Public Comment Draft

PUBLIC HEALTH ASSESSMENT

GOWANUS CANAL

CITY OF NEW YORK
BOROUGH OF BROOKLYN
KINGS COUNTY, NEW YORK

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Prepared by:

New York State Department of Health
Center for Environmental Health
Under a Cooperative Agreement with
The U.S. Department of Health & Human Services
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SUMMARY

INTRODUCTION

The New York State Department of Health (DOH) and Agency for Toxic Substances and Disease Registry (ATSDR) wish to ensure that the community around the Gowanus Canal has the best information possible about how contaminants in the canal might affect their health.

Some city residents use the Gowanus Canal for canoeing, scuba diving, and swimming, and some catch and eat fish and crabs from the canal.

To evaluate how people's health might be affected, DOH and ATSDR used data from an environmental investigation of the Gowanus Canal conducted by GEI Consultants, Inc. for KeySpan Corporation in 2007 and from the remedial Investigation conducted by the United States Environmental Protection Agency (EPA) in 2010.

CONCLUSION 1

DOH and ATSDR conclude that full body immersion recreation (e.g., swimming, scuba diving) in the Gowanus Canal could harm people's health.

BASIS FOR DECISION

There are physical, biological and chemical hazards for the few swimmers in the Gowanus Canal.

Large commercial boat traffic and high bulkheads (marine retaining walls) in many places represent physical safety concerns for swimming and other water recreation. Bulkheads may make it difficult to get out of the canal when necessary for safety. In addition, there are physical hazards that can cause injury, as well as drowning hazards (for example, steep slopes, drop offs and poor water clarity) that have not been assessed.

Water in the Gowanus Canal periodically contains levels of fecal coliform bacteria that indicate an increased risk of illness from recreational contact with the water. Water from the Gowanus Canal contains microorganisms, such as coliform bacteria, and likely contains viruses and parasites (protozoas) that can make a person ill if they enter the body. There is increased risk of contracting diseases through swallowing or skin contact with these disease-causing agents.

In some locations, exposure to chemicals in the surface water is also a potential health concern for swimmers. While most water samples from the Gowanus Canal contain chemical levels that are estimated to pose a minimal or low risk for health effects, about 8% of the samples taken in 2007 contained polycyclic aromatic hydrocarbons (PAHs), particularly benzo(a)pyrene, at levels that could pose a moderate to high increased cancer risk if people are exposed repeatedly over a long period of time (for example, 30 years) at those specific locations only. All but one of these samples were from the Middle Reach of the canal (from 2nd Street to the Brooklyn Queens Expressway). Benzo(a)pyrene contamination may be limited to specific areas of the canal where there is tar, creosote-treated bulkheads and petroleum sheens.

Also, exposure to chemicals in accessible sediments is a potential health concern for swimmers, as well as others, who might contact the sediments during fishing, boating or wading. Repeated and long-term exposure to the highest level of benzo(a)pyrene detected in surface sediments is estimated to pose a moderate increased risk for cancer (i.e., the estimated increased cancer risk is between one in ten thousand and one in one thousand). Lead in some of the sediment locations could increase a child's blood lead level if a child frequently contacts sediments in these high lead locations.

CONCLUSION 2

DOH and ATSDR conclude that recreational boating (for example, canoeing or kayaking) or “catch and release” fishing from a boat in the Gowanus Canal is not expected to harm people's health, although there may be some physical hazards, such as large commercial boat traffic. However, certain precautions are recommended because accidental swallowing and skin contact with the water when boating or fishing in some areas of the canal would lead to increased exposure to chemical and biological contaminants, and these are discussed under general recommendations below.

BASIS FOR DECISION

There is an increased risk of illness from water contact while boating and fishing when standards for indicator bacteria are exceeded. Because people do not usually submerge their heads during these activities, the presumed volume of incidental water consumption is lower than when swimming. Consequently, the risk of illness can also be assumed to be lower.

CONCLUSION 3

The DOH and ATSDR conclude that if people don’t follow DOH’s fish consumption advisories, and eat more fish and crabs from the Gowanus Canal than recommended, their risk for adverse health effects will increase and their health could be harmed.

BASIS FOR DECISION

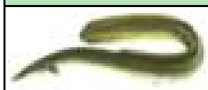
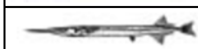
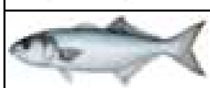
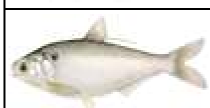
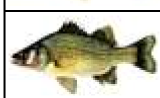
Based on the close association of the Upper Bay of New York Harbor and the Gowanus Canal, contaminant levels in fish and crabs from the waters probably are similar. DOH has extensive, restrictive fish advisories for the Upper Bay of New York Harbor that apply to the Gowanus Canal.

People who are considering eating fish and crab caught in the canal should follow the DOH consumption advisories for fish (including crabs) taken from the Upper Bay of New York Harbor to reduce their exposures to chemical contaminants. The advisory, available at http://www.nyhealth.gov/environmental/outdoors/fish/fish.htm) is:

"Women under 50 years old and children under 15 years old **should not eat any fish** from these waters."

The advice for women over 50 and men over 15 is less restrictive and is shown in the table that follows:

DOH Fish Consumption Advisory for the Upper Bay of New York Harbor, Applicable to the Gowanus Canal.

		Women Under 50 & Children Under 15	**Women Over 50 & Men Over 15**
	American eel	DON'T EAT	DON'T EAT
	Atlantic needlefish	DON'T EAT	Up to 1 meal/month
	Blue crabs	DON'T EAT DON'T EAT tomalley	Up to 4 meals/month (six crabs per meal) Don't eat tomalley
	Bluefish	DON'T EAT	Up to 1 meal/month
	Gizzard shad	DON'T EAT	DON'T EAT
	Rainbow smelt	DON'T EAT	Up to 1 meal/month
	Striped bass	DON'T EAT	Up to 1 meal/month
	White perch	DON'T EAT	DON'T EAT
Other fish not listed		DON'T EAT	Up to 4 meals/month

CONCLUSION 4

DOH and ATSDR conclude that breathing contaminants from the Gowanus Canal in outdoor air near the canal is not expected to harm people's health.

BASIS FOR DECISION

The health risks from long-term exposure to the concentrations of benzene, chloroform, ethyl benzene, methylene chloride and naphthalene detected in outdoor air near the canal (at street or canal level) are similar to those associated with the concentrations of these chemicals in typical urban air. Long-term exposure to total xylenes, which were measured near the canal or at street level at concentrations higher than those in typical urban air, poses a minimal risk for adverse health effects.

GENERAL RECOMMENDATIONS

There are a number of nearby alternative fishing/crabbing and recreational sites for New York City residents other than the Gowanus Canal that do not have the same risks as the Gowanus Canal; therefore, the DOH, ATSDR and New York City Department of Health and Mental Hygiene (NYCDOHMH) recommend that residents use those other sites. However, for those people who choose to use the Gowanus Canal for recreation, the DOH and ATSDR recommend measures to reduce exposures to biological and chemical contaminants. People using the canal can reduce the risk of becoming ill by avoiding the canal water after periods of effluent discharge, rainfall, when the water is cloudy or turbid, or when pollution is clearly visible (for example, petroleum sheens). People should avoid any activity that would result in swallowing canal water. People should wash their hands after contacting the water and sediments, especially before eating and at the end of the day. If people get water or sediments on more than just their hands and arms, it would also be prudent to take a shower to wash off the canal water and sediments.

