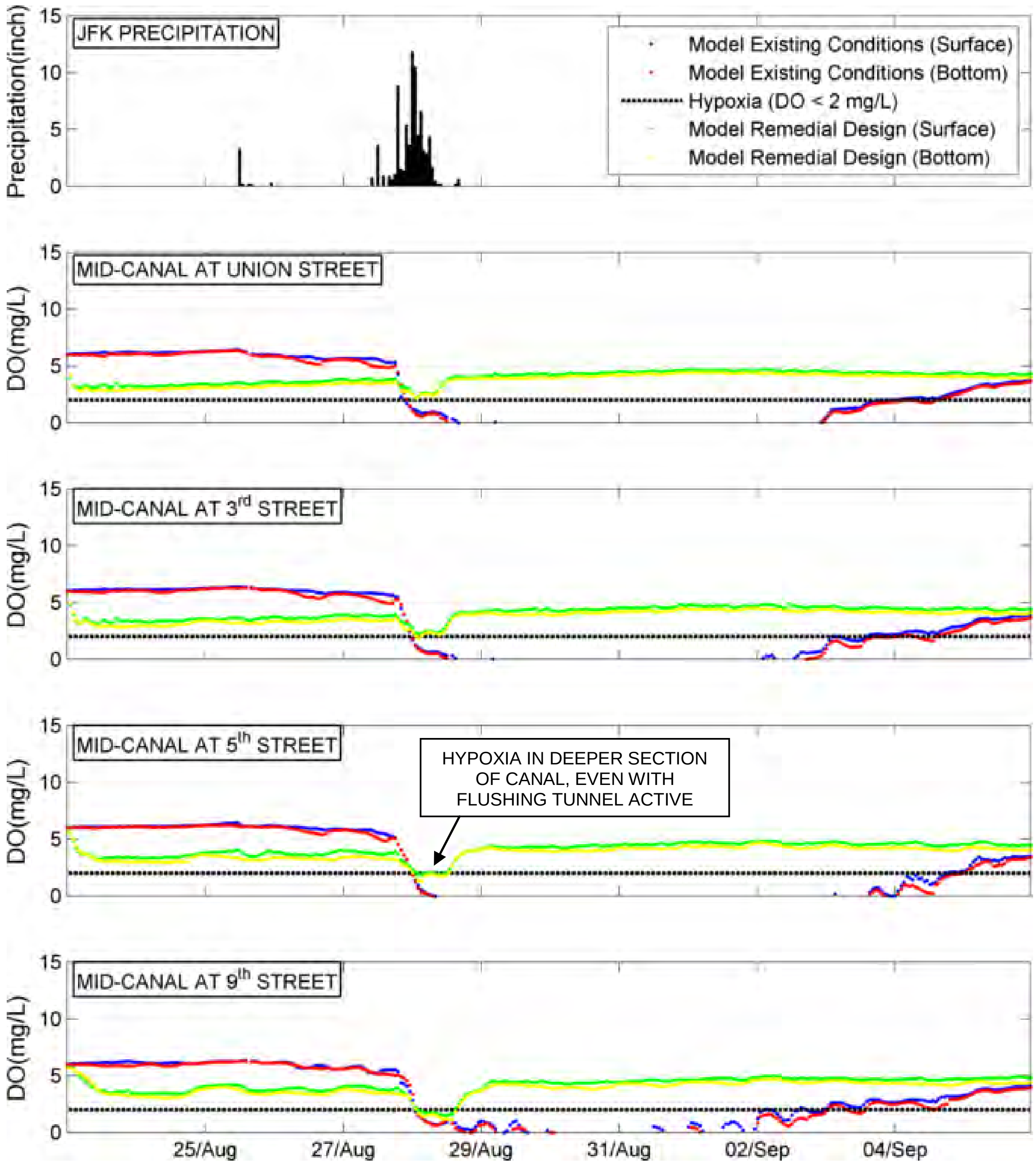


Figure 8. Comparison of modeled Remedial Design conditions with Existing Conditions for the Hurricane Irene event

Figure 9. Change in copper deposition rates resulting from dredging to -16 feet for a wet weather flow event

Figure 10. Change in lead deposition rates resulting from dredging to -16 feet for a wet weather flow event

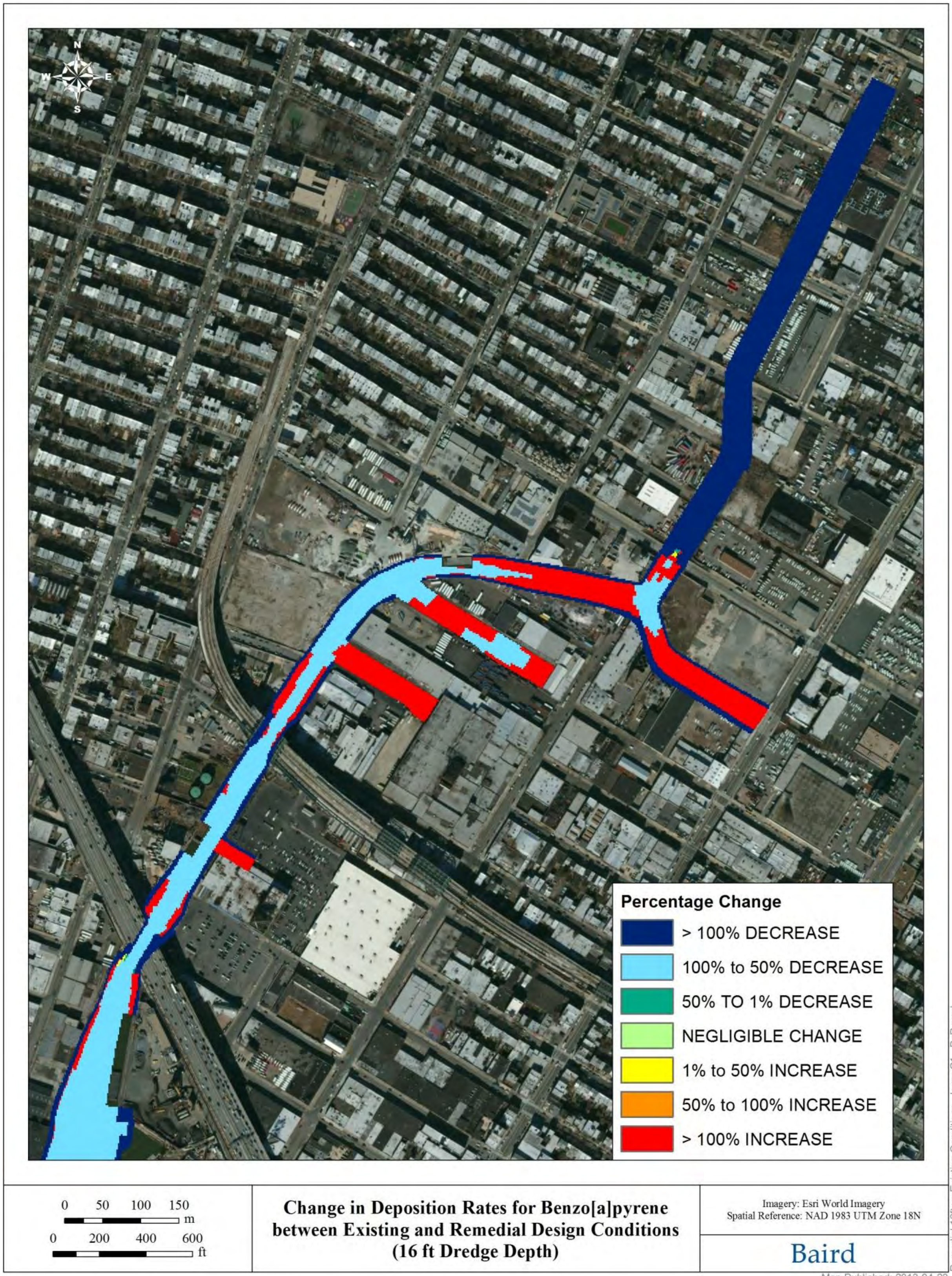


Figure 11. Change in benzo[a]pyrene deposition rates resulting from dredging to -16 feet for a wet weather flow event

Figure 12. Change in PCB-153 deposition rates resulting from dredging to -16 feet for a wet weather flow event

Appendix E

Comments on Upland Source Control and the Potential for Canal Recontamination, prepared for National Grid, by Exponent, Inc.

Comments on Upland Source Control and the Potential for Canal Recontamination

Contents

1 Comments on Upland Source Control and the Potential for Canal Recontamination

In its comments regarding the Gowanus Canal (the Canal), the Contaminated Sediment Technical Advisory Group (CSTAG) made clear that control of upland sources of contamination (such as combined sewer overflows [CSOs]) should be made a priority before any remedy is implemented (CSTAG 2012). CSTAG added that a final Record of Decision (ROD) should be issued “after the CSOs, ground-water, permitted and unpermitted discharges have been further controlled and their impacts on reducing risks are better understood” (CSTAG 2012). Otherwise, “there would be significant recontamination of the surface sediment after any sediment remedy” because “it may be many years if not decades before contaminant releases are reduced.” (CSTAG 2012).

The United States Environmental Protection Agency (EPA) Region 2 (the Region) responded that a detailed working schedule had been developed “for the control of major contaminant sources and the entity responsible for each activity.” The Region added that although it “has not yet achieved a consensus with the [New York City Department of Environmental Protection] [DEP] on the various issues relating to the CSOs,” the Region believes that CSO controls will be constructed in a “time frame not inconsistent with the remaining remedial work.” (EPA 2012).

However, the Region’s plan to reduce CSO discharges to the Canal, while a good first step, will not eliminate ongoing and future contamination from reaching the Canal. This is because CSOs, even at lower flow rates, will continue to discharge contaminants from historical and ongoing accidental spills of hazardous wastes that occur frequently around the Canal. Indeed, the recent chemical data obtained in 2012 from sediment mounds located near CSO outfalls confirmed that hazardous wastes are continuing to be conveyed to the Canal.

Storm water outfalls and other permitted and unpermitted outfalls also need to be addressed prior to any remedy implementation because they convey significant amounts of contamination to the Canal. For example, in Canal turning basins, accidental releases of waste oils from properties abutting the Canal have resulted in sheens on Canal surface water (e.g., NYDEC spill number 0800421, further discussed below). These impacts to the Canal were likely conveyed through permitted and non-permitted outfalls. Accidental releases of wastes will continue to occur in the future as they are part and parcel of industrial operations around the Canal. Although the Region’s investigations of unpermitted pipes identified only “minor releases from a handful” of pipes, those “snapshot” investigations are not representative because they were not conducted concurrent with releases of contaminants from upland sources. Indeed, the actual data from the Canal sediments suggests continuing CSO and other outfall inputs of contaminants.

Consistent with the CSTAG recommendations, we recommend that controlling all contamination sources around the Canal should be made a priority in the ROD. Otherwise, any dredging will be a wasteful use of resources and the Canal sediment will be recontaminated. As discussed below, such recontamination has occurred at many sites throughout the country where source control was either neglected or was conducted during remedy implementation. The

Proposed Remedial Action Plan (PRAP) does not provide a clear plan to address upland sources. Our comments on the PRAP with regard to controlling upland sources are presented below.

1.1 Comment 1: The recent (2012) CSO sediment mound data show that CSOs are conveying contamination from upland areas to the Canal. The proposed plan to reduce CSO flow rates will not eliminate Canal recontamination.

The 2012 core samples from sediment mounds along the Canal bottom confirm that CSOs continue to discharge contamination from historical and current upland sources. Direct discharges via seeps from upland sources also account for some of the contamination in the mounds. It is not clear how flow reductions will eliminate CSOs from conveying contaminants to the Canal.

GEI 2012 sampling event

Bathymetric surveys conducted between 2003 and 2010 showed that sediment was accumulating below and in the vicinity of CSO outfalls. Some of these CSO sediment mounds were up to five feet thick (bathymetric survey results were presented in the 2011 Remedial Investigation Report; EPA 2011). In 2012, GEI Consultants, Inc. collected four feet sediment cores from these sediment mounds. See Figure 1 for sediment core locations. The sediment cores, which were sliced every six inches, were analyzed for VOCs, SVOCs, TPH, metals, PCBs, PPCPs and pathogens[1], pesticides, and herbicides. Analytical results are presented in Appendix I. Below is an evaluation of these results.

Analytical results for sediment samples from mounds near CSO RH-031/OH-602 (see Figure 1)

Total polycyclic aromatic hydrocarbons (tPAH) concentrations in this sediment mound were as high as 3,581 mg/kg (as the sum of the 16 priority pollutant compounds– $tPAH_{16}$). With the exception of just one sample containing PAHs that originated from a tar-like source, PAHs in the sediment mound originated from petroleum sources, such as waste oils. Figure 2 presents example PAH and gas chromatogram profiles for a sediment sample that is consistent with waste oils. The figure also presents similar information for the one sediment sample with a PAH profile with a dominant pyrogenic (e.g., tar) signature. Figure 3 presents the ratio $tPAHs_{44}/TPH$[2] for all the sediment samples. This shows that the PAHs in the sediment mound at RH-031/OH-602 originated predominantly from petroleum sources, consistent with waste oils.

The presence of tar in the CSO mound is consistent with the use of tar at the former Honeywell tar felt plant. The Honeywell plant had coal tar and petroleum in its soil, with PAHs up to 473,000 mg/kg (Fleming 2005). The presence of waste oils in the mound appears to be

[1] Volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), total petroleum hydrocarbons (TPH), metals, polychlorinated biphenyls (PCBs), pharmaceuticals, and personal care products (PPCPs).

[2] $tPAH_{44}$ is the sum of 44 parent and alkylated PAH compounds. TPH is total petroleum hydrocarbons in the sediment sample.

consistent with contamination at the Witco Site, where PCBs and light non-aqueous phase liquid (LNAPL) were found in groundwater (WSP 2009). Indeed, PCBs were found in the sediment mound at concentrations up to 92 mg/kg; a concentration higher than any previously reported value in the Canal. It is clear that the CSO continues to convey contamination from historical upland sources to the Canal, including the last 10 years. Other example compounds in the CSO mound at high concentrations included DDT up to 1 mg/kg, lead up to 2,900 mg/kg, copper up to 1,200 mg/kg, the CSO marker *Clostridium perifringens* up to 410,000 cfu/mg, among other compounds exceeding their respective screening values (see Appendix I for details).

During the remedial investigation, a sediment sample was collected from RH-031 (EPA 2011). During dry weather, total PAH_{16} concentration in the CSO solids was 18 mg/kg and PCBs were not detected. These CSO sampling results are not representative of the contamination that has been discharging from RH-031, as the results are inconsistent with the CSO mound data. We believe that the CSO sediment mound data more accurately reflect the cumulative and time-integrated contamination that is being episodically discharged to the Canal.

The 2008 NYCDEP waterbody/watershed facility plan (NYCDEP 2008) for RH-031 is to reduce its flow rate by upgrading the Gowanus pump station. It is not clear how a 70% reduction in the flow from RH-031 will stop the conveyance of historical tars, waste oils, and PCBs to the Canal (in addition to future upland spills). As noted above, the CSO discharge concentration and volumes have not been adequately characterized. Furthermore, it has not been demonstrated and may be unlikely that a reduction in flow will reduce the concentration of contaminants in the discharge. The 2012 sediment mound core data showed that contamination discharged by CSOs to the Canal is variable in nature (e.g., core SED-522: tar impacts in a layer from 2.5-3 feet, with waste oils above and below the tar layer; see Figures 2 and 3). It is not clear if this variability is a function of CSO flow rates or other factors; such as direct discharges. This situation warrants additional investigation to understand how contaminants are being conveyed to the Canal through CSOs. Clearly, controlling the historical upland sources and future activities along the Canal before any remedy implementation should be made a priority in the ROD.

Results for CSO RH-035/OH-007 sediment samples (see Figure 1)

Total PAH concentrations in these sediment mound samples ($tPAH_{16}$) ranged from 16 to 647 mg/kg and originated predominantly from petroleum sources, consistent with mid- to heavy-range fuel oils, transmission oils, and other waste oils. The gas chromatograms in Figure 4 show clear evidence of petroleum and petroleum-related PAH in sediment samples from the mound. Figure 5 shows that the mound samples have ratios of $tPAH_{44}$/TPH that resemble petroleum sources.

Most likely, these petroleum and waste oil impacts resulted from frequent and recent upland spills. For example, near RH-035, recent spills that impacted the Canal include fuel oil spills (New York State Department of Environmental Conservation (DEC) spill number 9301903 (1993)), and diesel spills into sewers (DEC spill number 9401648 (1994)). This is in addition to several hundred thousand gallons of sewage that were discharged in 1997 to the Canal at the OH-007 location (e.g., DEC spill numbers 9710741 and 9706778, 263,000 and 12,750 gallons of sewage discharge, respectively).

In addition to PAHs, other compounds in the CSO mounds include PCBs up to 23 mg/kg, DDT up to 0.5 mg/kg, lead up to 1,400 mg/kg, and copper up to 3,200 mg/kg among other compounds.

The Region's plan for OH-007 is to construct a 3-4 million gallon in-line storage tanks to reduce the discharge, with no further information available. The tanks are anticipated to capture approximately two times the amount of first flush during wet weather events. However, the Region has not provided any evidence that the proposed in-line tanks will result in the 74% reduction of solids, which was noted in the Feasibility Study as required to meet the preliminary remediation goal (PRG) for PAH, PCBs, copper, and lead (CH2MHill 2012). (See additional comments on the Region's plan for OH-007 in Appendix G by Woodard and Curran).

For RH-035, the 2008 NYCDEP waterbody/watershed facility plan (NYCDEP 2008) is to reduce the flow rate by upgrading the Gowanus pump station. Conveyance of contaminants, however, will continue to occur even at the lower flows, unless protective measures are taken to control the flow from Bond Street to the catch basins or to redirect the flow from the outfall. Any of these alternatives will be time consuming. As it stands, the PRAP does not have a clear plan to control Canal recontamination in the RH-035/OH-007 area.

Results for sediment mounds at the northern reach of the Canal (see Figure 1)

Total PAH concentrations in these sediment mounds ($tPAH_{16}$) ranged from 5 to 1,508 mg/kg and originated from a mix of petrogenic and pyrogenic sources. Figure 6 presents exemplar sediment samples from the mounds with petrogenic and pyrogenic PAH/Gas chromatogram signatures. Figure 7 shows that the mound samples have ratios of $tPAH_{44}$/TPH that resemble a mix of sources. This mix is indicative of multiple ongoing upland sources along the Canal. Other contaminants included PCBs up to 3.5 mg/kg, DDT up to 0.099 mg/kg, and metals (lead up to 1,300 mg/kg, copper up to 740 mg/kg) among other contaminants.

The Region's plan to control the discharge from RH-034 is to install a 6-8 million gallon in-line storage tank for a 58% reduction of solids to meet the PRG for PAH, PCBs, copper, and lead. Again, the Region has not provided any evidence that the proposed in-line tanks would result in a 58% reduction of solids (See additional comments on the Region's plan for RH-034 in Appendix G by Woodard and Curran).

In summary, the 2012 sediment mound data confirmed that CSOs are conveying contaminants at concentrations much higher than characterized during the Remedial Investigation. The Region has failed to demonstrate that its plans to control CSOs and stop contaminants from reaching the Canal will be successful. This is a critical shortcoming. The proposed remedy for the Gowanus Canal is extensive and will be an engineering challenge. There must be assurance that this proposed massive cleanup will not be immediately reversed because of lack of CSO control measures.

1.2 Comment 2: Hazardous wastes from accidental spills are conveyed to the Canal through stormwater and non-permitted outfalls. These spills and transport routes must be recognized and addressed prior to any remedy selection.

Accidental releases of contaminants occur frequently around the Canal and impact the Canal through sewers, permitted discharge points, and non-permitted discharge points. DEC has extensive documentation of such contaminant releases to the Canal. Some examples are presented in Table 1 (which is by no means exhaustive and which does not cover all segments of the Canal) and Figure 8.

Among the accidental spills were releases of diesel fuels and waste oils that led to visible sheens on Canal surface water. Petroleum products, oils containing PCBs, and dielectric fluids were also found in manholes around the Canal at numerous locations. On some occasions, retaining walls collapsed into the Canal (e.g., location 204 in Table 1). Many other spills were reported in the DEC files to be of unknown sources, some of which were reported to be an “ongoing problem” of directly impacting the Canal (e.g., location 293 in Table 1). This is in addition to the hundreds of thousands of gallons of raw sewage that impacted the Canal over the past 20 years from pump and gate failures, as documented by the DEC.

This documentation of releases is important because it illustrates the nature of industrial operations around the Canal -- leaking underground storage tanks (USTs), truck and bus yards, salvage yards, and manholes with PCB filled transformers, among other sources. Clearly, controlling these hundreds of sources prior to any remedy selection must be made a priority in the ROD.

1.3 Comment 3: The effectiveness of upland source control measures must be demonstrated as effective prior to any remedy implementation.

In the past few years, many sediment remediation sites that included both dredging and capping have been recontaminated after implementation of remedial measures. Examples of these sites are included in Table 2. This fact underscores the importance of demonstrating that sources have been controlled prior to embarking on dredging or other sediment management activities.

In its *Contaminated Sediment Management Strategy* (EPA 1998), the EPA stated that “before initiating any remediation, active or natural, it is important that point and nonpoint sources of contamination be identified and controlled.” EPA site managers were advised to adopt a phased approach towards site remediation where the effectiveness of source control is in doubt (EPA 2005). Such instruction holds true for the Gowanus Canal. The Region must "phase" its next steps by identifying and controlling all sources of contamination first including discharges from adjacent upland sites, and discharges from the combined sewer system. Only after this is done may the Region move on to the second phase of designing the remedy.

As highlighted in Table 2, sources of recontamination include point sources (e.g., public sources like CSOs, storm sewer outfalls, and industrial discharges), and non-point sources (groundwater advection spills, runoff, adjacent upland contamination). As the data in Table 2 show, these sites became recontaminated relatively quickly after the completion of remedial actions.

Relevant to the setting of the canal, sources of recontamination included both storm sewer discharges (e.g., Thea Foss Waterway in Tacoma, Washington) and discharges from contaminated upland sites into existing storm sewer systems that subsequently impacted sediments around outfalls (St. Clair Shores, MI). Additional documentation on the extent of this problem and the costs associated with addressing recontamination is presented in the recently published Sediment Remedy Effectiveness and Recontamination: Selected Case Studies (ASTSWMO 2013). Notably, this document about recontamination was prepared with assistance from the EPA.

Based on experience from other sites around the country, source control at the Gowanus Canal must be in place and demonstrated to be effective prior to remedy selection. This is consistent with EPA's sediment strategy, policies, guidance, and prior experience.

ASTSWMO (Association of State and Territorial Solid Waste Management Officials). 2013. Sediment Remedy Effectiveness and Recontamination: Selected Case Studies. Prepared with assistance from the U.S. Environmental Protection Agency (EPA) under Cooperative Agreement RT-83376901. April.

Bergeron, R.E., B.S. Cushing, and M.K. Hammaker. 2000. "The Cable Arm Clamshell: Development and Track Record for Environmental Dredging." *World Dredging Mining and Construction*. 36(5).

Boston Globe (BG). 2005. "Recontamination feared for river getting cleanup. March 3.

Carlisle, C.L. 2002. *Convair Lagoon Remediation of PCBs*. California Regional Water Quality Control Board San Diego Region. June 18.

CH2MHill. 2012. Feasibility Study Report Addendum, Gowanus Canal, Brooklyn, New York. Prepared for U.S. Environmental Protection Agency, Region 2. CH2MHill. December.

Cieniawski, S. and D. Collier. 2003. *Post-Remediation Sediment Sampling on the River Raisin Near Munroe, Michigan Final Results from 2001-2001 Survey: PCB Chemistry, Caged Fish and Bioaccumulation Results.* U.S. Environmental Protection Agency Great Lakes National Programs Office, August.

Cleland, J. 2000. *Results of Contaminated Sediment Cleanups Relevant to the Hudson River*. ICF Consulting. October.

Cleland, J. 2001. *Results of Contaminated Sediment Cleanups: Experience to Inform Future Remedy Decisions*. ICF Consulting. May 31.

CSTAG. 2012. Memorandum: GSTAG Recommendations on the Gowanus Canal Superfund Site. From SJ. Ells to C Tsiamis. January 30.

Dredging News Online (DNO). 2002. "US Navy accused over Puget Sound Contamination." November 29.

Fleming. 2005. Red Hook Site. Phase II Environmental Investigation Report. April.

Hazardous Substance Research Center South & Southwest (HSRC). (undated) *Summary of Contaminated Sediment Capping Projects*. Downloaded December 17, 2006 at http://www.sediments.org/capsummary.pdf.

National Research Council (NRC). 2001. *A Risk-Management Strategy for PCB Contaminated Sediments*.

New York City Department of Environmental Protection. 2008. Gowanus Canal Waterbody/Watershed Facility Plan Report. Bureau of Engineering Design and Construction. August.

Palermo, M.R., T.A. Thompson, and F. Swed. 2002. *White Paper No. 6B – In-Situ Capping as a Remedy Component for the Lower Fox River [Response to a Document By The Johnson Company, Ecosystem-Based Rehabilitation Plan – An Integrated Plan for Habitat Enhancement and Expedited Exposure Reduction in the Lower Fox River and Green Bay]*. December.

Romberg, G.P. 2005. "Recontamination Sources at Three Sediment Caps in Seattle." *Proceedings of the 2005 Puget Sound Georgia Basin Research Conference*.

Seattle Post-Intelligencer (SPI). 2002. "The Navy, a top polluter, botched cleanup." November 18.

Seattle Post-Intelligencer (SPI). 2005. "Duwamish River doesn't stay clean, Source of new contamination still mystery." December 23.

Tacoma News Tribune (TNT). 2006a. "Foss Waterway dirty again?" March 1.

Tacoma News Tribune (TNT). 2006b. "Fresh contamination taints Superfund Foss Waterway." October 15.

The Macomb Daily (TMD). 2006. "EPA to begin cleanup of PCB contamination, Drains will be lines to prevent further pollution in Shores waters." May 5.

U.S. Agency for Toxic Substances and Disease Registry (ATSDR). 1992. *Public Health Assessment for Bloomington PCB Sites, Volume I Responses to Public Comments*.

U.S. Army Corps of Engineers (USACE). 2005. *Los Angeles Regional Dredged Material Management Plan Pilot Studies, Los Angeles, California, Long-Term Evaluation of Aquatic Capping Disposal Alternative*. September.

U.S. EPA. 1998. EPA's Contaminated Sediment Management Strategy. EPA-823-R-98-001. April.

U.S. EPA. 1999. *Superfund Record of Decision for Pacific Sound Resources Site Upland & Marine Sediments OUs, Seattle Washington, Part 3 Responsiveness Summary*. EPA541-R99-083.

U.S. EPA. 2001. *First Five-Year Report for United Heckathorn Superfund Site*. September.

U.S. EPA. 2003. *Fact Sheet Lower Duwamish Waterway Site*. June.

U.S. EPA. 2004a. *United Heckathorn Superfund Site Reinvestigation of Waterways Completed*. February.

U.S. EPA. 2005. Contaminated Sediment Remediation Guidance for Hazardous Waste Sites. EPA-540-R-05-012. December.

U.S. EPA. 2006. *Anacostia River Demonstration Finds Active Caps Effectively Contain Sediment Contaminants*. Downloaded at http://www.clu-in.org/products/newsltrs/tnandt/0706.cfm, July 10.

U.S. EPA. 2011. Draft Gowanus Canal Remedial Investigation Report. Volume 1. Prepared for U.S. Environmental Protection Agency. Prepared by HDR CH2MHill. January.

U.S. EPA 2012. Response to Contaminated Sediments Technical Advisory Group Recommendations for the Gowanus Canal Superfund Site. From C Tsiamis to SJ Ells. May 29.

Washington State Department of Ecology (WDE). 2003. *Norfolk Combined Sewer Overflow (Duwamish River) Sediment Cap Reconstruction, Phase I Investigation*. Publication 03-03-004. February.

Weston, D.P., W.M. Jarman, G. Cabana, C.E. Bacon, and L. Johnson. 2002. “An Evaluation of the Success of Dredging as Remediation at a DDT-Contaminated Site in San Francisco Bay, California, USA.” *Environmental Toxicology and Chemistry*. 21(16): 2216-2224.

Weston, 2004. *Remedial Investigation Report, Michigan Department of Natural Resources, Consolidated Packaging Corporation Site, Monroe, Michigan, Volume I – Report,* January 1994.

WSP Engineering of New York. 2009. PCB investigation Final Report, Chemtura Corporation, Brooklyn, NY, August 21.

Zeng, E.Y., J. Peng, D. Tsukada, and T.L. Ke. 2002. “In Situ Measurements of Polychlorinated Biphenyls in the Waters of San Diego Bay, California.” *Environmental Science and Technology*. 36(33): 4975-4980.

Figures

Figure 1. CSO Sediment Core Locations (Collected August 2012 by GEI)

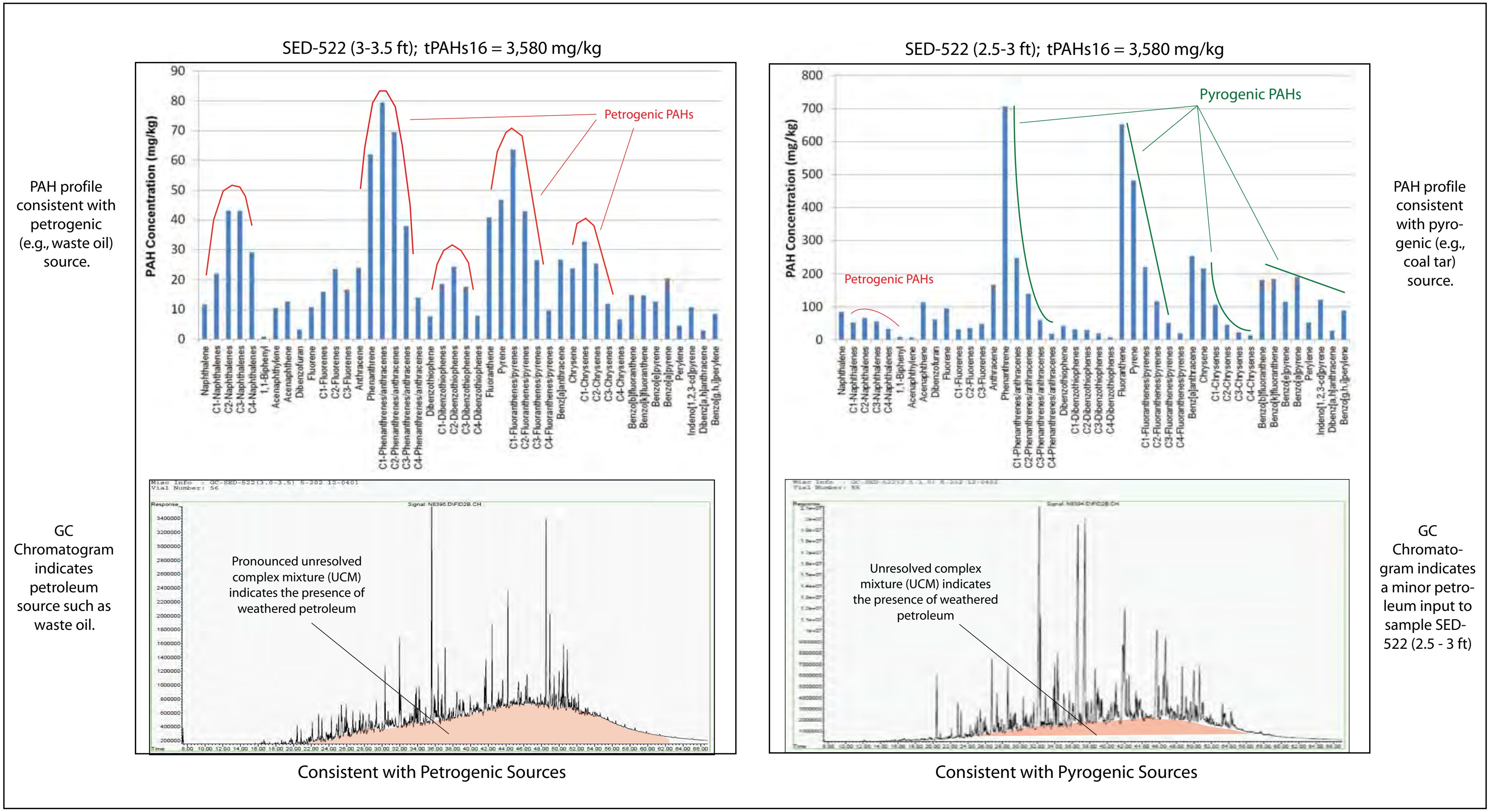
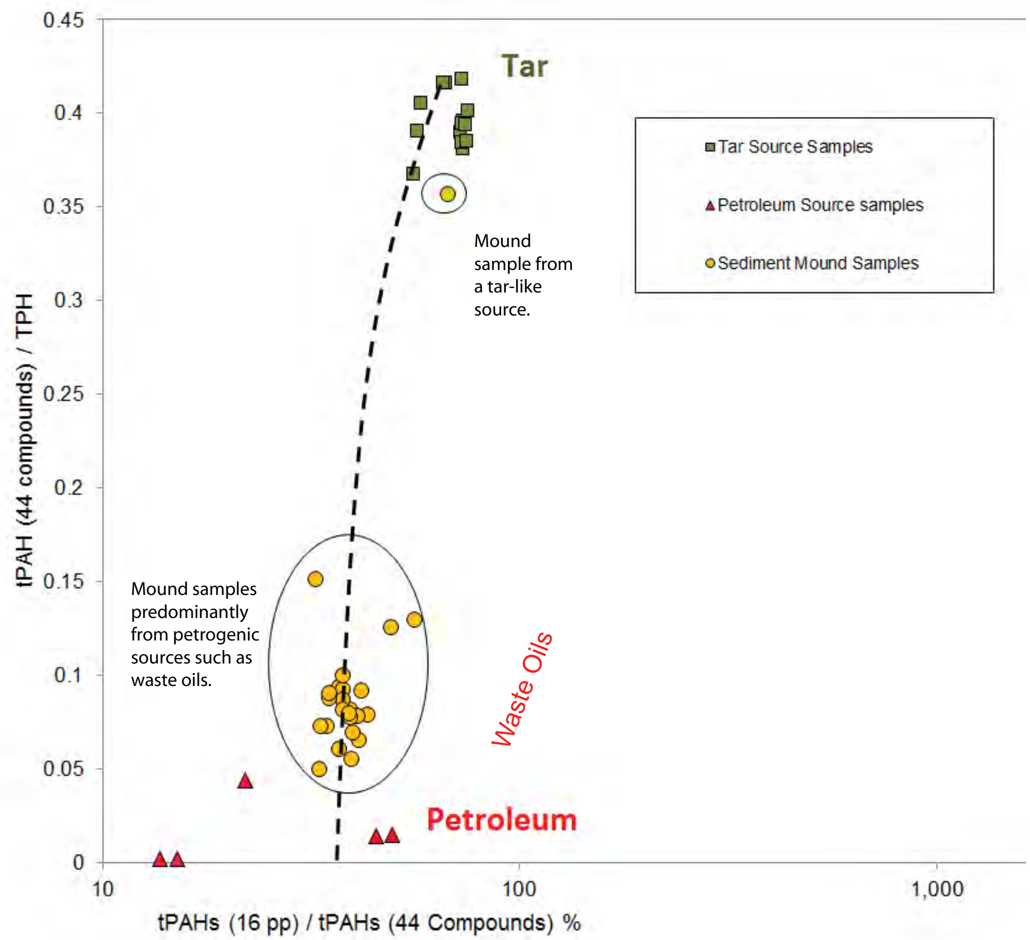


Figure 2. Example PAH and gas chromatogram profiles for samples from the RH-031/OH-602 sediment mound.

Exponent®

Sediment mound sample locations. (tPAH/TPH analysis results are presented on the adjacent graph)



tPAH 44 is the sum of 44 parent and alkylated compounds, tPAH 11 is the sum of the 16 priority pollutant compounds.
TPH is total petroleum hydrocarbons in the sediment sample

Figure 3. PAHs in the RH-031/OH-602 sediment mound originated predominantly from petroleum sources, consistent with waste oils, with PAHs in one sample originating from a tar-like source.