NEXT STEPS

The ATSDR and DOH will coordinate with EPA and the New York City Department of Environmental Protection (NYCDEP) on postings of public health messages regarding recreational use (e.g., swimming, boating and fishing) of the Gowanus Canal.

FOR MORE INFORMATION

If you have questions about the investigation of the Gowanus Canal, please contact the EPA Regional Office at (212) 637-3967. If you have questions about this public health assessment or other health concerns about this site, please contact Christopher Doroski of the DOH at 518-402-7860 or 1-800-458-1158, extension 27860.

PURPOSE AND HEALTH ISSUES

The purpose of this public health assessment (PHA) is to evaluate human exposure pathways and health risks for contaminants related to the Gowanus Canal. In addition, a congressional mandate requires that a PHA be conducted for all sites being proposed for the federal National Priorities List (NPL). The EPA added the Gowanus Canal to the NPL on March 4, 2010. This PHA fulfills the mandate for the Gowanus Canal. The data used in this document are based on the 2007 report from KeySpan Corporation's investigation, which was done to determine the extent of its contribution of historical discharges to the contamination in the canal (GEI Consultants Inc., 2007) and from the Remedial Investigation conducted by EPA and released in 2011 (EPA, 2011a,b).

BACKGROUND

A. Site Description and History:

The Gowanus Canal is in Brooklyn, New York City. It borders several communities, including Park Slope, Cobble Hill, Carroll Gardens and Red Hook. Because of many years of discharges, storm water runoff, sewer outflows and industrial pollutants, the Gowanus Canal is one of the nation's most extensively contaminated water bodies (GEI Consultants, 2007). Contaminants identified include biological organisms, polychlorinated biphenyls (PCBs), coal tar wastes, metals and volatile organic compounds (VOCs).

The State of New York authorized, in 1848, the creation of the Gowanus Canal to drain the wetlands of South Brooklyn and open the area to development (Richards, 1848a, b). The Gowanus Canal was constructed between 1853 and 1869 and was designed as a channel for barges. The canal enabled easy transportation and storage of coal, petroleum, asphalt and lumber to support the rapid growth of industry in Brooklyn. The canal continued to be a primary route of transportation for goods and materials into the area until the completion of the Gowanus Expressway in 1951 (New York City Department of City Planning, 1985). The historic land use next to the canal included oil and petroleum storage, coal yards, and manufacturing chemicals/fertilizers/plastics.

The Gowanus Canal also served as an outlet for sewage and industrial wastes. During its construction, the City of Brooklyn built sewers emptying into the Gowanus Canal as early as 1858. The confined nature of the canal and limited tidal exchange caused sedimentation and poor water quality. Accumulations of sludges and sediments in the canal became a problem in the late 1800s. By 1889, the Gowanus Canal was so affected by sewage and industrial discharges that it was considered a public health hazard. At that time, a state commission suggested that filling the Gowanus Canal was the best solution to the poor water quality (Hunter Research, Inc., 2004). To flush the canal, the City of Brooklyn constructed storm sewer outfalls that drained the Fort Greene section of Brooklyn at the top of the canal in 1899. However, this only added pollution to the canal.

In 1911, the Gowanus Canal Flushing Tunnel was designed to pull water, via a propeller and underground tunnel, from the Buttermilk Channel in the East River and discharge it to the head of the Gowanus Canal. The Flushing Tunnel added about 300 million gallons of water daily to the canal and it operated from 1911 until 1960 when it failed mechanically. With the flushing tunnel not operating, canal water once again became heavily polluted.

To reduce sewage discharge to the Gowanus Canal, the City of New York built the Gowanus Canal Pump Station at the head of the canal in 1947 and the Owl's Head sewage treatment plant in 1952. However, in 1984 the Gowanus Canal still had thirteen related outfalls: nine combined sewer overflows (CSOs) and four continuous dry weather sewer discharges. They discharged 16.6 million gallons of raw sewage and four million gallons of combined sewer overflows into the canal on a daily basis (Stone and Webster Engineering Corporation, 1984). The CSO discharges to the Gowanus Canal caused a buildup of sludges and sediments that were not removed by tidal flushing. Sewage discharge to the Gowanus Canal was reduced, but not eliminated, after the construction of the Red Hook Treatment Plant in 1987. In 1999, the Gowanus Canal Flushing Tunnel was reactivated and pumped about 150 million gallons per day of water. The flushing tunnel is now undergoing renovation and a large scale oxygen bubbler pipe is in place to aerate the upper third of the canal and reduce stagnation.

There are ten CSOs that discharge 293 million gallons of CSO waters and two storm water outfalls that discharge 59 million gallons of stormwater annually to the Gowanus Canal (NYCDEP, 2005). The CSO outfall locations are included in the State Pollutant Discharge Elimination System (SPDES) permits for the Owls Head and Red Hook Water Pollution Control Plants (WPCPs) in Brooklyn.

There are three NPDES/SPDES (National and State Pollutant Discharge Elimination System) permitted industrial discharges within the Gowanus Canal: Bayside Oil Fuel Depot and Universal Fixture Corporation in the Middle Reach of the canal and Amerada Hess Corporation Brooklyn Terminal in the Lower Reach of the canal.

Use and Characteristics

The Upper Reach is defined in the 2007 GEI investigation (GEI Consultants Inc., 2007) as the canal from Butler Street, south to the intersection of 2nd Street. The Middle Reach is the portion south of 2nd Street to Hamilton Avenue Bridge of the Brooklyn Queens Expressway (BQE). The Lower Reach is south of the Hamilton Avenue Bridge/ BQE to the Gowanus Creek Channel Outlet. Boundaries are shown on Figure 1 (Appendix A).

According to the EPA (EPA, 2010a), some city residents use the Gowanus Canal for recreation such as canoeing, scuba diving and swimming. A boat launching area (New York City Department of Parks and Recreation, 2012) is at the foot of Second Street. EPA also reports that there are houseboats on the canal where people may be living year-round (EPA, 2010a). There are no permitted bathing or swimming facilities.

People use the Gowanus Canal for fishing and crabbing and eat their catch. The heaviest fishing use is likely to be in the Lower Reach because it is closer to the Bay and there is more open water. Also, an area just downstream of the canal in Gowanus Bay is fished on a regular basis (EPA, 2010a).

The DOH issues yearly fish consumption advisories for New York State (DOH, 2013a; available at: http://www.nyhealth.gov/environmental/outdoors/fish/fish.htm) that cover the Upper Bay of New York Harbor, including the Gowanus Canal.