Exponent®

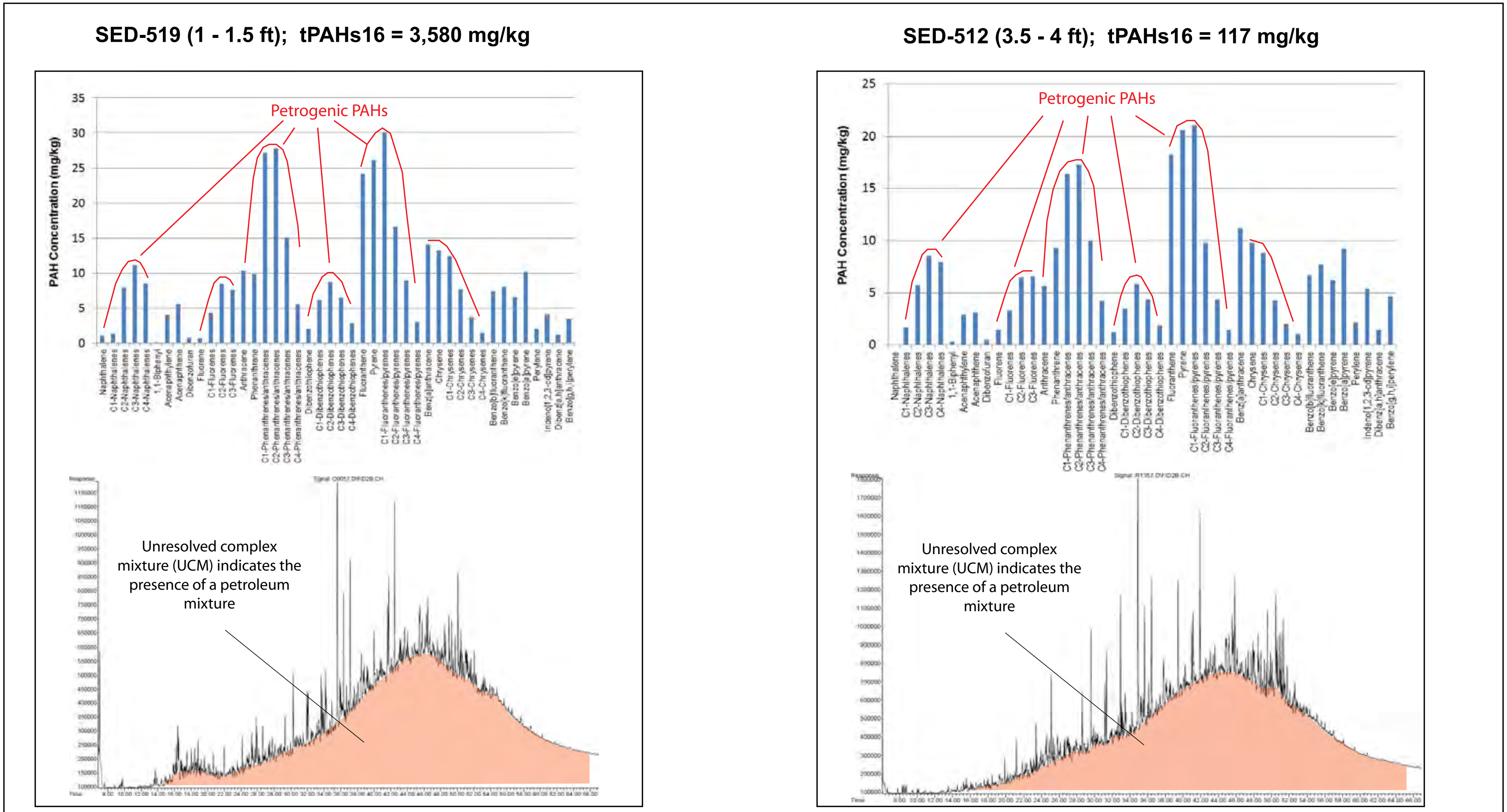
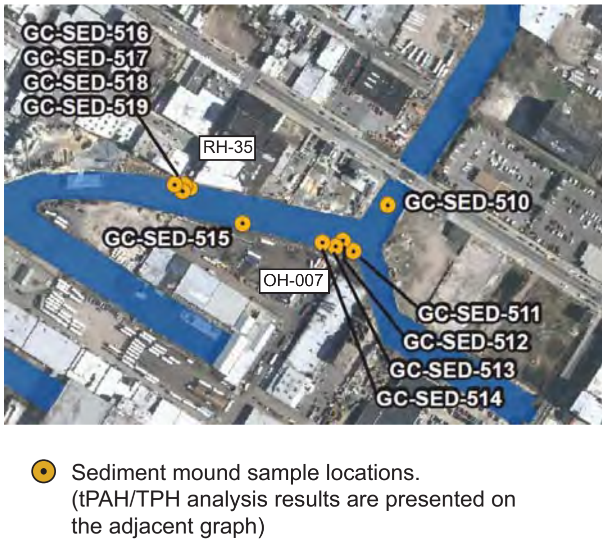
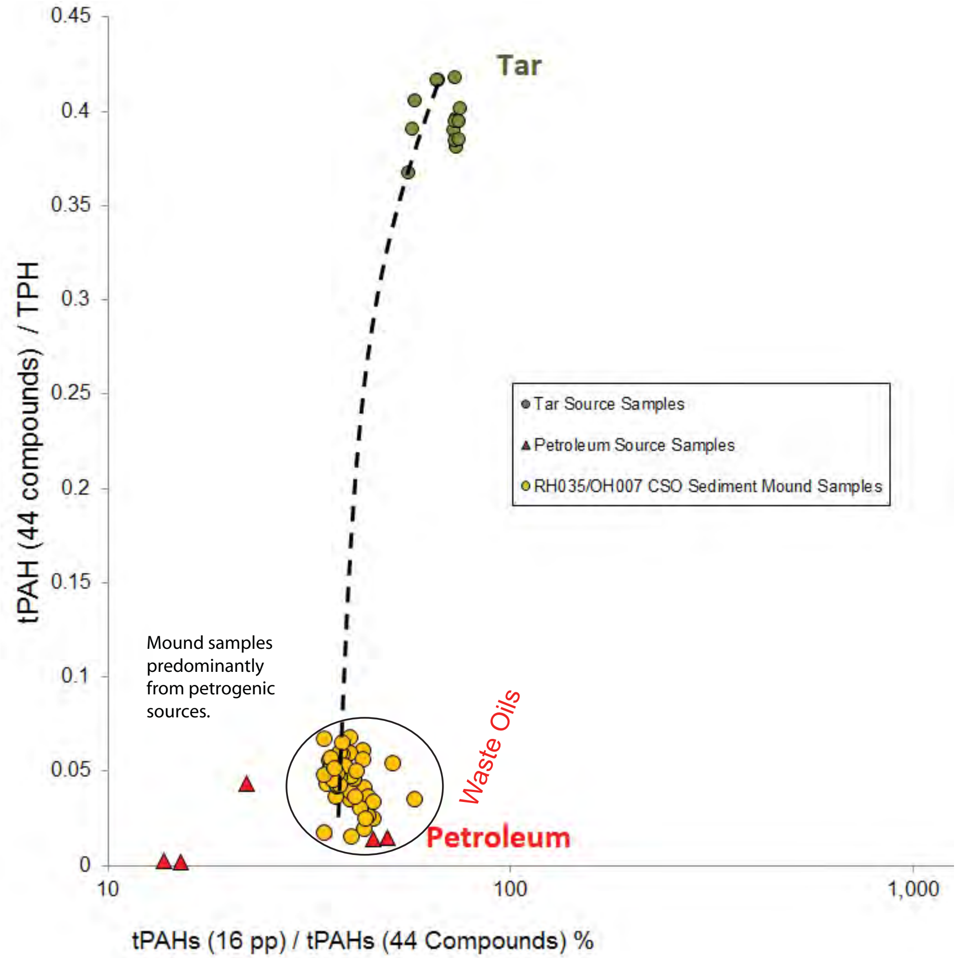


Figure 4. Example PAH and gas chromatogram profiles for samples from the RH-035/OH-007 sediment mound showing a mix of petroleum hydrocarbons in the samples, consistent with mid- to heavy-range fuel oils, transmission oils, and other waste oils

Exponent





tPAH 44 is the sum of 44 parent and alkylated compounds, tPAH 16 is the sum of the 16 priority pollutant compounds. TPH is total petroleum hydrocarbons in the sediment sample

Figure 5. PAHs in the RH-035/OH-007 sediment mound originated predominantly from petroleum sources.

Exponent

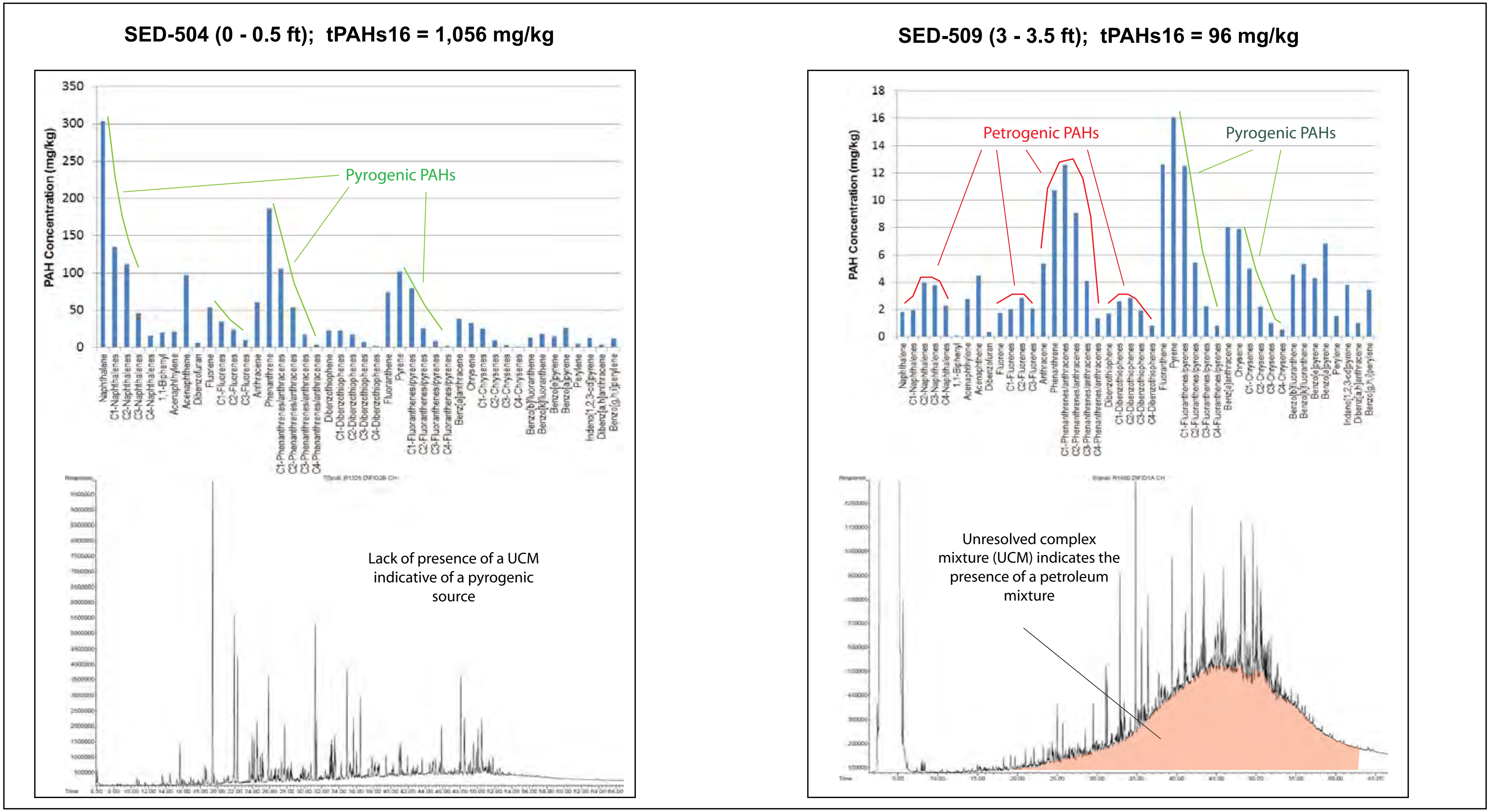
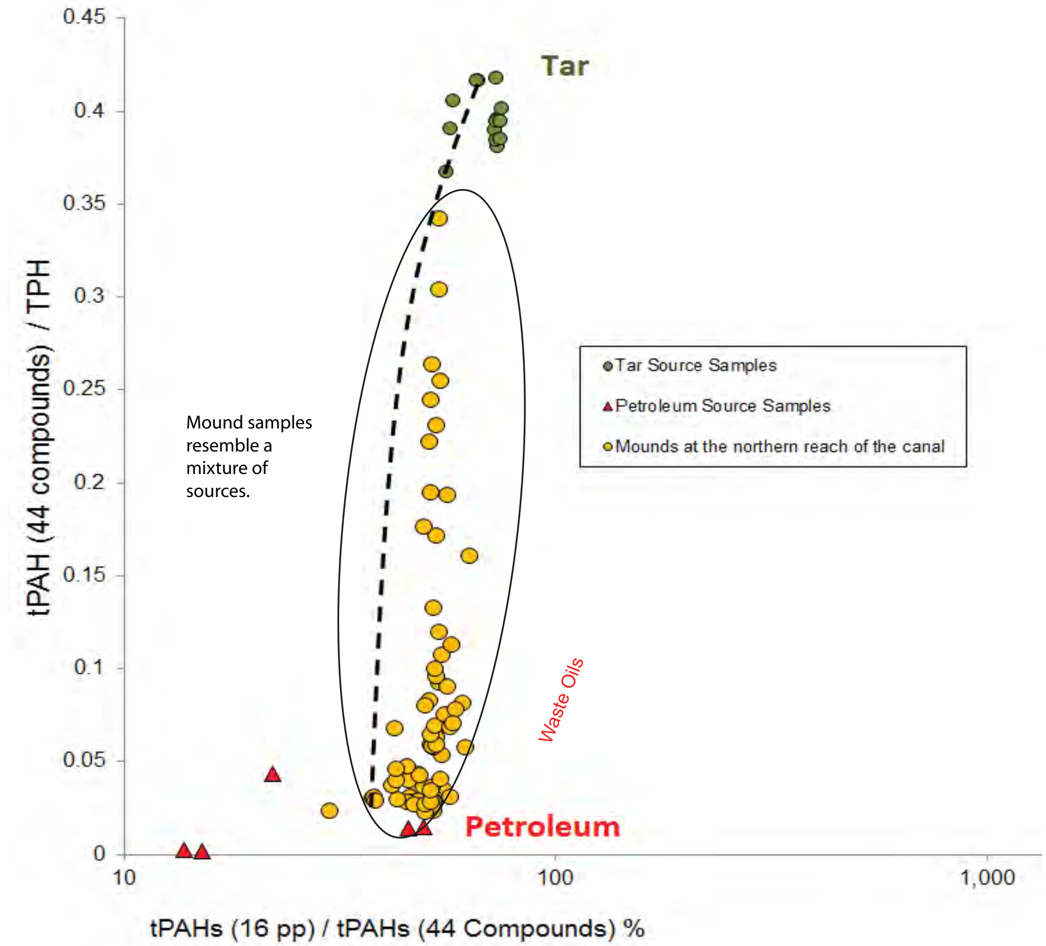


Figure 6. Example PAH/gas chromatogram profiles with petrogenic and pyrogenic signatures (samples from the sediment mounds at the northern reach of the Canal).

Exponent®

Sediment mound sample locations. (tPAH/TPH analysis results are presented on the adjacent graph)



tPAH 44 is the sum of 44 parent and alkylated compounds, tPAH 16 is the sum of the 16 priority pollutant compounds. TPH is total petroleum hydrocarbons in the sediment sample

Figure 7. PAHs in the sediment mounds at the northern reach of the Canal originated from a mix of petrogenic and pyrogenic sources indicative of multiple ongoing upland sources along the Canal.

Exponent

Figure 8. Example spill locations in upland areas around the Canal.

Tables

Table 1. Example Spills in the Vicinity of Gowanus Canal

Map Identification Number	Spill Date	NYDEC Spill Number	Spill Description	Comments	Page in Document
171	7/15/1992	9204442	200 gallons diesel spill directly next to the Gowanus Canal.		286
172	5/10/1993	9301903	250 gallons of #4 fuel oil spill, impacting the sewers.		287
164	4/10/2008	0800421	Petroleum spill, releasing petroleum products in sewers and the Gowanus Canal	From DEC investigator remarks: MCIZ CORP site is used for bus maintenance and parking. One Bus was in accident with two cars on the lot releasing sewage, waste oil, and motor oil. Sewers were affected. Remarks discussed continual problem of discharge to the Gowanus Canal.	275
336	9/7/1997	9706778	12,750 gallons of raw sewage discharged to Gowanus Canal	Nonchlorinated sewage discharge due to pump failure. Entered the Canal around 2nd Ave and 5th Street.	460
337	2/20/2007	0612588	100 gallons of diesel in a truck yard. Spill went into sewer.	Six drums of contaminated snow were hauled off the Williams Construction Site.	461
167	9/18/2004	0406715	Unknown amount of raw sewage discharged into the Gowanus Canal	Ongoing due to rain	282
168	7/10/2004	0403825	Wastewater release impacted groundwater	Caller remarks: "Fire in area. Fire hydrant water and wastewater flowing into Gowanus Canal".	283
169	3/31/200	031433	Unknown petroleum containing PCBs on 500	DEC investigator remarks: "there is smoke in MH-5389 due to burning wires, 1-sample	284

Table 1. (cont.)