B. Site Visit

DOH and EPA staff have made multiple visits to the Gowanus Canal and surrounding areas. Visits were made to evaluate inactive hazardous waste sites along the canal and assess the impact on the canal. DOH visited on March 15, 2010 to observe conditions within the canal. Staff observed that the flow of the canal was calm and the water appeared opaque. Additionally, the construction of the improved pumping station was underway at the head of the canal. DOH staff did not observe people using the canal for recreation. At the request of the DOH, on July 2, 2010, staff from the NYCDOHMH visited the Gowanus Canal to determine if there are areas where people using the canal for recreation could contact contaminated sediments. DOH and NYCDOHMH staff visited the Gowanus Canal after Hurricane Sandy. The most recent DOH site visit was on March 27, 2013.

C. Demographics

The Gowanus neighborhood has loosely been defined as the area bordered by Baltic St. to the north; Fifth Ave. to the east; 14th St. to the south; and Smith St. to the west. The DOH estimated, from the 2010 Census (US Census Bureau, 2011), that 21,407 people live in the area identified as the Gowanus neighborhood while about 185,952 people live within one mile of the site. The age distribution of the area is somewhat similar to that of the rest of Kings County as well as New York City, with a slightly higher percentage of individuals 20 to 64 years old living in the area and lower percentages of the young and old. There were 6349 females of reproductive age (ages 15-44) living in the neighborhood and 53,113 within one mile of the site. Based on the 2005 – 2009 American Community Survey (US Census Bureau, 2010), the area had a lower percentage of the population living below the poverty level while the median household income is higher than other areas of the city. These comparisons are provided in the following table.

Table A. Demographics of the Gowanus Neighborhood Compared to the Area within One Mile of the Gowanus Canal Site, Kings County (Brooklyn) and New York City.

2010 Census Demographics	New York City	Kings County	Gowanus Neighborhood	Area Within 1 Mile of Gowanus Canal Site
Age Distribution[1] (%)				
<6	7.5	8.4	7.6	7.3
6-19	16.9	18.1	11.4	11.1
20-64	63.4	62.0	71.9	72.7
>64	12.1	11.5	9.2	8.8
Race Distribution[1] (%)				
White	44.0	42.8	65.3	68.7
Black	25.5	34.3	14.3	11.3
Native American	0.7	0.5	0.6	0.3
Asian	12.7	10.5	6.4	6.6
Pacific Islander	0.1	0.0	0.1	0
Other	13.0	8.8	8.7	8.2
Multi-Racial	4.0	3.0	4.6	4.7
Percent Minority*	66.7	64.3	45.4	42.9
Ethnicity Distribution[1] (%)				
Percent Hispanic	28.6	19.8	23.3	23.6
Median Household Income[2]	$50,160	$42,894	$72,673	$66,534
% Below Poverty Level[2]	18.6	21.8	14	11.5

* Minority includes Hispanics, African-Americans, Asian-Americans, Pacific Islanders and Native Americans.
[1] US Census Bureau. 2011.
[2] US Census Bureau. 2010.

The DEC (DEC, 2003) and the EPA (EPA, 2000a) have guidelines for identifying potential environmental justice communities. A potential environmental justice community is a minority or low income community that may bear a disproportionate environmental burden resulting from industrial, municipal and commercial operations. A low income community is one in which at least 23.59% of the population is living below the poverty level as defined by the 2000 US Census. A minority community is defined as one having a minority population equal to or greater than 51.5% of the total population in an urban area or 34.73% of the total population in a rural area as defined by the 2000 US Census. If a community is found to be either low income or minority then it is defined as a potential environmental justice community. Based on 2010 Census estimates, the Gowanus would not be considered a potential environmental justice community.

In acknowledgment of the ethnic and language diversity of the neighborhood surrounding Gowanus Canal, as well as other areas of New York City adjacent to marine waters, the DOH is making efforts to reach out to the diversity of New York City anglers. The DOH released a fish consumption advisory brochure created specifically for New York City waters in August 2010 (updated April 2013). The brochure contains color coded maps and tables with fish pictures as guides to help communicate fish advisory messages to a broader audience including non-English speaking populations. The DOH shared the new brochure among local New York City anglers and identified multiple fishing communities including Polish, Russian, Asian and Hispanics. The NYC brochure is currently available in both print and online form from the DOH in English, Spanish and Chinese (DOH, 2013a). This information is updated when new information requires a change in fish consumption advisories.

DISCUSSION

A. Environmental Contamination

For this PHA, DOH used environmental data that were gathered during the investigation of the Gowanus Canal conducted by GEI for KeySpan Corporation in 2007 (GEI Consultants Inc., 2007) and the 2011 EPA Remedial Investigation (EPA, 2011a,b). We used the surface water chemical and biological sampling data from the GEI 2007 report and the surface water, sediment, air and fish data from the EPA 2011 report [Appendix L (Human Health Risk Assessment (HHRA)) of the Gowanus Canal Remedial Investigation Report (EPA, 2011a)]. We did not use sediment sampling data from the 2007 report because the sediment data were not collected from locations where people could contact sediments, whereas the 2011 sediment data included samples collected at locations specifically identified by the EPA as places where people could contact sediments (EPA, 2011a). The 2007 data were collected and evaluated using a sampling scheme that divided the canal into three segments (Upper, Middle and Lower Reaches). We evaluated the 2011 data as one set, we did not subdivide the canal into segments.

Outdoor Air

EPA sampled air along the Gowanus Canal and at background locations two times. The samples were analyzed for VOCs, PCBs, and PAHs. The outdoor air samples were collected at locations considered representative of the breathing zone of a recreational canoeist on the canal, the breathing zone at the street level along the canal, and at background locations (i.e., outside of the area potentially impacted by emissions from the canal) at street level.

Sampling Methods

Surface Water: 2011 EPA Remedial Investigation

EPA collected surface water samples from the Gowanus Canal during dry-weather (June 19, 2010) and wet-weather (July 13, 2010) conditions. The objectives were to collect information on contaminants in surface water over the length of the canal and to evaluate differences in surface water contaminant concentrations in the canal during dry weather and following rainfall when there are additional discharges into the canal from the CSOs.

Because of the shallow water depth, EPA collected a single sample from each location at a depth of six inches below the water surface. The surface water sample locations generally coincided with the surface sediment sample locations and included 27 locations in the Gowanus Canal and one additional sample in the Gowanus Canal at the end of Sackett Street, which was collected in response to a resident's concern about a sheen on the water surface.

EPA collected dry-weather surface water samples following two days of dry weather and no CSO discharges. Thirty-eight surface water samples were collected during the dry-weather event. EPA collected wet-weather surface water samples following a rain storm that produced 1.02 inches of rain over two hours during mid- to low-tide. CSO discharges were visually confirmed during the rain event, and both Owls Head and Red Hook WPCPs reported operating near-maximum flow rates before the wet-weather sampling event was begun. Thirty-seven surface water samples were collected during the wet-weather event. Surface water samples from all locations were analyzed for organics and metals.