Map Identificati on Number	Spill Date	NYDEC Spill Number	Spill Description	Comments	Page in Document
	4	3	gallons of water and mud in manhole (MH-5389).	taken envir tag #33745 placed". Lab results received 3/31/04 Lab ID: 04-02439 results: 135 ppm PCBs…Tanker drained 31 hundred gallons of liquid from structure"	
170	10/8/200 0	000800 8	Unknown oil on 1,000 gallons of water in manhole with transformer that historically contained PCBs.	Liquids and solids removed from manhole.	286
335	12/19/19 97	971074 1	263,000 gallons of raw sewage discharged into Gowanus Canal.	Caller Remarks: "Malfunction of tide gate. DDC Emergency sewer lining malfunction"	459
334	5/4/1994	940164 8	125 gallons of diesel spilled into sewer.	DEC Investigator remarks: "ON SCENE: SADDLE TANK RUPTURE, OIL RAN DOWN STREET INTOGOWANUS CANAL, KTL IS SPILLER, FDNY RECOVERED 1-DRUM FROM TANK, LIGHT SHEEN IN CANAL"	458
114	6/3/1986	860150 2	Unknown petroleum product released in Gowanus Canal	Caller Remarks: "OIL SHEEN ABOVE SHORE LINE & SHEEN IN WATER"	203
115	1/25/201 0	091143 4	200 gallons of dielectric fluid spilled in manhole.	DEC Investigator Remarks: "Spill contained and cleaned up by Con Edison"	204
333	9/8/1997	970683 3	100 gallons of waste oil impacted sewers	DEC Investigator Remarks: "THREE CATCH BASINS STARTING AT 3RD STREET WERE OPENED AND CLEANED BY FLUSH AT THE REQUEST OF DEP".	457
176	5/30/200	050241	Unknown petroleum release	Caller Remarks: "unknown substance on	292

Table 1. (cont.)

Map Identification Number	Spill Date	NYDEC Spill Number	Spill Description	Comments	Page in Document
	5	6	affecting surface water	body of water of union st west side of Canal"	
177	7/1/2009	0914289	Unknown petroleum release in the vicinity of the Canal		293
179	11/4/2004	0408640	1/2 Pint of oil on 400 gallons of water.	DEC investigation remarks: "Approximately 600 gallons of liquid was removed by tanker"	295
78, 185	9/25/2001 9/12/2001	0106619 0106920	Unknown amount of #2 fuel oil leaked into the environment	Cause of spill was reported as "Tank Test Failure". DEC Investigator remarks included: "Consolidating open spills on property. Spill closed and cross referenced to spill #0106920. Additional remarks included: "DR. YOUSSEFNIA STATED THAT THERE IS A 275 OR 550 UST AT SAID SPILL LOCATION THAT FAILED ATANK TEST. THE UST LEAKED FUEL OIL OVER AN UNKNOWN PEROID OF TIME."	159, 301
184	9/20/2000	0007226	Unknown oil bubbling to surface of Canal		300

Table 1. (cont.)

Map Identification Number	Spill Date	NYDEC Spill Number	Spill Description	Comments	Page in Document
201	12/11/2001	0109040	Oil leaks from trucks impacting sewer during rain events	DEC remarks: "in alleyway between 6th and 7th Street on 2nd Ave there are 3 sets of double parked unused oil delivery trucks in front of GEMTEC owned by T&S Trucking (718)499-2900. The rear of the two rear trucks were underlain by used speedy dry which was leaking sheen into the nearby sewer during rain events. The sewer appears to be connected to the Gowanus Canal on 7ths Street east of 2nd Ave. A large 300' x 100' sheen was present on the Canal. T&S responded by sweeping used speedy dry and spreading new speedy dry. Coast Guard 718-354-4121 was notified regarding sheen on12/14/2001. DEP (Andrew Kelley 718-595-6700) was notified on 12/14/2001 regarding illegal sewer discharge. Spill will be referred to Environmental Conservation Officers to see if trucks can be stored in alley and to determine if the alley is a public street. Spill closed 12/17/2001"	323
204	11/13/2000	0030027	Unknown petroleum spill impacting the Gowanus Canal.	Spill Caller remarks: NOTICED SHEEN ON GOWANUS CANAL POSSIBLY COMING FROM SPILL LOCATION. WALL COLLAPSE INTO GOWANUS CANAL. POSSIBLE FORMERPBS FACILITY.	326

Table 1. (cont.)

Map Identification Number	Spill Date	NYDEC Spill Number	Spill Description	Comments	Page in Document
205	2/17/2005	0412308	One gallon of unknown oil on 100 gallons of water in a sump near the Canal.	DEC Investigator remarks: FOUND ONE GALLON OF UNKNOWN OIL ON 100 GALLONS OF WATER IN MH5436...CAN NOT VERIFY IF THERE IS ANY OTHER OIL FILLED EQUIPMENT IN HOLE. ENV STOP TAG# 11976 WAS PLACED.ALSO CAN NOT VERIFY IF THERE IS ANY SEWER CONNECTIONS OR SUMPS.	327
72	5/31/1995	9502574	Four abandoned barrels, possibly containing hazardous material	Cause of spill was reported as "Tank Failure"	153
269	11/24/1997	9709837	20 gallons diesel spill.	Caller Remarks: Spill from a truck saddle tank.	395
293	8/18/1999	9905930	Unknown oil spill impacting Gowanus Canal	Caller stated that this is an ongoing problem. No DEC remarks for this spill.	420
294	7/21/1999	9904739	Unknown oil spill impacting Gowanus Canal	Caller stated that sheen was covering most of the Canal.	420
297	7/30/2007	0704871	Milky substance bubbling up into Gowanus Canal water	DEC Investigator Remarks: Unknown material dissipated.	423
122	7/10/2000	0004300	1 gallon of unknown petroleum	"1qt unknown oil on floor of manhole. 3" inactive drain exists in manhole... Adjacent sewer checked and found 4" pipe in the direction of manhole. There is product dripping onto floor. No free flowing water involved. 2gal product removed from	211

Table 1. (cont.)

Map Identification Number	Spill Date	NYDEC Spill Number	Spill Description	Comments	Page in Document
				structure."	
137	2/14/2000	9912931	2 gallons of hydraulic oil to sewer	"Caller Remarks: rain did cause some to go into sewer…"	243
141	5/14/1998	9801934	4 gallons of unknown material spilled to sewer	"Product similar to dielectric fluid (< 1ppm PCB); vendor's dumpster overflowed the liquid…" Additional remarks included: "GAL OF UNKNOWN OIL ON PAVEMENT. AREA IS NOT CONTAINED, & SEWERS ARE AFFECTED."	247
149	2/8/1996	9514237	2 gallons of diesel discharged into sewer	"Caller Remarks: crew found a trail of diesel that leads to a storm drain." Additional remarks include: "2 gallons spilled by pumps, slight sheen through cable yard to drain... Unsure when it occurred... Later determined none in drain."	256
214	6/25/2002	0203199	3 gallons of unknown petroleum spilled on soil.	DEC Investigator Remarks: "FOUND APPROX 3-GALLONS OF UNKNOWN OIL ON 500 GALLONS OF WATER IN MH-55750. IT APPEARS TO BE CONTAINED AT THIS TIME NO SEWERS OR WATERWAYS EFFECTED."	337

Table 1. (cont.)

Map Identification Number	Spill Date	NYDEC Spill Number	Spill Description	Comments	Page in Document
229	7/10/2004	0403837	200 gallons of gasoline discharged to sewer.	DEC Investigator Remarks: "Spill was called in by Fire Department Owner was not aware of an open spill violation at this site. The site had a waste oil tank when the factory was hit by fire... the spill was washed away when FD injected water to put down fire."	353
250	6/30/1999	9903695	3 gallons of unknown petroleum spilled in a manhole	DEC Investigator Remarks: "discovered approx. 2800 gallons of water and 3 gallons of oil in MH 65436." Apparently, spill was contained in the manhole, and did not impact sewers or waterways.	375
251	3/3/1999	9814432	5 gallons of unknown petroleum in a manhole.	Caller Remarks: "5 GALLONS OF UNK OIL ON TOP OF 7000 GALLONS OF WATER - CONTAINE DIN MANHOLE."	377
253	5/23/2005	0502141	4 gallons of unknown petroleum in a manhole.	DEC Investigator Remarks: "WHILE ON LOCATION TO INSPECT M65434 FOR AN ABATENENT JOB... FOUND: APPROX. 4 GALS OF UNKNOWN OIL ON APPROX. 75 GAL'S OF WATER. NO SEWERS OR WATERWAYS APPEAR TO BE AFFECTED."	379
255	1/1/1996	9515448	Unknown petroleum	Caller Remarks: "caller complained to sewer dept because she was getting a fuel smell from sewer... possibly underground spill from a nearby gas station and oil company"	381

Table 1. (cont.)

Map Identification Number	Spill Date	NYDEC Spill Number	Spill Description	Comments	Page in Document
286	3/5/2003	0211997	5 gallons of unknown petroleum in a manhole.	Caller Remarks: "UNKNOWN FOUND FLOATING ON WATER IN THE ABOVE MANHOLE." DEC Investigator Remarks: "5 gallons of oil on top of approximately 2500 gallons of water in Manhole 70465, Feeder 41/42. The spill is contained in the manhole."	410
306	11/11/1994	9410709	Unknown petroleum in sewer.	Caller Remarks: "OIL SMELL COMING FROM SEWERAGE VENT."	431

Toxics Targeting, Inc. 2011. Phase I Environmental Database Report, Carroll Street, Brooklyn, NY 11215. March 15.

Table 2. Sediment sites with reported recontamination

Site	Response Measure(s)	Recontamination Information	References
Anacostia River, DC	2004 Cap	2006 Urban sources, upstream sources	USEPA 2006
Bloomington, IN (3 creeks)	1987 Sediment Removal	1992 All sources unclear – point source discharge included	ATSDR 1992
Bremerton Naval Complex, WA	2000 Dredge	2000 Losses from CAD placement	SPI 2002, DNO 2002
Convair Lagoon, CA	1998 Cap	2002 Public storm drain discharges	Zeng 2002, Carlisle 2002
Denny Way Site, WA	1990 Cap	1993 CSO point source discharges	Palermo 2002, NRC 2001, Romberg 2005, WDNR 2002
Duwamish Norfolk CSO, WA	1999 Dredge-Cap	2001 CSO point source discharges; unremediated adjacent contaminated sediment	WDE 2003, USEPA 2003
Duwamish River Diagonal, WA	2004 Dredge	2005 Sewage system discharges	SPI 2005
Eagle Harbor Site, WA	1994 Cap	1999 "Surface sources", "offsite sources"	USEPA 1999, Palermo 2002
Ford Outfall/River Raisin, MI	1997 Dredge	2001 Unremediated upstream sediments and/or upland sources; sediments sloughed from adjacent navigational channel	Cieniewski 2003, Bergeron 2000, Cleland 2000, Cleland 2001, Weston 2004
Housatonic River, MA	2002 Dredge-Cap	2005 Upstream sediments, CSO and SSO point source discharges	Boston Globe 2005
Lauritzen Canal, CA	1996 Dredge-Cap	1998 Undetected point source(s); incomplete remediation near margins of site	USEPA 2001, Weston 2002, USEPA 2004a
Long Beach North Energy Island	2001 Cap	2004 "Deposition from the surrounding harbor"	USACE 2005

Table 2. (cont.)

Site	Response Measure(s)	Recontamination Information	References
Borrow Pit (NEIBP), CA			
Pier 51 Ferry Terminal, WA	1989 Cap	1990 PAHs due to pile pulling; metals from “new sediment deposition”	HSRC
Pier 53-55, WA	1992 Cap	2002 Prop wash resuspension near edges; PAHs due to pile removal	Romberg 2005
Pier 64-65, WA	1994 Cap	2002 Piling repair work released creosote	Romberg 2005
St. Clair Shores, MI	2002 Dredge	2003 Recontamination from PCBs in the sewer pipes	TMD 2006
Thea Foss Waterway, WA	2002 Dredge-Cap	2006 City storm drain discharges	TNT 2006a, TNT 2006b

Appendix F

Dr. Marc Wilkenfeld CV and Human Health Risk Assessment, prepared for National Grid by GEI Consultants Inc.

Marc Wilkenfeld MD
453 FDR Drive C2002
NY, NY 10002
917-318-4557
Marcwilkenfeld@cs.com

EDUCATION

MT. SINAI SCHOOL OF MEDICINE, New York, NY
M.P.H. Equivalent, 6/89

UNIVERSITY OF VERMONT COLLEGE OF MEDICINE, Burlington, VT
M.D. 5/85

McGill UNIVERSITY, Montreal, Canada
B.S. 6/81, Physiology

PROFESSIONAL TRAINING

7/87 – 6/89 Mt. Sinai Medical Center**,** New York, NY
Resident in Occupational/Environmental Medicine

Screened and treated cases of occupational illness including exposure to asbestos, heavy metals, solvents, and other hazardous substances. Examined patients, read X-rays for evidence of change secondary to exposure and educated patients on hazardous exposure. Developed medical programs for workers and their families. Served on advisory committee to major occupational medicine screening program. Carried out research activities. Taught medical students. Also provided urgent and primary care to Mt. Sinai Hospital employees both years.

7/85 – 6/86 Roosevelt Hospital, New York, NY
Intern – Department of Internal Medicine

CERTIFICATIONS Board Certified in Occupational Medicine, 2011
ACLS Certification, 2011
Certified by NIOSH as an "A" Reader, 1990

LICENSURE New York, Florida, New Jersey and Missouri (Active)

Environmental Disaster Management:

2004 – 2005	Member/Expert Technical Panel for evaluation of 9/11-related health and environmental effects formed by Senators Hillary Clinton and Joseph Lieberman in conjunction with White Council on Environmental Quality
2003 – 2009	Medical Consultant for deconstruction of 130 Liberty Street
2002 – 2008	Member/Medical Working Group, Mt Sinai Medical Center World Trade Center (WTC) Worker and Volunteer Screening Program. Assisted in development of protocols for screening individuals with exposure at the WTC site.
2001 – 2008	Evaluated environmental data from the WTC site. Presented to community boards and tenant groups about the potential health effects 9/11. Assisted in implementation/interpretation of independent testing in Lower Manhattan. Developed and moderated major health effects forum in September 2002.

Clinical/Health Management:

2010-Present	Chief, Division of Occupational Medicine Winthrop University Hospital, Mineola NY
2007-2010	Physician Specialist-WTC Environmental Health Center-Gouverneur Health Care Services
9/2005-10/2007	Medical Director-Arbor We Care Brooklyn New York-Supervised Primary Care specialists and specialist performing fitness for duty Evaluations
5/1997 – 2010	Consultant in Occupational Medicine - Columbia University Health Science Division, New York, NY
9/1993 – Present	Founding Partner, Medlantic LLC, New York, NY Consulting firm specializing in occupational and environmental medical issues.
10/1991 – 10/1997	Staff Physician (PT), Bristol Myers Squibb Employee Health,
10/1991 – 4/1997	Medical Director (PT**),** Barnert Occupational Health Center,

11/1986 – 5/1987 Primary Care Physician, Executive Health Examiners, New York, NY. Provided walk-in medical care, pre-employment physicals, and periodic examinations to employees of contracted companies

ACADEMIC AND HOSPITAL APPOINTMENTS

10/2010-Present Winthrop University Hospital, Mineola NY
Chief, Division of Occupational Medicine

12/2007 – Present: New York University Medical Center, New York, NY
Clinical Assistant Professor in Medicine

9/2007 – Present: Gouverneur Health Care Services, New York, NY
Attending Physician

5/1997 – Present: Columbia University Medical Center, New York, NY
Assistant Professor in Clinical Medicine and Environmental Sciences

NEW YORK PRESBYTERIAN HOSPITAL, New York, NY
Assistant's Attending

10/1989-Present BETH ISRAEL HOSPITAL, New York, NY
Attending Physician, Staff Member

10/1989-9/2005 BARNERT HOSPITAL, Patterson, NJ
Consulting Physician, Staff Member

PROFESSIONAL AND ACADEMIC PANELS

- Member –NY State Task on Toll Plaza Air Quality 2009-Present
- Past President – New York Occupational Medicine Association, 1997
- Co-Chair Environmental Health Section ,ACOEM 2010-2011
- Medical Advisory Committee NYS Workers Compensation Board 2011
- Member (Representative of Assembly Speaker Silver) – NY Health Sciences Research Board, 2004 – Present

PRESENTATIONS

Multiple presentations since 1988 to:

- White Lung Association of New Jersey
- Asbestos Environmental Institute of New York

- Environmental/Occupational Safety at Health Institute of New Jersey
- National Safety Council
- American Society of Safety Engineers
- American Industrial Hygiene Association

Occupational Liver Disease – Presented to the American Liver Foundation, January 1998

Diagnosis and Management of Tight Building Syndrome, Indoor Air, Toronto, Canada, 1990

Environmental Medicine in Primary Care – Presented to the American Cancer Society, 1990

Health Promotion in the Workplace – Presented at the American Society of Safety Engineers, Washington, D.C. 1990

Indoor Air Pollution – Presented at the Annual Meeting of the Medical Society of the State of New York, 1989

Cholesterol Determination by a Corporate Medical Department – Presented to the AOHC in Boston, May 1989. Awarded resident research award by American College of Occupational Medicine.

Wilkenfeld M The WTC Disaster and Community Rebuilding -SOTAC 2007

PUBLICATIONS

Wilkenfeld, M. Occupational Medicine and 9/11. JOEM 53:9,956-57,2011

Wilkenfeld, M. and Shafer, N. “Blood Transfusion Reactions,” *Legal Medicine*, 1989

Wilkenfeld, M. and Shafer, N. “Gunshot Wounds,” *Legal Medicine*, 1990

Wilkenfeld, M. “Diagnosis Management of Tight Building Syndrome.” *Proceedings of Indoor Air 90*, Toronto, June 1990.

Wilkenfeld, M. “Simple Asphyxiants.” Occupational and Environmental Medicine. Edited by W. Rom, pp. 535-539. Little Brown and Co., 2007.

Wilkenfeld, M. “Metal Compounds and Rare Earths.” Occupational and Environmental Medicine. Edited by W. Rom, pp. 815-831. Little Brown and Co., 1993.

Wilkenfeld, M., Crowley, K.A., Dawudo, O. “Occupational Eye Injury Due to Phototoxity.” Journal of Occupational Environmental Medicine, 44 (6), pp. 488-9, 2004.

Manuscript in In Preparation

Wilkenfeld, M., Crane, M., Leary, L., Lowe, W. “Risk Assessment and Communication with Populations Near Former Manufactured Gas Plant Sites in New York City.”

Appendix G

Gowanus Canal: Response to NYDEC Approach for Stormwater Control, prepared for National Grid by Woodard & Curran, Inc.

GOWANUS CANAL: RESPONSE TO NYDEC APPROACH FOR STORMWATER CONTROL

Woodard & Curran Inc.
April 23, 2013

The United States Environmental Protection Agency (EPA) Proposed Remedial Action Plan (PRAP) for the Gowanus Canal proposes that two large capacity storm water storage tanks be installed to accept overflow from combined sewer outfalls (CSOs) RH-034 and OH-007 during high-flow storm conditions. The tank for CSO RH-034 is to be six to eight million gallons and the tank for CSO OH-007 is to be three to four million gallons in size. As indicated in note 14 (page 19) of the PRAP, storm water flow that exceeds the capacity of the sewer system would be diverted to and stored in these tanks until storm conditions subside. At that point the storm water flow would be directed to the wastewater treatment plant.

The size of the two tanks is based in part on data presented in Stein et al (2006), which indicates that the "first flush" of storm water comprises approximately 20% of the total discharge volume and contains between 30% and 60% of the total PAH load of the total storm discharge. According to the PRAP, "capturing approximately twice the amount of the 'first flush' of the design storm water event from CSO outfalls...would ensure that the protectiveness of the remedy is maintained." This statement suggests that the tanks will be designed to accommodate in excess of 40% of the design storm discharge (assuming a portion continues to be conveyed to treatment through the CSOs).

Although the approach set forth in the PRAP will capture a large portion of the sediment and pollutant mass, the scientific literature suggests that the potential still exists for the continued discharge of PAHs and metals to the Canal during storm events that produce a flow volume in excess of the capacity of both the tanks and the sewer system. This is due to the different flow behaviors of various particles sizes in storm water runoff, and the well-documented association of PAHs with the finer fraction of storm water particles. As summarized below, the first flush tends to include a larger proportion of coarse particulate matter. Since PAH concentrations tend to be higher on finer particulates, PAHs in the CSO flow may continue to be discharged to the Canal later in a storm event, after the CSO tanks are full.

I. Summary of Issue

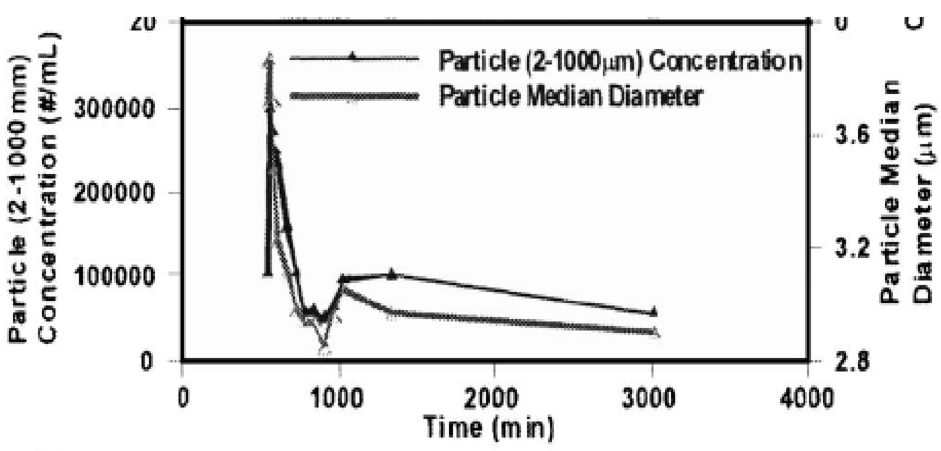
Contaminants in storm water exist both in dissolved form and bound to particles. Contaminants bound to particles are of primary interest because of their ability to be deposited in the sediment of receiving waters such as the Gowanus Canal. The mass-based "first flush" phenomenon of storm water discharges occurs when the early stages of a storm contain a disproportionately large amount of the total particulate mass. Because PAHs are typically associated with particulates, the mass of PAHs is related to the size and number of particulates. However, PAHs have been shown to be distributed unevenly across size classes. Because of the presence of total organic carbon (TOC) in silt and other fine material, PAH concentrations tend to be higher on fine particulate matter than on coarse particulates. In a typical mass-based first flush of storm water, a large proportion of the particulate material consists of coarse material transported by the high energy of the larger flows produced by intense rainfall. Transport of the coarse fraction is flow-dependent and so tends to decrease rapidly as the flows in the storm decrease. In contrast, the fraction of fine material remains elevated throughout the entire duration of a storm. Thus, PAHs bound to fine particulates may continue to be discharged to the Canal during late stages of storm events, when runoff volume exceeds conveyance capacity and the proposed storage tanks are full.

II. Scientific Literature

Review of the scientific literature on storm water composition and management supports the foregoing view. The key studies and sources are described below.

(a) Discharge of Fine Particulates. The differing discharge patterns of coarse and fine particulates in storm water has been documented by several researchers (Furumai et al. (2004), Crista and Sansalone (2003), Hergen et al. (2003), Li et al. (2005)). The sustained nature of fine particulate discharge is illustrated in the following figure from Li et al (2005), who studied roadway runoff patterns from two heavily traveled urban highways in Los Angeles. In this study, the highest concentration of particles of all sizes combined occurred within the first hour of the storm and declined rapidly. However, the discharge of very fine particles continued for the duration of the storm, with a steady decline in the median size of particles.

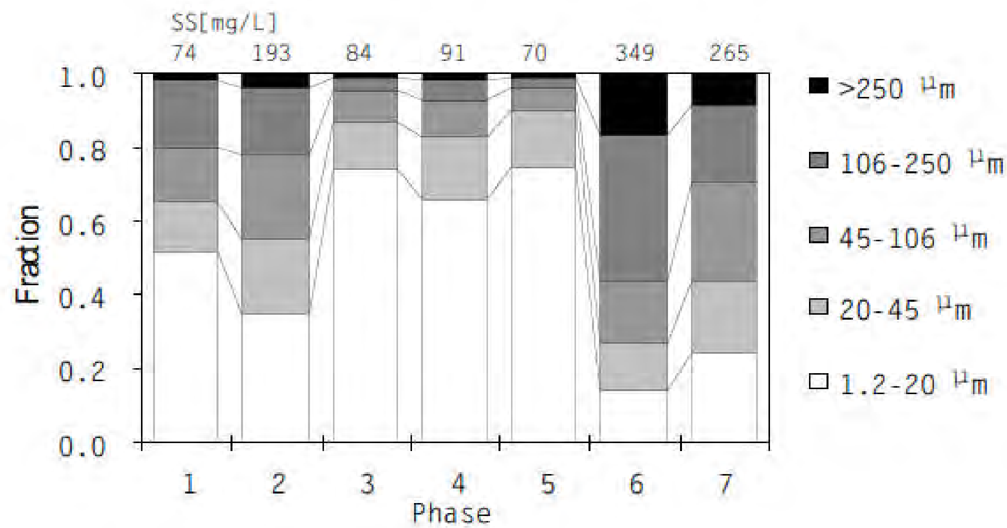
Figure 1. Relationship of Particle Size and Storm Duration (from Li et al. (2005))



Source: Li et al. (2005).

The predominance of coarse particulates is associated with high intensity flows, which may occur at multiple times during a storm event. The effect of later flow peaks is illustrated by data from Furumai et al. (2004), which describes storm water runoff from a highway system in Switzerland. In this event, a small spike in precipitation occurred in the early part of the storm (Phase 2), but heavy precipitation arrived at the end of the storm (Phase 6). The effect of these flow increases on storm water particle size and suspended solids concentrations is shown in Figure 2.

Figure 2. Changes in Particle Size and Suspended Solids with Increased Flow (Phases 1 and 6) (Furumai et al. (2004))



As the data from this study shows, particles less than 45 µm in diameter comprised over half of the particulate fraction, except following the intense precipitation at the end of the storm. The discharge of fine particulates occurs in all flow stages, but dominates during low flow conditions and tends to decline in later stages of the storm, as the surface is essentially washed free of movable particulates (Mitsova et al. (2011), Li et al. (2005), Furumai et al. (2004), Cristina and Sansalone (2003).

Throughout a typical storm, fine particulates comprise a small to moderate percentage of the total mass of storm water discharge, but dominate the composition numerically. Yun et al. (2010) found that particles less than five µm in diameter accounted for more than 80% of the number fraction while their mass was about 12%. Particles with a diameter of 50 µm or less comprised over 99% of the number fraction, and 59% of the mass throughout the storm event. Herngren et al.(2012) found up to 85% of the total particle volume was in the 0.45 – 75 µm size fraction, and Li et al (2005) found that while 97% of the particles were less than 30 µm, particles smaller than 50 µm accounted for 30% - 60% of the total mass.

While the concentration of all particulates decreases significantly after periods of intense precipitation, these values indicate the importance of the fine particulate fraction in the transport and distribution of storm water contaminants during all stages of a storm. Fine suspended particulates from storm water have been found to contribute to lethal and sub-lethal toxicity due to their ability to stay suspended in the water column. Suspended fine particles with size ranges less than 25 µm are easily trapped by gill tissue and once trapped, interfere with gill function of fish (Liu and Sansalone 2007).

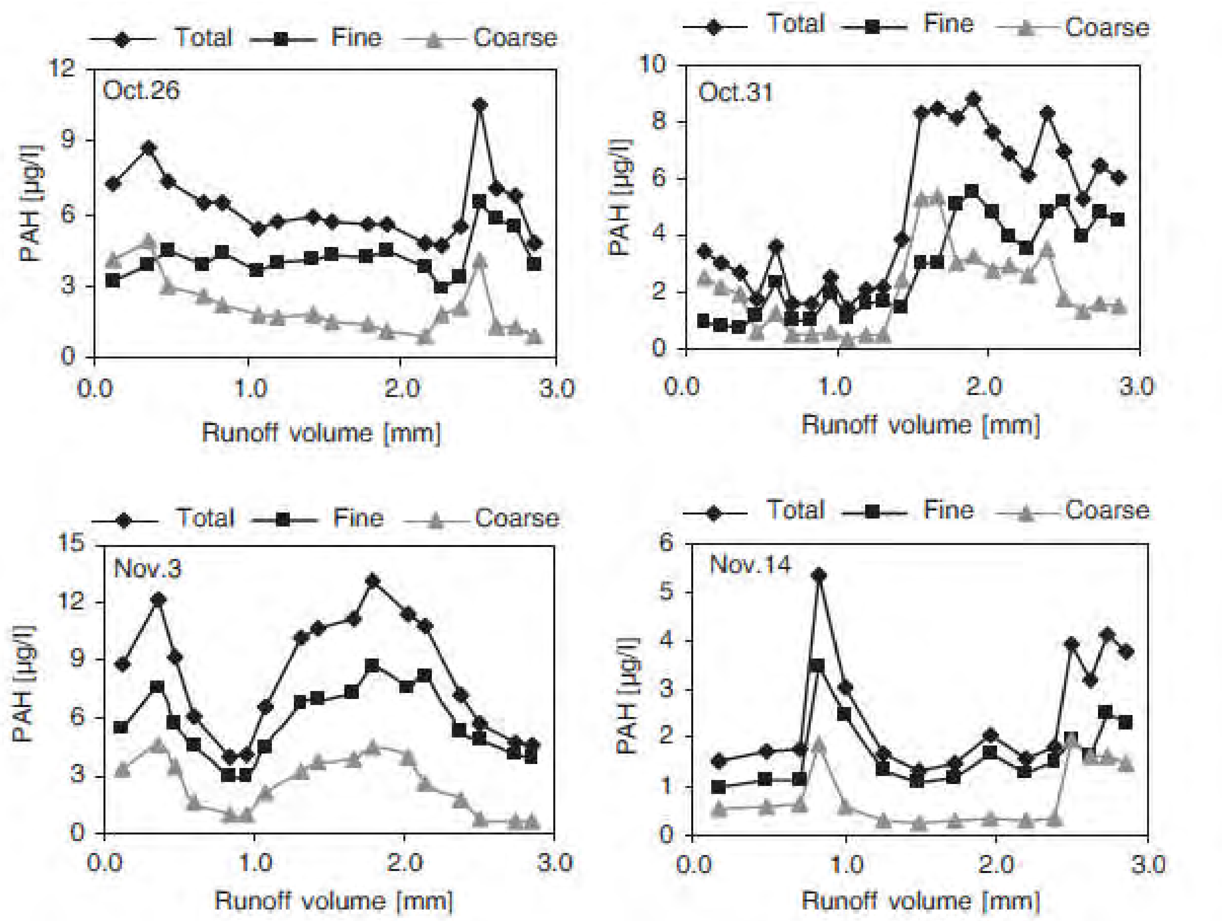
(b) Association of PAHs with Fine Particulates. Numerous studies have documented the association of PAHs with the fine particulate fraction of storm water runoff, an association attributed largely to the higher surface area and TOC content of fine particulates. Results from Lee et al. (2005) illustrate this association with data from a study of urban street particulates, which form the fine fraction of surface runoff. As shown in Table 1, below, both TOC and PAH increase with decreasing particle size.

Table 1. Association of PAHs with TOC and Particle Size in Street Sweepings in Japan (Lee et al. 2005)

Size Fraction:	<20 um	20-53 um	53-106 um	106-250 um	250-500 um	500-1000 um	1000-2000 um
Wt (%)	0.5	2.6	5.1	13.9	24.1	29.2	24.6
TOC mg/kg	0.81	0.32	0.17	0.11	0.08	0.06	0.04
TPAH (24 PAHs) mg/kg	4.740	4.017	4.268	3.883	1.790	0.922	0.493

Likewise, Herngren et al (2012) found that runoff particles in the 0.45 µm – 75 µm size range exhibited the highest PAH concentrations in runoff from industrial, commercial, and parking lot areas, and also contributed the highest volume of particles (up to 85%). Aryal et al. (2005) studied the relationship of particulate size and PAH composition in runoff collected in the first three mm of precipitation (the first flush period) and found concentrations higher in the smaller fraction (< 45 µm) during all storm events studied, as illustrated in Figure 3.

Figure 3. Size-fractionated PAH Concentrations in Initial 3 mm of Storm Runoff (Aryala et al (2005))



Because of the association of PAHs with fine particulates, the continuing discharge of fine particulates during the later phases of large or long storms remains a concern. PAHs in the particulate fraction of storm water runoff can lead to elevated concentrations in receiving streams (Bathiet al (2012), Mahler and Metre (2003)).

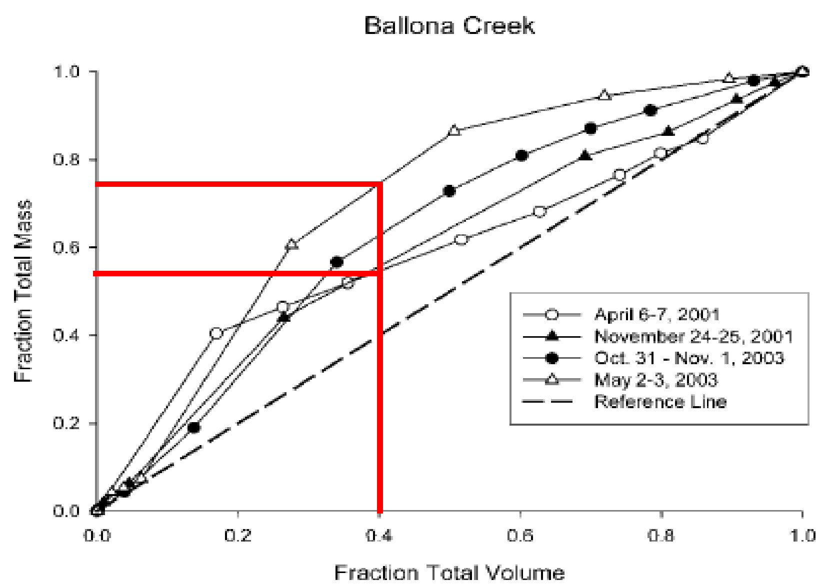
III. Potential for effects on the Gowanus Canal

Although the proposed storage tanks will capture the early discharge from CSOs RH-034 and OH-007, further evaluation is needed to determine if the volume of the tanks will be sufficient to capture enough of the particulate mass throughout the storm to prevent recontamination of the Canal. In particular, the dependence on an early-stage mass first-flush event to deliver most of the contaminant load to the storage tank merits further examination. Stormwater discharge patterns vary widely, and are influenced by watershed and conveyance characteristics, storm hydrography, type of impervious surfaces, number of preceding dry days, and other characteristics (Hergren et al. (2012), Mitsova (2011), Stein et al. (2006)).

Many studies are conducted in arid environments such as Los Angeles, where the long dry period combined with intense rainfall typically produce distinct mass-based first-flush effects. See for example, Stein et al. (2006). Data from other areas suggest that the first flush effect is less pronounced in areas that receive rainfall frequently, or in cases where fewer dry days precede storm events (Mitsova (2011), Zhang et al (2008)). The first flush effect itself has been shown to vary in both flow and concentration (Sansalone and Cristina (2004)).

Even in events where a first flush is evident, a large proportion of the particulate mass may still discharge late in the storm. Figure 4, below, shows the cumulative mass versus volume data from Stein et al. (2006), which illustrates the increase in PAH mass in this urban watershed in the early stages of the storm. Additional lines (red) have been added to Figure 4 to reflect the 40% cumulative volume value (twice the "first flush" volume of 20%) used in the sizing of the storage tanks at CSOs RH-034 and OH-007. On this data set, a 40% capture rate would contain approximately 55% to 75% of the storm water volume (depending on the storm event), but would still allow between 25% and 45% of the volume to bypass the system. The particulates in this portion are expected to be largely fine particulates, with relatively elevated PAH concentrations. This fraction would either remain in the conveyance, if flow is low enough, or be discharged to the Canal.