Surface Water: 2007 GEI Data

GEI collected surface-water samples using transects laid out across the canal. Samples were collected at two locations on each transect across the canal, with a sample collected near the water column surface and one near the bottom of the water column. Visual and olfactory (odor) observations were recorded for each surface water sample. A total of 138 surface water samples (plus 7 duplicate samples) were analyzed for VOCs, semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), pesticides, herbicides, metals, total cyanide, sulfate and fecal coliforms. Nitrate and nitrite concentrations were analyzed and were reported as total nitrogen. Samples were taken in each of the three separate reaches of the canal (Lower, Middle and Upper Reaches)

Sediment: 2011 EPA Remedial Investigation

Surface sediment samples were collected from 27 locations in the Gowanus Canal. Sediment samples from all locations were analyzed for organics, metals (including mercury and cyanide), grain size and total organic carbon (TOC). Nineteen samples from the canal were also analyzed for PCBs. The Gowanus Canal locations used for PCB analyses were selected to provide data for areas with the greatest potential for human exposure (e.g., the canoe launch site), areas where high-PCB concentrations were previously measured in sediment, and to provide spatial coverage throughout the canal.

Fish

Field Collection and Initial Sorting

EPA collected fish and crab samples from the Gowanus Canal and reference locations in Gowanus Bay and Upper New York Bay from June 21 through July 9, 2010. The following target and alternate species were collected from one or more canal or reference sample reaches and were identified for analysis:

• Small prey fish: Atlantic tomcod, hake, mummichog
• Crab: blue crab
• Larger fish: American eel, scup, striped bass, weakfish, white perch.

Each species was prepared for analysis based on sample type:

• Small prey fish: Small prey fish were analyzed for whole body tissue residue only.
• Crab: The analytical laboratory picked and separated the tissues of each crab into three separate components: edible tissue, hepatopancreas and eggs.
• Larger fish: The analytical laboratory separated the tissues of each larger fish into fillet and remaining carcass components.

Following tissue preparation, samples were combined by tissue type (whole body, edible crab, hepatopancreas, fillet and carcass) until the mass necessary for chemical analysis was reached.

Results

We used a two-step process to evaluate environmental data. For surface water and surface sediments, we screened the highest detected levels against appropriate standards and guidelines (maximum contaminant levels for water and soil cleanup objectives for sediment), and then evaluated the health risk for those contaminants that exceeded the screening levels based on media-specific exposure scenarios. For outdoor air, the highest levels of detected chemicals are screened against levels in outdoor air background databases, and if the background levels were exceeded, the air levels of the contaminant were evaluated further.

Outdoor Air

<u>Screening of Outdoor Air Chemical Contaminants</u>

The EPA took canal and street level air samples at several locations along the length of the canal. The data are summarized in Appendix L (Human Health Risk Assessment (HHRA)) of the Gowanus Canal Remedial Investigation Report (EPA, 2011a). The EPA compared the sampling results to EPA residential air regional screening levels (RSLs) for cancer and noncancer effects (EPA, 2011d). The noncancer RSLs were adjusted 10-fold lower to account for exposure to multiple chemicals. The air levels for five

VOCs (benzene, chloroform, ethyl benzene, methylene chloride and total xylenes) and naphthalene exceeded the EPA RSLs. The EPA also compared the levels of these chemicals to their corresponding mean outdoor air levels from the Health Effects Institute study on the Relationships of Indoor, Outdoor, and Personal Air (RIOPA; Weisel et al., 2005) as part of the process of selecting their constituents of potential concern. The RIOPA study includes outdoor air levels of VOCs from 100 locations in each of three US cities (Los Angeles, CA, Houston, TX and Elizabeth, NJ).

To evaluate the air sampling data, we compared the levels of the chemicals that exceeded the EPA RSLs to the entire range of results from the RIOPA studies rather than only the mean. Using the entire range of percentiles from the RIOPA study for comparison provides a reasonable basis for determining if the levels of air contaminants measured near the canal are within or above the range of values we would typically expect to find in an urban environment. As can be seen in Table B, below, the levels of benzene, chloroform, ethyl benzene and methylene chloride detected in air at the canal or street level are within the range of values for outdoor air from the RIOPA study. Therefore, we did not evaluate canal or street air levels for these chemicals further.

Table B: Comparison of Outdoor Air Contaminant Concentrations near the Gowanus Canal to Mean and Percentile Values from the RIOPA Study.

All values in micrograms per cubic meter (mcg/m^3)

Chemical	Range of Detected Values[2]	Health Effects Institute RIOPA Study[1]					
		Mean	Percentiles				
			1st	5th	50th [3]	95th	99th
benzene	0.61 - 3.8	2.15	0.41	0.48	1.68	5.16	11.1
chloroform	0.16 - 0.45	0.32	0.08	0.09	0.17	0.76	2.35
ethyl benzene	0.41 - 5.1	1.29	0.15	0.3	0.93	3.04	7.05
methylene chloride	1.7 – 5.1	0.95	0.04	0.07	0.84	2.46	9.32
xylenes (total)[4]	1.8 - 28	---	---	---	---	---	---
naphthalene[4]	0.1 - 4.4	---	---	---	---	---	---

[1]Weisel et al., 2005.
[2]Range of values from EPA (2011a) at canal or street level.
[3]Median value.
[4]The RIOPA study does not contain a mean value or percentiles for total xylenes, and did not measure naphthalene.

The RIOPA study did not measure naphthalene and does not contain a mean value or percentiles for total xylenes. Accordingly, we compared the levels of naphthalene near the canal to outdoor air levels measured in the EPA Building Assessment and Survey Evaluation (as summarized in DOH, 2006), which included measurements of outdoor air at 100 randomly selected public and commercial office buildings across the United States, sampled for a one-week period in either winter or summer. The range of naphthalene concentrations in air samples near the canal (0.1 to 4.4 mcg/m^3) is within the range of percentiles reported for the Building Assessment and Survey Evaluation (Table C), and, therefore, we did not evaluate canal or street air levels of naphthalene further. Like the RIOPA study, the EPA assessment does not contain a mean value or percentiles for total xylenes. Therefore, we further evaluated the levels of total xylenes in the Public Health Implications Section.

Table C: Comparison of Naphthalene Outdoor Air Concentrations Near the Gowanus Canal to Mean Percentile Values from the EPA Building Assessment and Survey Evaluation.

All values in micrograms per cubic meter (mcg/m[3])

Chemical	Range of Detected Values[2]	EPA Building Assessment and Survey Evaluation[1]						
		Mean	Percentiles					
			25th	50th [3]	75th	90th	95th	99th
naphthalene	0.1 - 4.4	10.6	< 2.0	< 2.4	< 4.8	4.9	15.1	379.8

[1]Summarized in DOH, 2006.
[2]Range of values from EPA (2011a) at canal or street level.
[3]Median value, naphthalene was not detected in 254 of 296 samples.

Surface Water

Screening of Surface Water Chemical Contaminants: EPA 2011 Data

To screen surface water contaminants, we compared the highest levels of contaminants detected in surface water of the canal in dry and wet weather conditions (Tables H-2.2 and H-2.3 of EPA, 2011a) to New York State public drinking water standards (maximum contaminant levels (MCLs)) found in Part 5 (Subpart 5-1) of the New York State Sanitary Code (DOH, 2013b). Public drinking water standards are derived to protect the public against adverse health effects from drinking water containing contaminants, assuming people drink two liters of water per day on a long term basis. Since water from the canal is not used for drinking, use of the MCLs as screening values is a conservative approach to selecting contaminants for further evaluation. We selected contaminants having surface water levels that exceeded the MCL (Table D, below) for further evaluation. Contaminants without a drinking water standard were selected for further evaluation if they were included in the EPA's list of contaminants of concern for surface water in the HHRA (Appendix L) of the Gowanus Canal Remedial Investigation Report (EPA, 2011a).