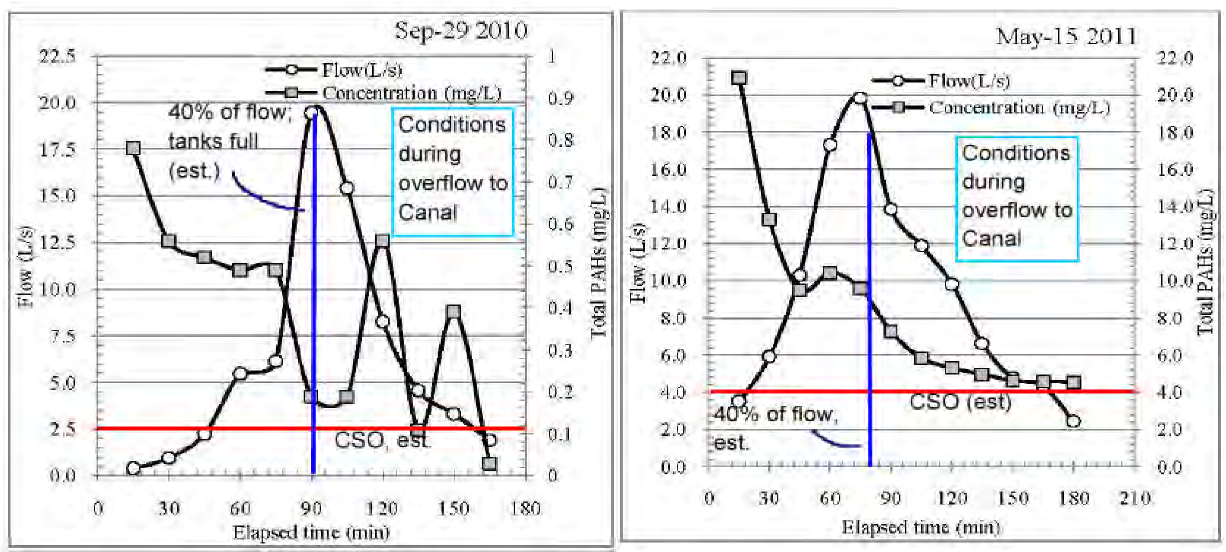
Figure 4. Fraction of PAH Mass Associated with 40% of Cumulative Flow (Stein et al. 2006)



The portion of a storm event that may be released by the system in overflow conditions is better visualized with a so-called "pollutograph," which illustrates changes in volume and runoff concentration throughout the duration of a storm. Such visuals do not clearly reveal the first flush phenomena, but do illustrate runoff composition at different points in a storm. Typically concentrations are low during peaks flows, as a result of dilution.

Figure 5 shows pollutographs from two storms in a highly urbanized area near Biscayne Bay, Florida (Mitsova et al (2011)). These depict changes in road runoff PAH concentration and flow as a function of time for storms two to three hours in length. To illustrate conceptually how the proposed tank system might affect discharges, we have overlaid lines that represent the boundary conditions that would affect the potential for overflow to the Canal: namely, the flow capacity of the sewer system (in L/s) and the capacity of the tanks, estimated at 40% of total storm flow volume. Since the total flow volume is the area under the flow curve, 40% of flow occurs somewhere near peak intensity. In these figures, storm water that would be contained by the tanks is represented by the area on the left of the vertical blue line (which represents tank capacity), while the storm water potentially discharging to the Canal is represented by the area to the right of the blue line and above the red line (which represents CSO capacity).

Figure 5. Estimated Gowanus BMP Boundary Conditions on Urban Stormwater Flow Data (data from Mitsova 2011)



As illustrated, potential overflow to the Canal could occur during conditions when both flow rate and PAH concentrations are declining, but still variable and high. Variability is shown by the figure on the left, for September 2010, which reflects pulses in rainfall intensity that occurred late in the storm and mobilized additional particles. The figure on the right shows conditions under more steadily declining precipitation intensity (Mitsova et al (2011)). Both cases illustrate the potential for continuing PAH discharges even after a significant volume of storm water has been contained.

As noted previously, the size and presence of a first-flush phenomenon is dependent on an array of site and storm specific factors. The selection of best management practices (BMPs) to capture first flush storm water flow is often based on precipitation guidelines applied to the unit watershed area. However, a study of four such state and literature guidelines used to size hypothetical BMPs for using runoff data from an interstate highway in Cincinnati found that BMPs designed according to the guidelines (which ranged one-half to one inch of rainfall per specific area) experienced bypass in from one to four of eight storm events studied. For this dataset, the total mass of sediment bypassing the BMPs ranged from 0.02 to 0.59 kg per storm for a 300 m^2 (57 x 57 ft) study area (Sansalone and Cristina (2004)). While these data do not necessarily reflect the conditions in the watershed surrounding the Gowanus Canal, they do indicate the magnitude of particle bypass that can occur when units are designed based on first flush characteristics.

IV. Conclusion

Numerous studies indicate that PAHs on fine particulates are present in storm water throughout the entire storm event. Review of proposed BMPs for Gowanus storm water suggests that the potential exists for PAHs to be discharged to the Canal during periods of high and extended flow, when the capacity of both the sewer system and the storage tanks are exceeded. We suggest that the combined capacity of the storage tanks and the sewer conveyance be examined further, using hydraulic modeling and historical precipitation data as appropriate, to obtain additional information about the potential frequency and volume of storm water that may be discharged from the system. Without this analysis, the actual effectiveness of the proposed CSO remedy cannot be evaluated.

REFERENCES

Aryal, R.K. et al. 2005. Dynamic behavior of fractional suspended solids and particle-bound polycyclic aromatic hydrocarbons in highway runoff. Water Research, 39(2005): 5126-5134.

Bathi, Jejal Reddy et al. 2011. Polycyclic aromatic hydrocarbons in urban stream sediments. Advances in Civil Engineering, 2012: 1-9.

Cristina C. and J. Sansalone, 2003.''First Flush,'' Power Law and Particle Separation Diagramsfor Urban Storm-Water Suspended Particulates. J. Environ. Eng. April, 298-307

Furumai, H. et al. 2004. Profile analysis of polycyclic aromatic hydrocarbons and heavy metals in size fractionated highway dust and runoff samples. Global Solutions for Urban Drainage, Proc. Of the Ninth Int. Conf. on Urban Drainage, Sept. 8-13, 2002, Portland, OR, CD-ROM.

Herngren, Lars et all. 2010. Distribution of polycyclic aromatic hydrocarbon in urban stormwater in Queensland, Australia. Environmental Pollution, 158(2010): 2848-2856.

Lee, Byung-Cheolet all. 2005. Characterization of polycyclic aromatic hydrocarbons (PAHs) in different size fractions in deposited road particles (DRPs) from Lake Biwa area, Japan. Environ. Sci. Technol., 39(2005):7402-7409.

Li, Yingxia. 2005. Particle size distribution in highway runoff. Journal of Environmental Engineering, September 2005: 1267-1276.

Liu, B. et al. 2007. Toxicity of particulates in urban stormwater on indicator and commercial aquatic species. World Environmental and Water Resources Congress 2007: Restoring Our Nature Habitat, 2007 ASCE, 1-10.

Mahler, B.J. et al. 2002. A simplified approach for monitoring hydrophobic organic contaminants associated with suspended sediment: methodology and applications. Archives of Environmental Contamination and Toxicology, 44(2003): 288-297.

Mitsova, Diana et al. 2011. Variability in road runoff pollution by polycyclic aromatic hydrocarbons (PAHs) in the urbanized area adjacent to Biscayne Bay, Florida. Journal of Environmental Protection, 2(2011): 1317-1330.

Sansalone, John J. et al. 2004. First flush concepts for suspended and dissolved solids in small impervious watersheds. Journal of Environmental Engineering, 130(2004): 1301-1314.

Stein, E. D. et al. 2006. Watershed-based sources of polycyclic aromatic hydrocarbons in urban storm water. Environmental Toxicology and Chemistry, 25(2): 373-385.

Yun, Yeobog et al. 2009. Size distributions and settling velocities of suspended particles from road and highway. KSCE Journal of Civil Engineering, 14(4): 481-488.

Zhang, Wei et al. 2008. Characterization and loading estimation of polycyclic aromatic hydrocarbons in road runoff from urban regions of Beijing, China. Environmental Toxicology and Chemistry, 27(1): 31-37.

Appendix H

In Situ Solidification Treatability Study Status Report, prepared for National Grid by GEI Consultants Inc.

Appendix I

CSO Investigation – Sediment Cores and Analytical Results, prepared for National Grid by GEI Consultants Inc.

Appendix J

CSO Investigation – CSO Samples and Analytical Results, prepared for National Grid by GEI Consultants Inc.

Appendix K

Initial Geotechnical Investigation in Support of Cap Design, prepared for National Grid by GEI Consultants Inc.

Appendix L

RTA 3B figures, prepared for National Grid by GEI Consultants Inc.

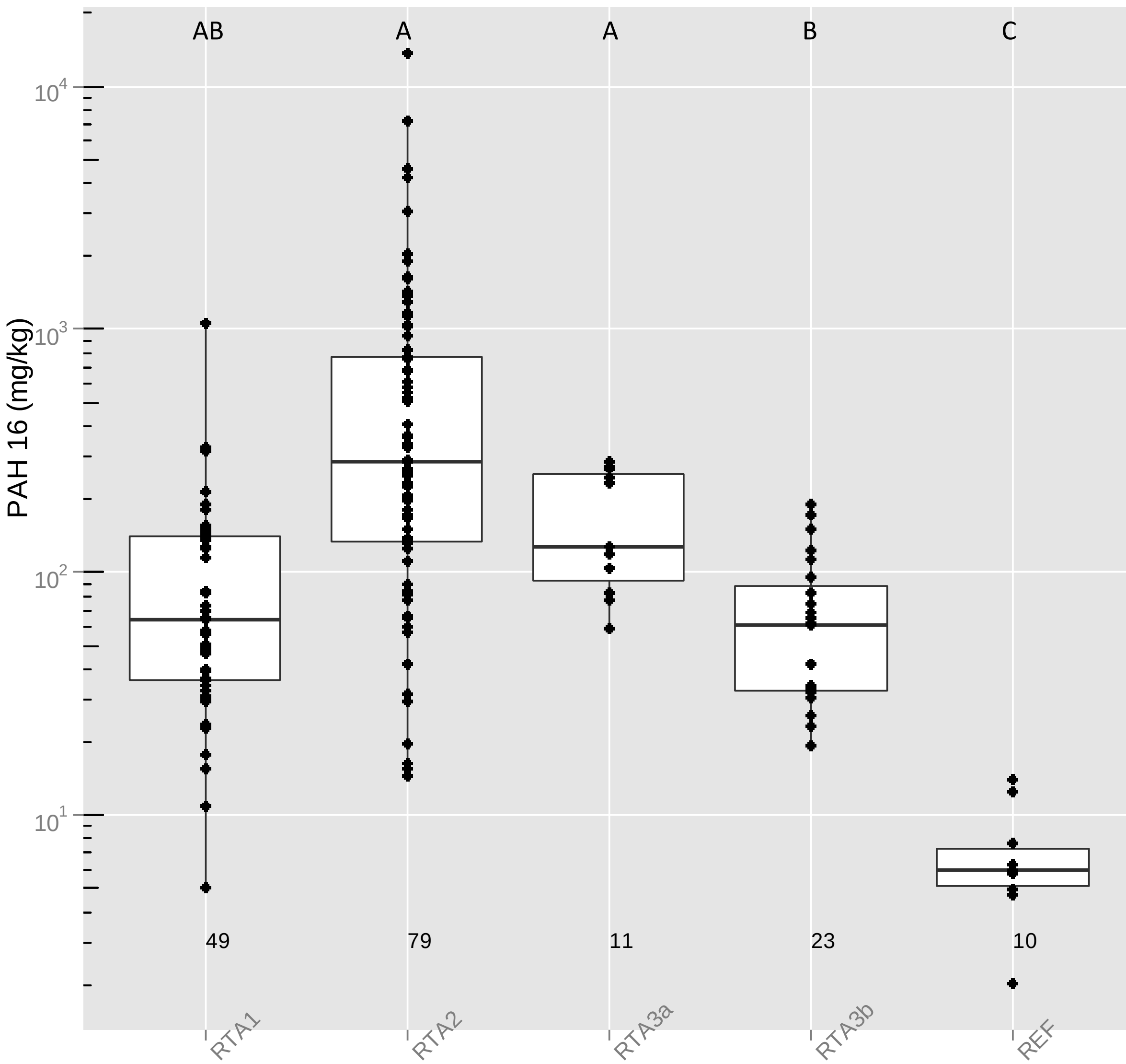


Figure 1. Total PAH_{16} in surface sediments (0 to 6 inches) measured in five sediment sampling events (GEI 2011, 2012a, 2012b, 2012c; CH2M Hill, 2011). Number of samples per group is displayed at bottom of figure. Letters at top indicate analysis of variance and Tukey's pairwise test results; data with the same letters are not significantly different ($p<0.05$ significance level).

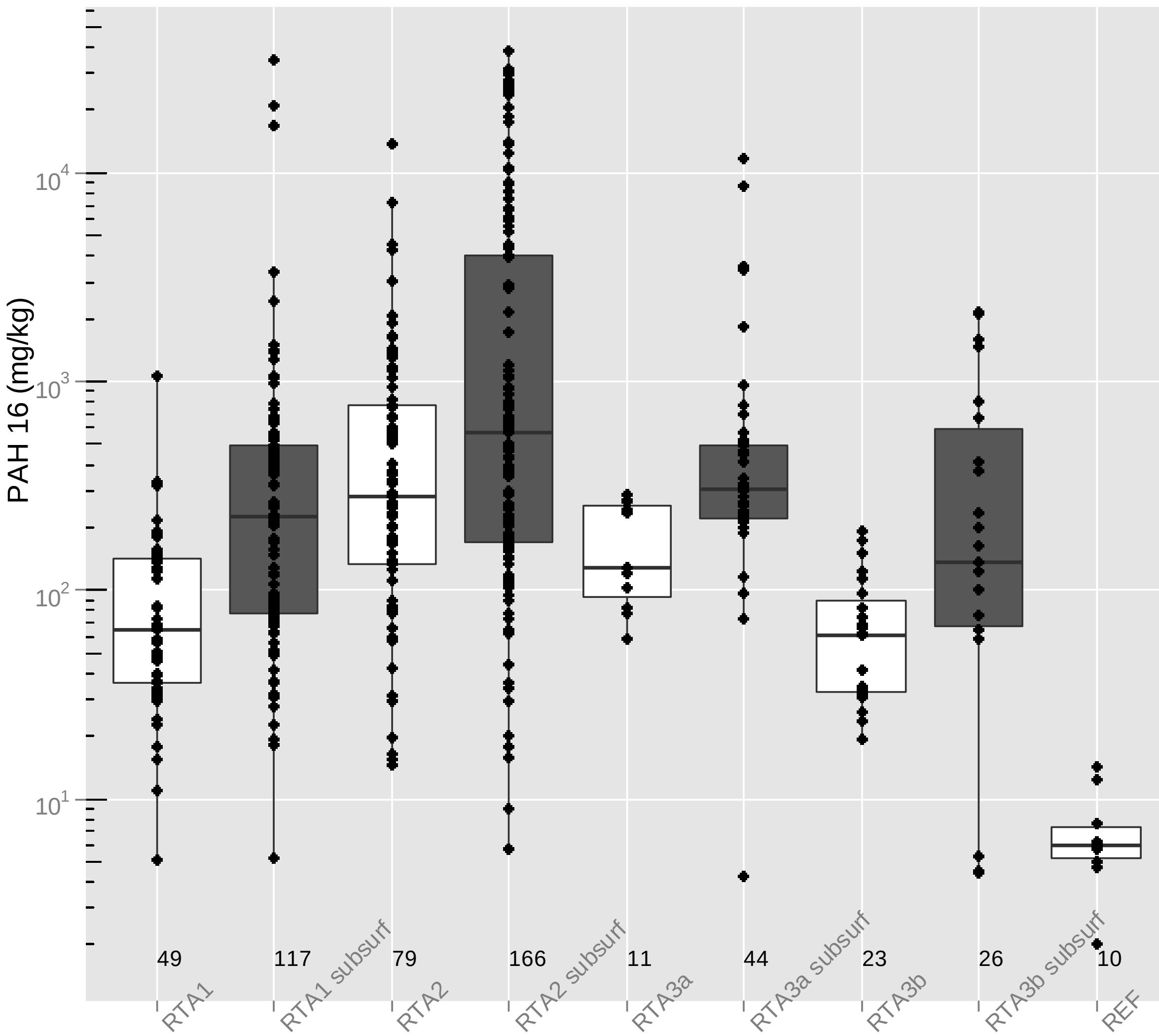


Figure 2. Total PAH_{16} in surface and subsurface sediments measured in six sediment sampling events. All surface data were collected by GEI (2011, 2012a, 2012b, 2012c) and CH2M Hill (2011), and subsurface data were collected by GEI (2007, 2012c). Number of samples per group displayed at bottom of figure.