Table D. Gowanus Canal Surface Water Contaminants Selected for Further Evaluation (EPA, 2011 Data).

Contaminant	Maximum Detection for Dry Conditions (mcg/L)[1]	Maximum Detection for Wet Conditions (mcg/L)[2]	NYS Drinking Water Standard (mcg/L)
benzene	11	2.9	5
o-xylene	0.53	5.1	5
tetrachloroethene	ND	40	5
toluene	0.95	16	5
benzo(a)pyrene	0.66	0.3	0.2
arsenic	23.4	26.2	10
chromium	99.7	29.3	100
cobalt	ND	3.9	--[3]
iron	ND	1040	300
lead	4.9	26.8	15[4]
selenium	50.9	64.6	50
thallium	2.1	ND	2

[1]From Table H-2.2 of Appendix L (Human Health Risk Assessment) of EPA, 2011a.
[2]From Table H-2.3 of Appendix L (Human Health Risk Assessment) of EPA, 2011a.
[3]No MCL available. Included as a chemical of concern in EPA, 2011a.
[4]EPA Action Level.
mcg/L = micrograms per liter; ND = not detected.

Since benzo(a)pyrene was one of the contaminants selected for further evaluation in surface water, we added six additional carcinogenic PAHs (benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene and indeno(1,2,3-c,d)pyrene) to the list of contaminants for further evaluation. The rationale for including these chemicals is that they are typically found with benzo(a)pyrene in the environment, they cause similar types of toxicity as does benzo(a)pyrene, and carcinogenic PAHs are typically evaluated together in generally accepted risk assessment practice.

Screening of Surface Water Chemical Contaminants: GEI 2007 Data

The GEI investigation (GEI Consultants Inc., 2007) collected surface water samples in three sections of the canal (i.e., the Lower, Middle and Upper Reach). As with the 2011 EPA data, we compared the levels of contaminants detected in the surface water to New York State public drinking water standards (maximum contaminant levels (MCLs)) found in Part 5 (Subpart 5-1) of the New York State Sanitary Code (DOH, 2013b). Appendix B, Table 1 shows the number of samples that exceeded the MCL for each chemical in each section. In both the Lower and Upper Reach, exceedances of drinking water standards were infrequent, and in the Lower Reach, the vast majority of chemicals were not detected in any of the samples. Elevated levels of contaminants, primarily PAHs, were found most often in the Middle Reach area of the canal. A single sample from the Middle Reach of the canal contained the highest levels of the PAHs benz(a)anthracene, benzo(k)fluoranthene, benzo(b)fluoranthene and chrysene, which ranged from 50 to 130 mcg/L. This sample also contained elevated levels of benzo(a)pyrene. The highest level of benzo(a)pyrene in surface water (85 mcg/L) was also found in the Middle Reach of the canal. All of these levels exceeded or equaled the MCLs for these PAHs (see Appendix B, Table 1). The samples were taken in an area of the Middle Reach where the investigators observed tar-saturated sediments, creosote-treated bulkheads, heavy petroleum sheens and surface water turbidity. Since tar is known to be a source of PAHs, these tar-like materials may have contributed to the levels of PAHs found in the canal. Since the elevated PAH levels were confined to a small number of the 145 samples collected and were found almost exclusively in the Middle Reach, the PAH contamination may be limited to specific areas of the canal that are affected by tar.

We selected contaminants having surface water levels that exceeded the New York State MCL (Table E, below) for further evaluation. Several of the same surface water contaminants were detected in both the EPA 2011 and GEI 2007 investigations.

Table E. Gowanus Canal Surface Water Contaminants Selected for Further Evaluation (GEI, 2007 Data).

Contaminant	Maximum Detection in Surface Water (mcg/L)[1]	NYS Drinking Water Standard (mcg/L)
benzene	6.1	5
bromoform	98	5
ethyl benzene	12	5
methyl-*tert*-butyl ether	26	10
toluene	31	5
xylenes (total)	20	5
acenaphthene	56	50
acenapthylene	94	50
anthracene	110	50
benz(a)anthracene	110	50
benzo(a)pyrene	85	0.2
benzo(b)fluoranthene	50	50
benzo(k)fluoranthene	54	50
bis(2-ethylhexyl)phthalate	8	6
chrysene	130	50
fluoranthene	220	50
fluorene	52	50
phenanthrene	450	50
pyrene	320	50
iron	4870	300
nitrate/nitrite (total nitrogen)	16,000	10,000
thallium	57	2
sulfate	2,280,000	250,000

[1]From GEI Consultants Inc., 2007.
mcg/L = micrograms per liter.

Comparison of Surface Water Chemical Contaminants Selected for Further Evaluation to Health-Based Comparison Values

We further evaluated chemicals that exceeded New York State drinking water standards in either the GEI 2007 or the EPA 2011 investigation using health-based cancer and noncancer comparison values (Appendix B, Table 2). The health-based comparison values are contaminant concentrations in surface water that pose very low or minimal health risks to adults or children who may be exposed to water contaminants by incidental ingestion or dermal contact while swimming in the canal one hour per day, two days per week, three months per year. The cancer comparison values also assume 30 years of exposure (see Appendix B, Table 2 for specific exposure assumptions). Of the 29 chemicals that were detected in the Gowanus Canal above New York State drinking water standards, benzo(a)pyrene, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene and chromium exceeded the health-based comparison values (Appendix B, Table 2). We characterized the cancer and noncancer health risk for these chemicals (see Public Health Implications Section).

Surface Sediment

Screening of Surface Sediment Chemical Contaminants

In Table 2-4 of the Gowanus Canal Remedial Investigation Report (EPA, 2011b), the EPA identified several areas of the canal where surface sediments are exposed at low tide. EPA took a total of 14 surface sediment samples in exposed areas under dry conditions, and an additional 13 samples to represent sediments under wet (overflow) conditions. We compared the highest levels of surface sediment contaminants during dry and wet (overflow) conditions (Tables H-2.1 and H-2.12 of EPA, 2011a) to the corresponding New York State restricted residential soil cleanup objectives (SCOs; DEC/DOH, 2006). SCOs are soil concentrations that are contaminant-specific remedial goals based on current, intended or reasonably anticipated future land use. The restricted residential SCOs are based on the assumption that people living at a property are exposed through ingestion of contaminated soil, indoor dust and inhalation of soil particles in air. The SCOs are set at a soil concentration at which cancer and noncancer health effects are unlikely to occur (i.e., a cancer risk level of one in one million for carcinogens, or at a hazard quotient of one for noncancer effects). If a risk-based SCO is calculated to be lower than the contaminant's rural soil background concentration (i.e., typical levels of the contaminant in soil), the SCO is set at the rural soil background concentration. Using the restricted residential SCOs as screening values for contaminants in nonresidential surface sediments (such as those in the canal) is a conservative approach to selecting contaminants for further evaluation. We selected surface sediment contaminants for further evaluation if the detected levels in canal sediment exceeded their New York State restricted residential SCO (Table F, below). If the contaminant had no restricted residential SCO, we selected it for further evaluation if the contaminant was included in the EPA's list of contaminants of concern for surface sediments in the HHRA (Appendix L, Gowanus Canal Remedial Investigation Report (EPA, 2011a)).