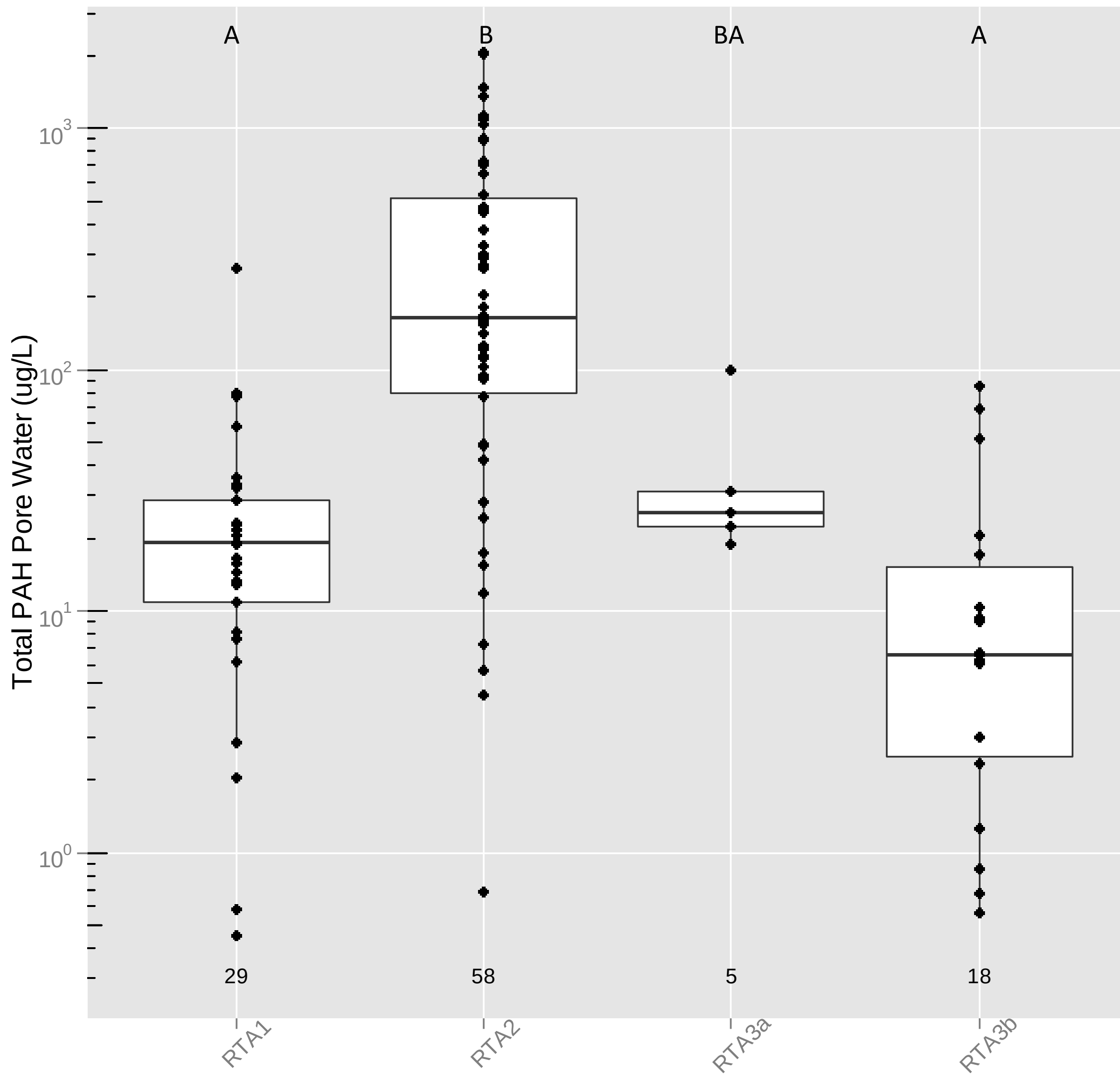


Figure 3. Total PAH_{34} measured in surface sediment pore water samples in each of three GEI (2011, 2012a, 2012b) seasonal sampling events. Number of samples per group displayed at bottom of figure. Letters at top indicate analysis of variance and Tukey's pairwise test results; data with the same letters are not significantly different ($p<0.05$ significance level).

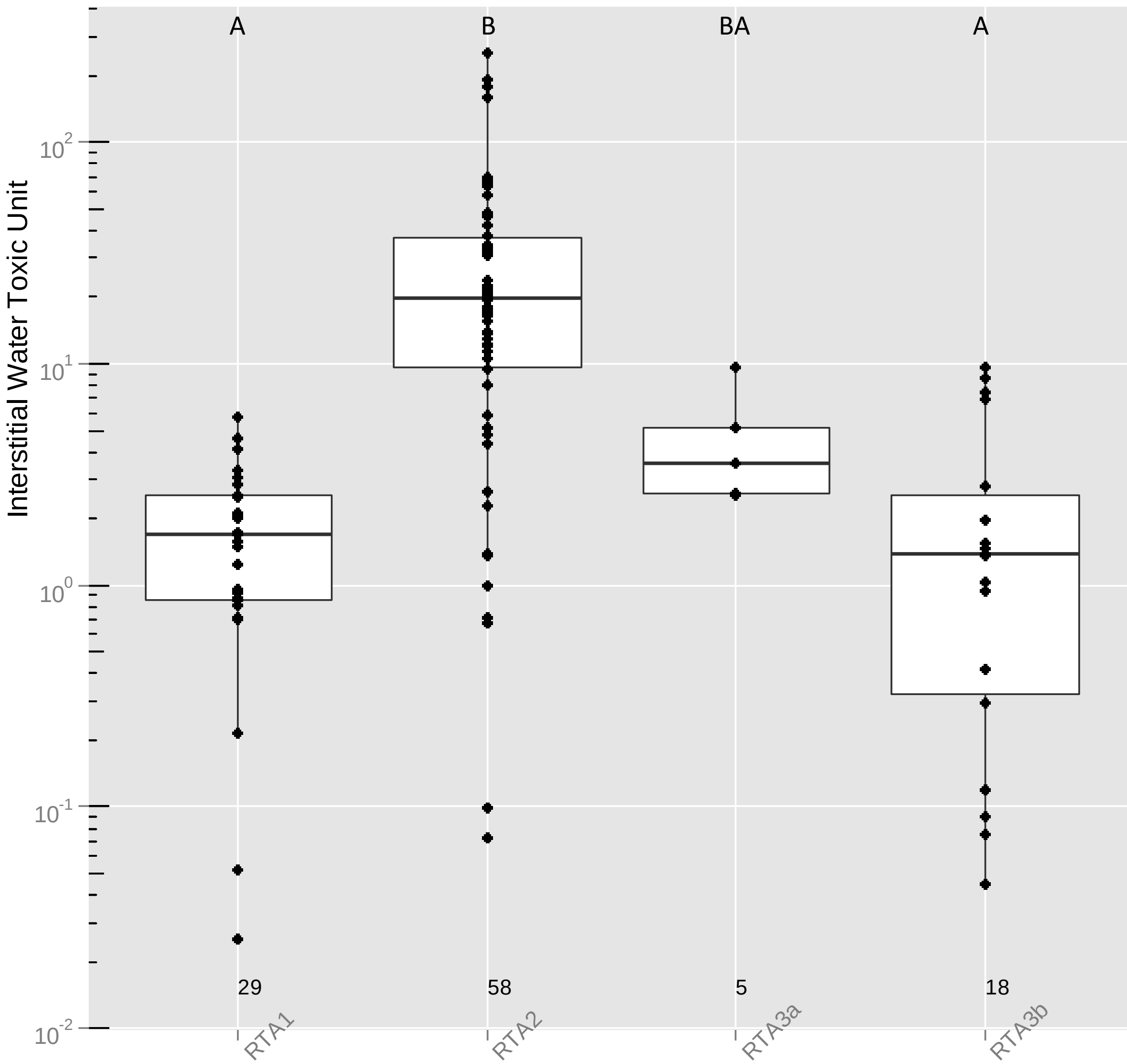


Figure 4. Interstitial water toxic units estimated from Total PAH_{34} in interstitial water; data were measured in surface sediment samples in each of three GEI seasonal sampling events. Number of samples per group displayed at bottom of figure. Letters at top indicate analysis of variance and Tukey's pairwise test results; data with the same letters are not significantly different ($p<0.05$ significance level).

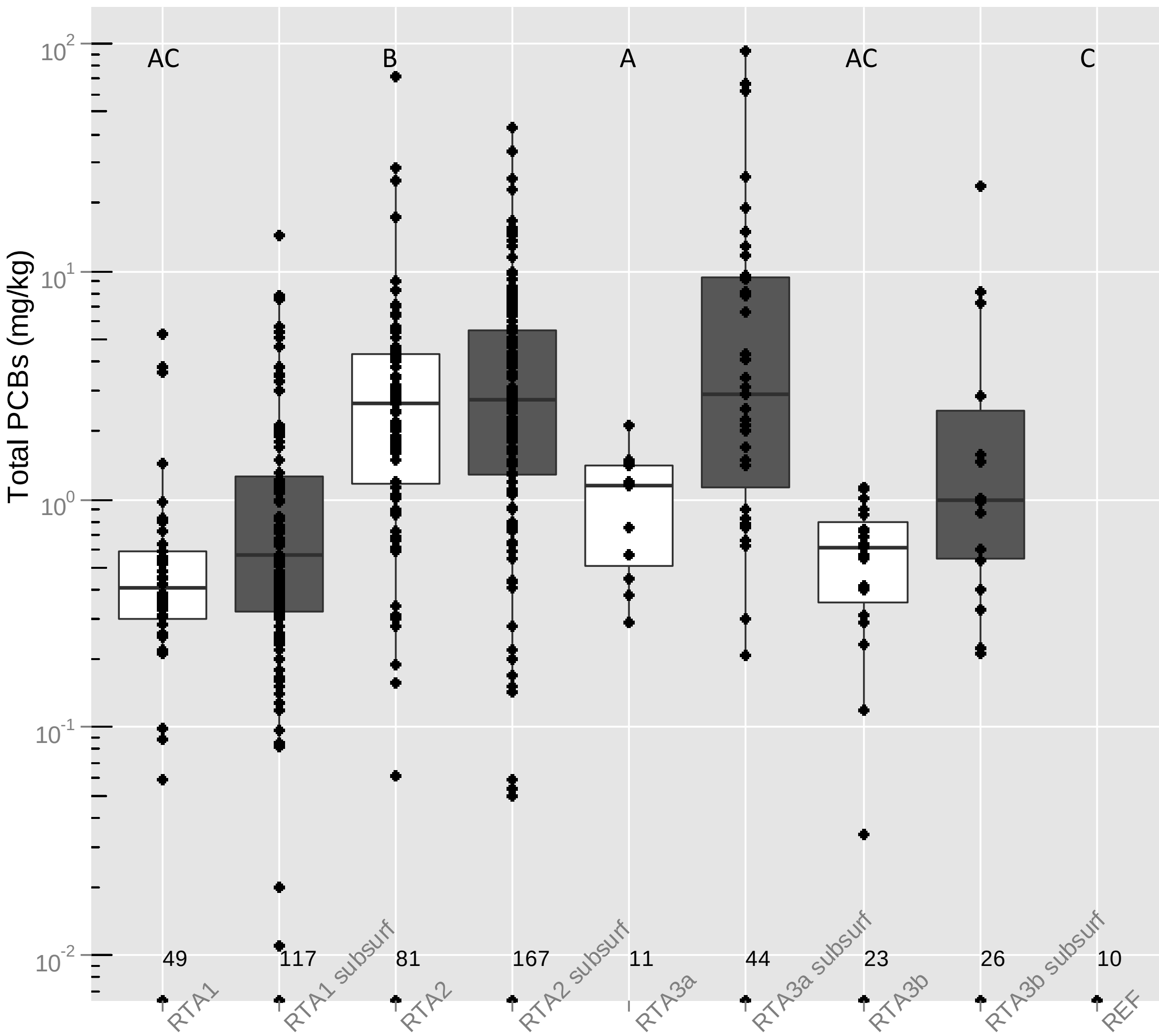


Figure 5. Total PCBs as the sum of measured PCB Aroclors in surface and subsurface sediments measured in six sediment sampling events. All surface data were collected by GEI (2011, 2012a, 2012b, 2012c) and CH2M Hill (2011), and subsurface data were collected by GEI (2007, 2012c). Number of samples per group displayed at bottom of figure. Letters at top indicate analysis of variance and Tukey's pairwise test results (surface samples only); data with the same letters are not significantly different ($p<0.05$ significance level).

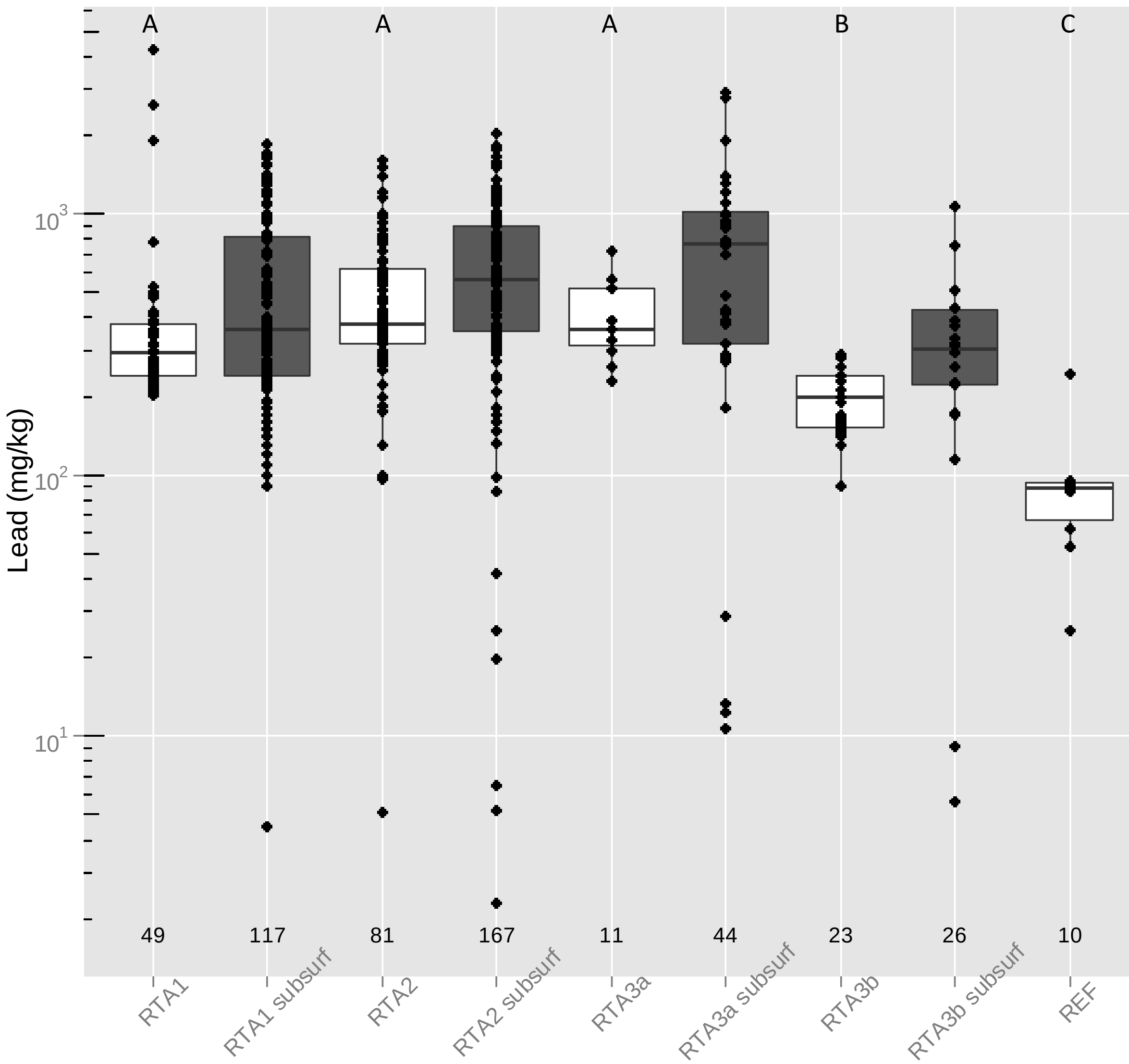


Figure 6. Lead measured in surface and subsurface sediments measured in six sediment sampling events. All subsurface data shown were collected in the GEI RI (2007) and GEI CSO Mound Core Analysis (2012c). Number of samples per group displayed at bottom of figure. Letters at top indicate analysis of variance and Tukey's pairwise test results (surface samples only); data with the same letters are not significantly different (p<0.05 significance level).

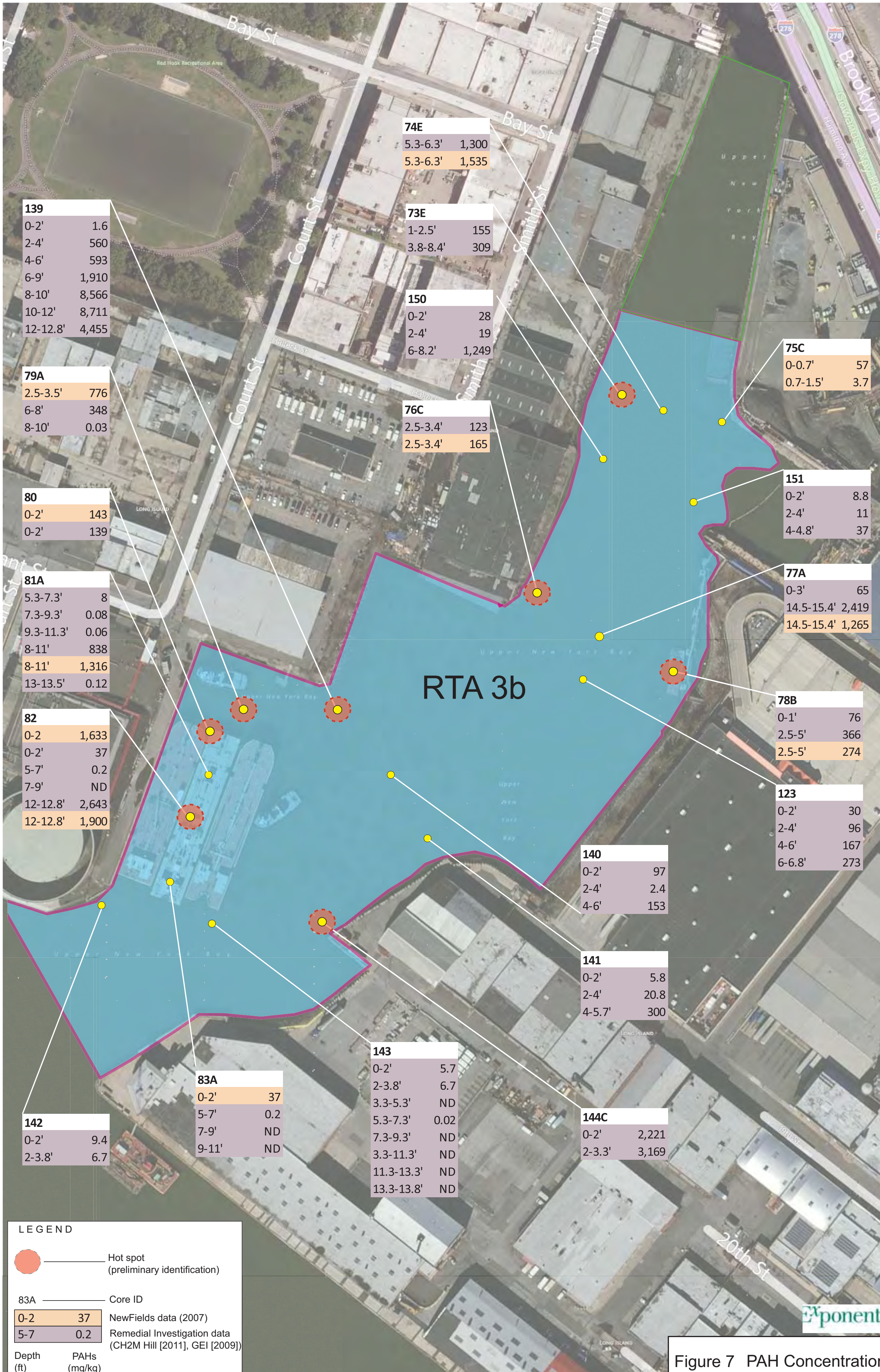


Figure 7 PAH Concentrations in RTA 3b sediment

Data sources:
- NewFields. 2007. Environmental Forensic Investigation, Gowanus Canal, Brooklyn, New York. March.
- GEI Consultants, Inc. 2009. Remedial Investigation Technical Report, Gowanus Canal, Brooklyn, New York.
- CH2M Hill. 2011. Gowanus Canal Remedial Investigation Report. January.