Table F. Gowanus Canal Surface Sediment Contaminants Selected for Further Evaluation.

Contaminant	Maximum Detection for Dry Conditions (mg/kg_s)[1]	Maximum Detection for Wet Conditions (mg/kg_s)[2]	NYS Restricted Residential SCO (mg/kg_s)
acenaphthene	460	580	100
acenaphthylene	150	150	100
anthracene	350	610	100
benz(a)anthracene	320	490	1
benzo(a)pyrene	200	200	1
benzo(b)fluoranthene	210	210	1
benzo(k)fluoranthene	120	12	3.9
bis(2-ethylhexyl) phthalate	57	57	--[3]
chrysene	320	490	3.9
dibenz(a,h)anthracene	15	14	0.33
fluoranthene	630	630	100
fluorene	130	540	100
indeno(1,2,3-cd)pyrene	120	120	0.5
2-methyl naphthalene	15	870	--[3]
naphthalene	9.1	1600	100
phenanthrene	470	1100	100
pyrene	670	670	100
Aroclor 1248	2.2	2.2	--[3]
Aroclor 1254	0.59	0.59	--[3]
Aroclor 1260	3.4	3.4	--[3]
Total PCBs	15.1	15.1	1
aluminum	18,900	18,900	--[3]
arsenic	44.7	44.7	16
barium	397	631	400
cadmium	20.2	20.2	4.3
chromium	139	139	110
cobalt	14.8	14.8	--[3]
copper	790	790	270
iron	12,400	87,000	--[3]
lead	4220	4220	400
mercury	1.8	2.3	0.81
vanadium	61.2	61.2	--[3]

[1]From Table H-2.1 of Appendix L (Human Health Risk Assessment) of EPA, 2011a.
[2]From Table H-2.12 of Appendix L (Human Health Risk Assessment) of EPA, 2011a.
[3]No SCO available. Included as a chemical of concern in EPA, 2011a.
mg/kg_s = milligrams per kilogram of soil; SCO = soil cleanup objective.

Comparison of Surface Sediment Chemical Contaminants Selected for Further Evaluation to Health-Based Comparison Values

We further evaluated chemicals that exceeded New York State restricted residential SCOs using health-based cancer and noncancer comparison values for sediment (Appendix B, Table 3). Analogous to those previously discussed for surface water, the health-based comparison values are contaminant concentrations in sediment that pose very low or minimal health risks to adults or children. They assume a person is exposed to contaminants in sediments by incidental ingestion and dermal absorption two days per week, three months per year. The cancer comparison values also assume 30 years of exposure (see Appendix B, Table 3 for specific exposure assumptions). Of the 32 chemicals that were detected in the Gowanus Canal at levels above the New York State restricted residential SCOs or (in the absence of an SCO) chosen for further evaluation in sediments by the EPA, the highest sediment contaminant levels for benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, Aroclor 1260, total PCBs, arsenic and chromium exceeded their cancer comparison values. The highest sediment levels for phenanthrene and total PCBs exceeded their noncancer comparison values. Health risks are characterized for the contaminants whose levels in surface sediment exceeded their comparison values (see Public Health Implications section).

Fish

DOH reviewed data on contaminants in fish and crabs collected in 2010 from the Gowanus Canal and adjacent waters of the Upper Bay of New York Harbor (the PCB data are summarized in Table G). Based on this review, DOH staff concluded:

- PCBs are the predominant contaminant of concern in Gowanus Canal fish and crabs;
- due to the limited number of species and samples analyzed, the available data are inadequate to establish whether fish and crabs caught in the Gowanus Canal have higher PCB levels than those caught in adjacent waters of the Upper Bay of New York Harbor;
- the relative differences in PCB levels between fish and crabs from the Gowanus Canal and Upper Bay of New York Harbor reference locations are small, so that the differences may not be meaningful for risk assessment/fish advisory purposes; and,
- the current DOH advisories for the Gowanus Canal are still appropriate.

Table G. Total PCBs in Fish and Crabs from the Gowanus Canal and from the Upper Bay of New York Harbor Reference Locations.
PCB values are in micrograms per kilogram (mcg/kg).

Species	Gowanus Canal		Reference Locations (Upper Bay of New York Harbor)	
	Number of Fish/Analyses*	Average Total PCBs (range)	Number of Fish/Analyses*	Average Total PCBs (range)
Blue crab muscle tissue	12/6	0.12 (0.073-0.17)	8/3	0.084 (0.059-0.13)
Blue crab hepatopancreas	2/2	0.15 (0.076-0.22)	1/1	0.11
American eel	6/6	0.86 (0.52-1.4)	1/1	0.48
Striped bass	5/3	0.35 (0.26-0.43)	None collected	
White perch	2/2	0.39 (0.32-0.46)	None collected	
Scup	None collected		3/3	0.043 (0.041-0.046)
Weakfish	None collected		1/1	0.11

* More than one fish may be combined into one analysis.

Biological Contamination of Surface Water

Background Information for Biological Sampling of Surface Water

The maximum single sample concentration of fecal coliform bacteria that is permitted in approved recreational bathing waters is 1000 colonies/100 milliliters (New York State Sanitary Code, 2012). Sample results in excess of 1000 colonies/100 milliliters are suggestive that pathogens are present at a concentration that will result in an increased risk of gastrointestinal illnesses through participating in swimming activities. Water pollution caused by fecal contamination is a serious public health concern due to the risk of contracting diseases through swallowing, inhaling or skin contact with disease-causing agents such as bacteria, viruses and protozoa. Collectively, these agents are known as pathogens. Frequently, concentrations of pathogens from fecal contamination are small, and the number of different possible pathogens is large. As a result, it is not practical to routinely test for pathogens in water samples. Instead, the presence of pathogens is determined through indirect evidence by testing for an "indicator" organism such as fecal coliform bacteria. Fecal coliform bacteria likely come from the same sources as pathogenic organisms. Fecal coliform bacteria are relatively easy to identify, are usually present in larger numbers than pathogens, and respond to the environment and wastewater treatment similarly to many pathogens. As a result, testing for fecal coliform bacteria can be a reasonable indication of whether water is contaminated with fecal pollution and whether pathogens are likely to be present.

Biological Sampling Results

The samples taken in the 2007 GEI investigation (GEI Consultants, Inc., 2007) were also analyzed for biological contaminants. The results for each section of the canal are as follows.

- Of 30 Lower Reach samples, 19 contained fecal coliforms and none exceeded the standard for bathing beaches.
- Of 85 Middle Reach samples, 72 contained fecal coliforms and 10 exceeded the standard for bathing beaches.
- Of 30 Upper Reach samples, 20 contained fecal coliforms and three exceeded the standard for bathing beaches.

The fecal coliform monitoring data show that bacteriological standards for bathing beaches in New York State (1000 colonies/100 milliliters, single sample) were exceeded in samples from the Middle and Upper Reaches of the Gowanus Canal. Better interpretation of the monitoring results to assess the risk of illness through recreational contact would include an assessment of potential pollution sources and other environmental conditions at the time of sample collection that may affect the numbers of fecal coliform bacteria (DOH, 2012).

B. Pathways Analysis

Exposure pathways for the Gowanus Canal are presented in Table H.

One of the ways that people may be using the Gowanus Canal for recreation is swimming, however, we do not have clear evidence that people are actually swimming in the canal. Nevertheless, we evaluate this potential exposure further in the health assessment.

Breathing outdoor air is another potential exposure pathway to site-related contamination, if the air quality above and near the canal is affected by site-related contaminants. People living, working or recreating near or on the canal could be breathing these contaminants.

DOH and ATSDR identified two ways that people are actually using the canal for recreation - boating and fishing (including crabbing). Exposures to contaminants present in the surface water can occur through incidental ingestion or dermal absorption during these recreational activities. Although the exact number of people participating in recreation in the canal is not known, increased access to the canal in the future may increase the number of people using it. We have limited information about how many people fish in the canal and eat fish and crabs taken from the canal. The DOH has a health advisory for limiting the consumption of fish and crabs taken from the canal (DOH, 2013a).

People may come into contact with contaminated sediments and dermally absorb contaminants while entering/launching or exiting/beaching small water craft in areas of the canal. People will not be contacting sediments that are deep under water and, therefore, sediments in these locations are not evaluated further.

Table H Exposure Pathways Summary Table for the Gowanus Canal Site.

Activity	Exposure Pathway Elements				Pathway Classification
	Environmental Medium	Route of Exposure	Location	Exposed Population	
Full Body Immersion Recreation (swimming, scuba diving)	Surface water and sediments	Ingestion and Skin Contact	In the Canal	Adults and Children	Potential
Breathing	Outdoor Air	Inhalation	On and Near the Canal	Adults and Children	Potential
Entering and Leaving the Canal	Sediments	Ingestion and Skin Contact	On the Banks of the Canal	Adults and Children	Potential
Boating	Surface water and sediments	Ingestion and Skin Contact	In the Canal	Adults and Children	Completed
Eating Fish and Crabs	Fish and Crabs	Ingestion	Fish and Crabs taken from Canal	Adults and Children who eat fish and crabs from canal	Completed

C. Public Health Implications

Recreational use of the Gowanus Canal for activities such as swimming, boating and fishing can result in exposure to canal-related chemical contaminants in outdoor air, surface water and surface sediments. An evaluation and characterization of the health risks for exposure to outdoor air contaminants, surface water contaminants by incidental ingestion and dermal absorption during recreational swimming, and surface sediment contaminants by incidental ingestion and dermal absorption are presented below.

<u>Outdoor Air</u>

The air levels for five VOCs (benzene, chloroform, ethyl benzene, methylene chloride and total xylenes) and naphthalene exceeded EPA RSLs. The levels of benzene, chloroform, ethyl benzene and methylene chloride detected in air at the canal or street level are within the range of values for outdoor air from EPA's RIOPA study. The range of naphthalene concentrations in air samples near the canal are within the range of data reported for the EPA's Building Assessment and Survey Evaluation. Therefore, the health risks from long-term exposure to these chemicals in air near the canal (at street or canal level) are expected to be similar to those associated with their concentrations in typical urban air. The air levels of total xylenes at the canal or street level (1.8 to 28 mcg/m^3) are below the EPA reference concentration for total xylenes (100 mcg/m^3; EPA, 2013a). A reference concentration is a concentration of a contaminant in air that is without appreciable risk for adverse noncancer health effects assuming a lifetime of exposure. Therefore, long-term exposure to the air levels of total xylenes measured at the canal or street level poses a minimal risk for adverse health effects.

<u>Surface Water</u>

We characterized the health risks for PAHs (benzo(a)pyrene, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene and indeno(1,2,3-c,d)pyrene) and chromium, for which the highest level detected in surface water during the GEI 2007 or EPA 2011 investigations (GEI Consultants Inc., 2007; EPA, 2011a) exceed their cancer comparison values for surface water (see Appendix B, Table 2). No noncancer comparison values for surface water were exceeded, therefore we do not expect adverse noncancer health effects.

Health Effects of PAHs and Chromium

PAHs are a group of over 100 chemicals that are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances, such as tobacco and charbroiled meat (ATSDR, 1995). They can also be found in substances, some natural, such as crude oil, coal, coal tar pitch, creosote and tar used for roofing. There are potentially a large number of PAHs, but attention has been focused on only some of the PAHs. Of particular concern as environmental contaminants are seven PAHs (benzo(a)pyrene, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene) that are known to be carcinogenic in animals. Occupational exposure to complex mixtures containing PAHs (e.g., during coal gasification, coke production, coal-tar distillation, paving and roofing, aluminum production, and chimney sweeping) increases the risk of cancer in humans. Benzo(a)pyrene is considered a probable human carcinogen by the EPA (EPA, 2013b) and a human carcinogen by other agencies (WHO, 2012).

Chromium is a common element in rocks, soil, water, plants, and animals. It gets into surface or groundwater after dissolving from rocks and soil. Chromium is used to manufacture steel, to electroplate metal, and in the textile, tanning and leather industries. Chromium is found in the environment in two principal forms: chromium (III) and chromium (VI). Chromium (III) compounds are the most common chromium compounds in the environment. Chromium (VI) compounds are less common in the environment and are typically associated with an industrial source. Depending on the conditions, each form of chromium can be converted into the other form in the environment.

Chromium (VI) is the more toxic form of chromium. There is strong evidence from human studies in many countries that occupational exposures to chromium (VI) in air can cause lung cancer (ATSDR, 2012). There is weaker evidence from studies in China that long-term exposure to chromium (VI) in drinking water can cause stomach cancer. Chromium (VI) causes cancer in laboratory animals exposed almost daily to high levels in air (lung cancer) or drinking water (mouth and intestinal cancers) over their lifetimes (NTP, 2008). Adverse noncancer gastrointestinal tract effects (oral ulcers, stomach or abdominal pain, diarrhea) also are associated with long-term human exposures to oral doses of chromium (VI). In laboratory animals, repeated exposures to high oral doses of chromium (VI) has caused blood, liver, and kidney damage in adult animals, and can adversely affect the developing fetus and the male and female reproductive organs (ATSDR, 2008).