Project # / January 23, 2013 / C:\Jane\Tarek\Gowanus_Canal.mxd

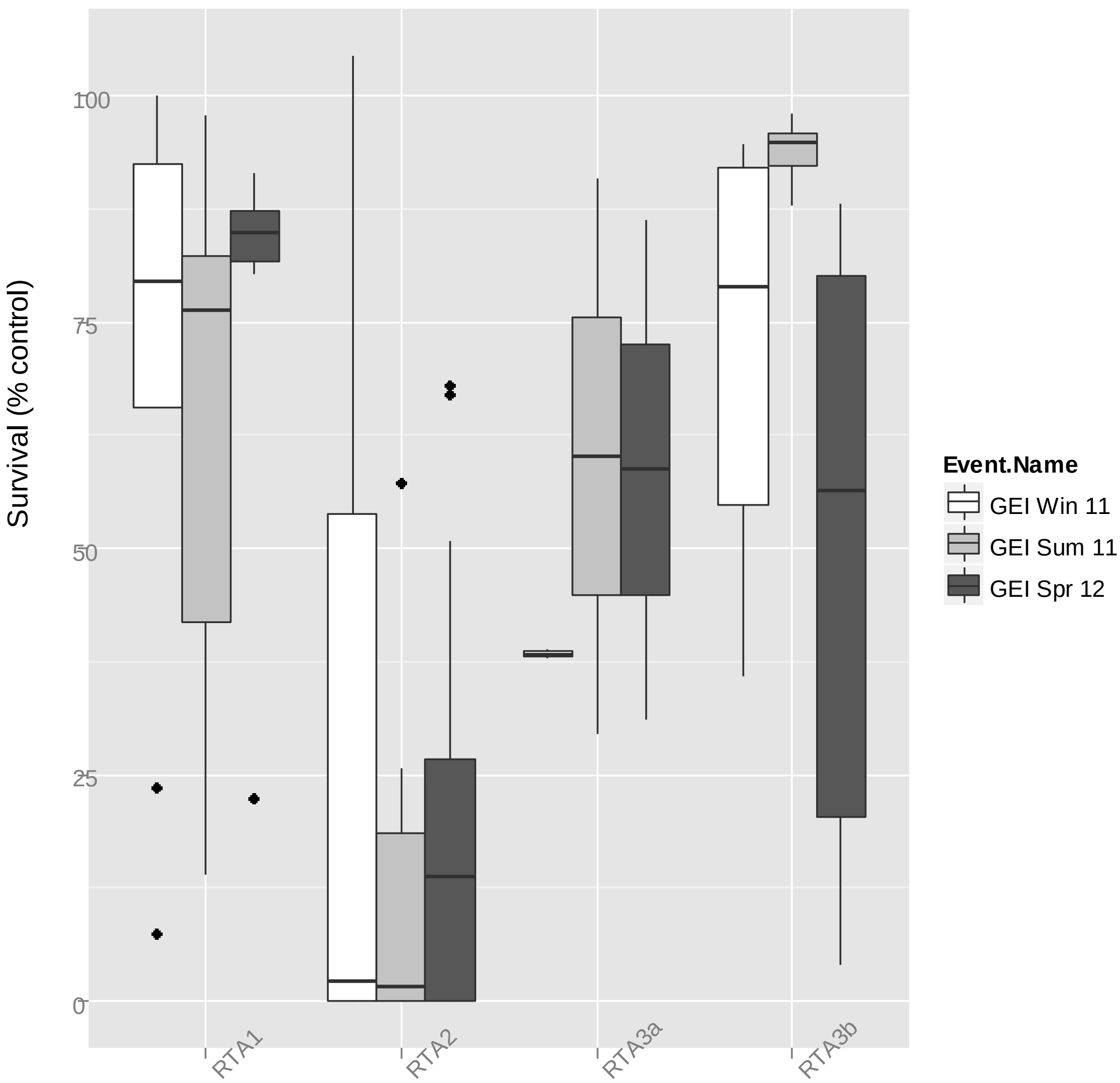


Figure 8. Control-normalized percent survival for *Leptocheirus plumulosus* 10 day toxicity test samples for the three GEI seasonal sampling events (GEI 2011, 2012a, 2012b).

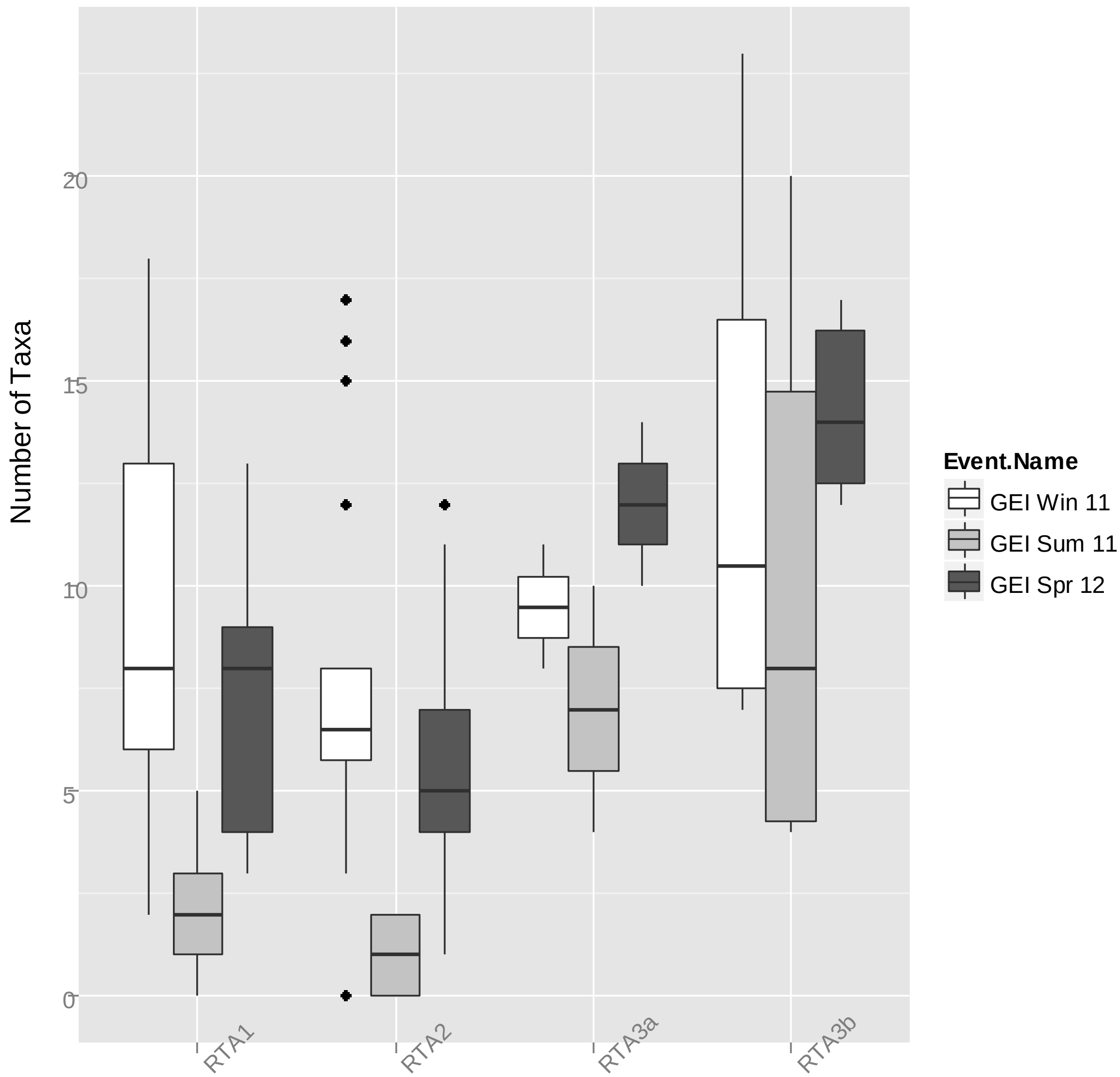


Figure 9. Benthic invertebrate taxa observed in each remedial target area for the three GEI seasonal sampling events (GEI 2011, 2012a, 2012b).

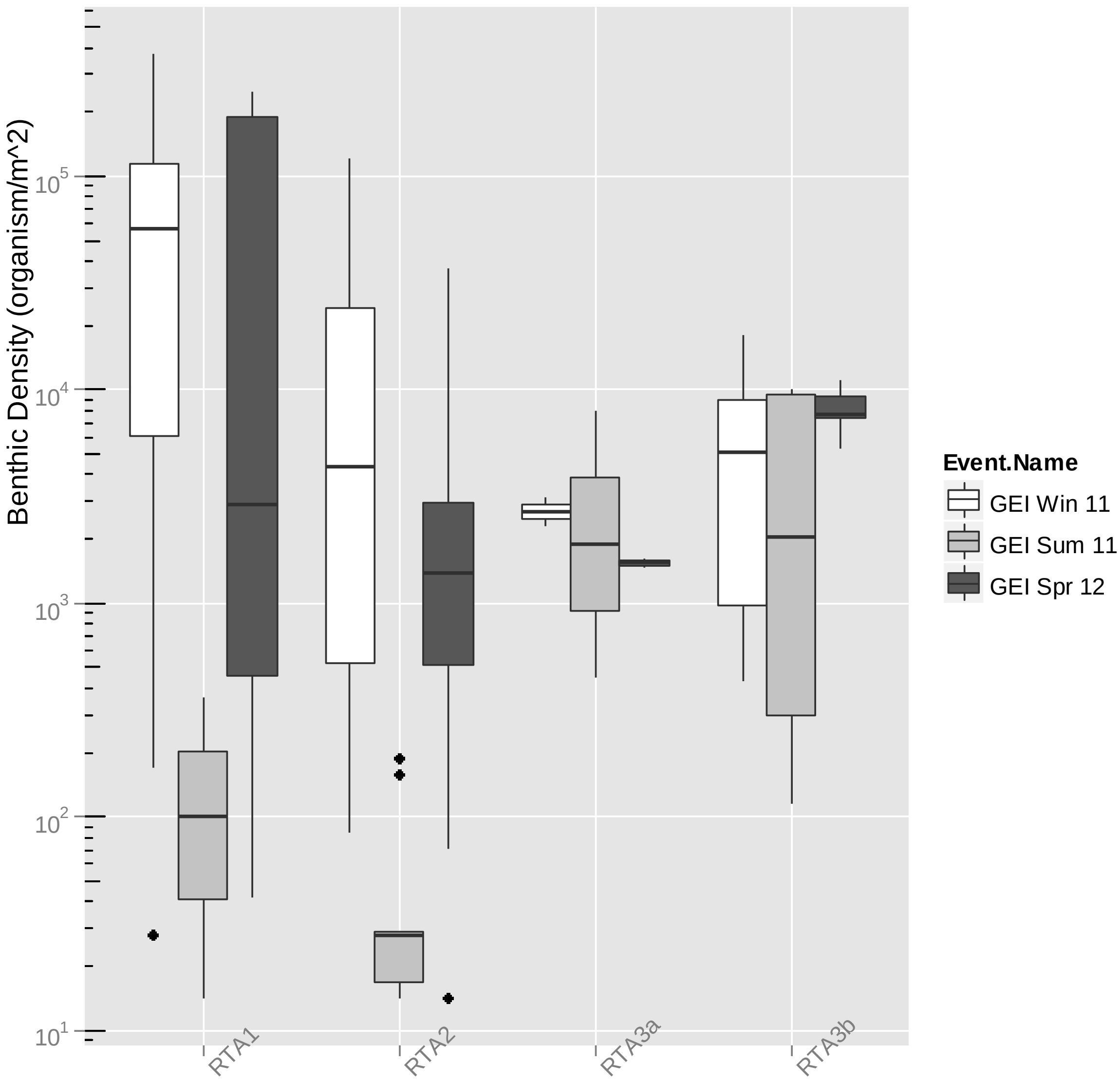


Figure 10. Benthic invertebrate density calculated in each remedial target area for the three GEI seasonal sampling events (GEI 2011, 2012a, 2012b).

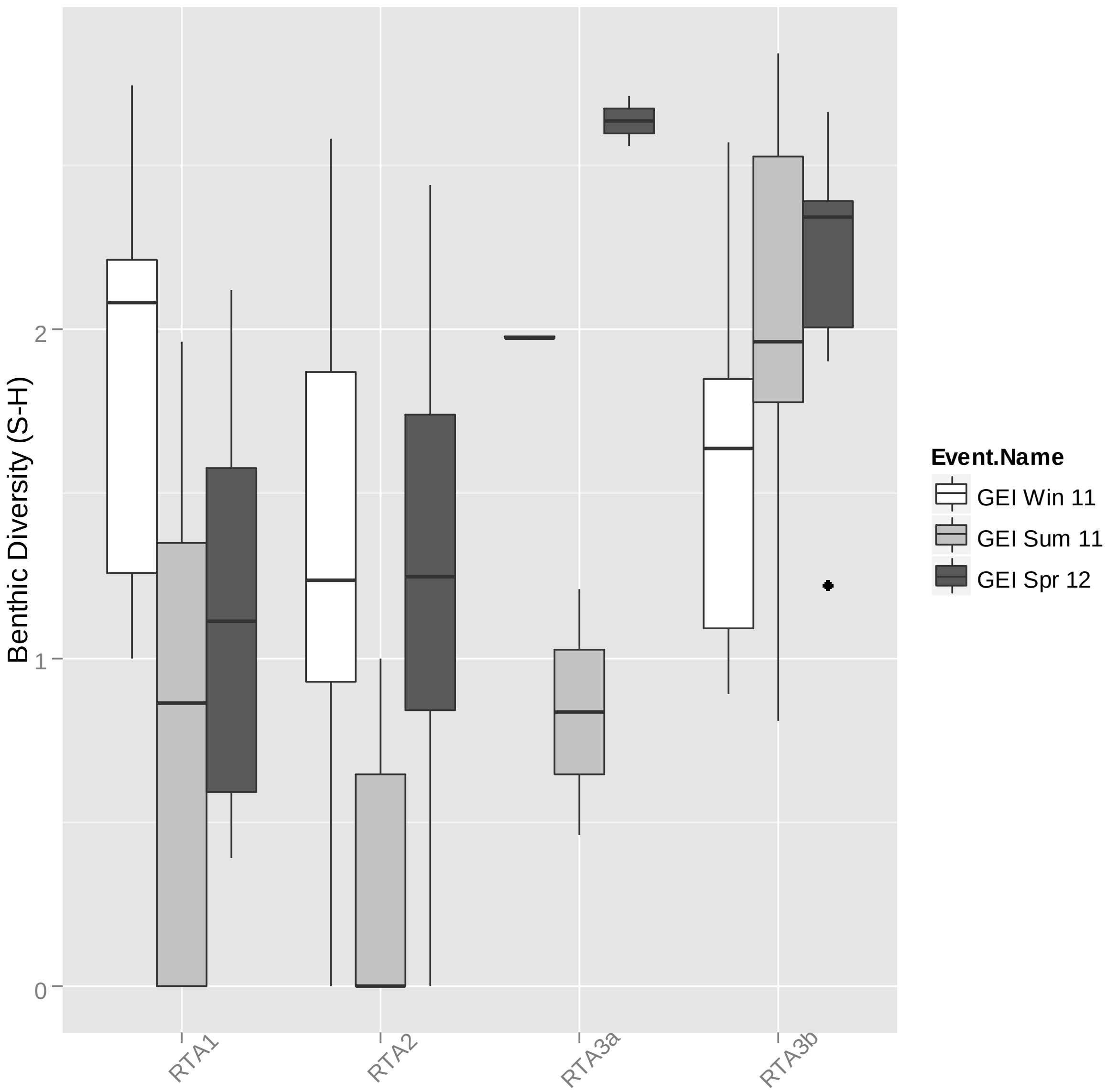


Figure 11. Benthic diversity calculated in each remedial target area for the three GEI seasonal sampling events (GEI 2011, 2012a, 2012b).

Table 1. Comparison between PAH_{16} in hot spots versus the remainder of RTA 3b

Sediment Core	**Average $tPAH_{16}$ concentration (mg/kg) Depth: 0-2 ft**	**Average $tPAH_{16}$ concentration (mg/kg) Depth: 2-4 ft**
Hotspot cores (preliminary identification): Core 82, 80, 79A, 139, 144C, 76C, 78B, 73E (see Figure 7 for core locations and sample results)	808 mg/kg	828 mg/kg
Non-hotspot cores: 142, 83A, 81A, 143, 141, 140, 123, 77A, 151, 150, 74E, 75C	31.5 mg/kg	23 mg/kg

Prepared for National Grid by Exponent, Inc.

Data Sources:

CH2M Hill. 2011. Gowanus Canal Remedial Investigation Report. January.
GEI Consultants, Inc., 2009_ Remedial Investigation Technical Report, Gowanus Canal, Brooklyn, New York. December.
NewFields, 2007. Environmental Forensic Investigation, Gowanus Canal, Brooklyn, New York. March.