Risk Characterization for Surface Water Contaminants

Our estimates of the increased estimated risk of getting cancer (above the background rate for cancer) from swimming in the canal assume that an adult is exposed by ingesting surface water and absorbing surface water contaminants through the skin one hour per day, two days per week, three months per year for 30 years. These exposure estimates are combined with the chemical's cancer potency factor to calculate the estimated increased cancer risk. A cancer potency factor is a numerical estimate that expresses the strength (potency) of the chemical to cause cancer. Eleven of the over 200 surface water samples taken in the 2007 GEI and 2011 EPA investigations had levels of benzo(a)pyrene significantly higher than all the other samples. These were taken in the Middle Reach of the canal in areas where the investigators observed tar-saturated sediments, creosote-treated bulkheads, heavy petroleum sheens and surface water turbidity. The two highest levels of benzo(a)pyrene in surface water (28 and 85 mcg/L) could pose an increased risk for getting cancer of over one in one thousand[1], assuming repeated and long-term exposure while swimming at the locations where the highest levels were detected. We consider this increased risk to be high. Nine samples had benzo(a)pyrene detections between 4 and 18 mcg/L, which could pose a moderate increased risk for getting cancer (i.e., the increased estimated risk is between one in ten thousand and one in one thousand). The levels of benz(a)anthracene and benzo(b)fluoranthene in a single sample (110 mcg/L and 50 mcg/L, respectively) also could pose a moderate increased risk for getting cancer. These samples also may be limited to specific areas of the Middle Reach of the canal, where there are sources of PAHs (e.g., tar, creosote bulkheads and petroleum sheen). People are not likely to swim only at these locations. In addition, the actual risks posed by the presence of these contaminants in surface water may be lower than those estimated here due to the conservative nature of our evaluation.

[1] Sample calculation: Cancer risk for benzo(a)pyrene in surface water = [85 mcg/L/0.02 mcg/L] x 0.000001 = 4.3 in 1000 (high). See Appendix B, Table 2 for specific exposure parameters, used in the calculation of comparison values.

The estimated increased risk for getting cancer from repeated and long-term exposure while swimming to the highest detected levels of chrysene, benzo(k)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene and chromium in the canal surface water is estimated to be low (i.e., the increased estimated cancer risk is between one in one million and one in ten thousand). The increased cancer risk for exposure to the levels of carcinogenic PAHs detected in samples from other areas of the canal is either low or very low.

Our noncancer risk estimates assume that a 6 to 10 year-old child is exposed (via oral and dermal routes of exposure) to surface water from swimming in the canal one hour per day, two days per week for three months per year. The noncancer health risks from exposure to the highest detected levels of the seven PAHs (i.e., benzo(a)pyrene, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene and chrysene) detected above health-based comparison values and chromium in surface water are estimated to be minimal.

People use the Gowanus Canal for recreational activities other than swimming, such as boating and fishing, which also could result in exposure to surface water contaminants by incidental ingestion and dermal contact. The level of exposure and associated health risks for these activities, except for eating caught fish and crabs, would be lower than those associated with swimming.

<u>Sediments</u>

DOH further evaluated contaminants having levels that exceeded the New York State restricted residential SCOs in surface sediments, using risk-based comparison values. Analogous to those previously discussed for surface water, the comparison values are derived for cancer and noncancer health effects. They represent surface sediment concentrations at which health effects are unlikely, assuming a person is exposed via incidental ingestion and skin contact with sediments during activities in the exposed sediment areas two days per week, three months per year. The cancer comparison values also assume 30 years of exposure. As shown in Appendix B, Table 3, the highest sediment contaminant levels for benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, Aroclor 1260, total PCBs, arsenic and chromium exceed their cancer comparison values, and the highest sediment levels for phenanthrene and total PCBs exceed their noncancer comparison values. Health risks are estimated for the contaminants having levels in surface sediment that exceed comparison values.

Health Effects of Contaminants Exceeding Sediment Comparison Values

The health effects of PAHs and chromium have been discussed previously. PCBs are a large group of related man-made chemicals that were used in many commercial and electrical products until their manufacture was banned in the mid-1970s. Most PCBs in the United States were mixtures of PCBs sold under the trade name Aroclor. The most commonly observed health effects in people exposed to large amounts of PCBs are skin conditions such as acne and rashes (ATSDR, 2000). Studies in exposed workers have shown changes in blood and urine that may indicate liver damage. PCB exposures in the general population are not likely to result in skin and liver effects. Women who were exposed to relatively high levels of PCBs in the workplace or ate large amounts of fish contaminated with PCBs had babies that weighed slightly less than babies from women who did not have these exposures. Babies born to women who ate PCB-contaminated fish also showed abnormal responses in tests of infant behavior. Some of these behaviors, such as problems with motor skills and a decrease in short-term memory, lasted for several years. Other studies suggest that the immune system was affected in children born to and nursed by mothers exposed to increased levels of PCBs. A study of older adults (49 to 86 years old) who ate fish containing PCBs (and other contaminants) suggests that PCB exposure is associated with lower scores on several measures of memory and learning. A study of environmental exposures suggested that PCBs may be associated with some measures of memory and learning and depression among adults 55-74 years of age whose current body burdens are similar to those of the general population. Although some of the studies controlled for the possible effects of other chemical contaminants, the role of these chemicals in causing the observed effects is not fully understood.

Animals that ate food containing large amounts of PCBs for short periods of time had mild liver damage and some died. Animals that ate smaller amounts of PCBs in food over several weeks or months developed various kinds of health effects, including anemia; acne-like skin conditions; and liver, stomach, and thyroid gland injuries. Other effects of PCBs in animals include changes in the immune system, behavioral alterations, and impaired reproduction. PCBs are not known to cause birth defects.

Few studies of workers indicate that PCBs were associated with certain kinds of cancer in humans, such as cancer of the liver and biliary tract. Rats that ate food containing high levels of PCBs for two years developed liver cancer. The National Toxicology Program of the US Department of Health and Human Services has concluded that PCBs may reasonably be anticipated to be human carcinogens (NTP, 2011).

Arsenic is found in ores of copper, lead and other minerals, and in soil, groundwater and surface water. Arsenic compounds are used in wood preservatives and have been used in commercial pesticides. The EPA classifies arsenic as a human carcinogen based on evidence that long-term human exposure to high levels of arsenic in drinking water increases the risk of lung, skin and bladder cancer (EPA, 2013c; 2001). Some people exposed to high levels of arsenic in drinking water for long periods of time also developed a characteristic darkening and thickening of the skin on the hands and feet. Long-term exposure to high levels of arsenic is also associated with nerve and liver damage, high blood pressure, damage to the vascular system (i.e., blood vessels of the heart and brain), and may lead to learning deficiencies (ATSDR, 2007).

Risk Characterization of Sediment Contaminants

Our estimates of increased estimated cancer risks assume that a person is exposed (via oral and dermal routes of exposure) to surface sediments two days per week, three months per year from ages 3 to 33 years. Noncancer risks are evaluated assuming a child is exposed by the oral and dermal routes to surface sediments two days per week for three months per year. Repeated and long-term exposure to the highest level of benzo(a)pyrene detected in surface sediments (200 mg/kg_s) is estimated to pose a moderate estimated increased risk for getting cancer, which means the estimated increased risk is between one in ten thousand and one in one thousand.[2] However, this estimate is based on the level of benzo(a)pyrene detected at a single location, and repeated, long-term exposure to sediment at this one location is unlikely. Exposure to the highest surface sediment levels of benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, Aroclor 1260, total PCBs, arsenic and chromium is estimated to pose a low increased risk for getting cancer, which means the estimated increased risk is between one in one million and one in ten thousand. The noncancer risk for exposure to phenanthrene and total PCBs in surface sediments is estimated to be low.[3] The noncancer risk for exposure to the remaining contaminants is minimal.

Lead in Surface Water and Sediments

Lead was detected in surface water samples (highest level of 26.8 mcg/L) from the Gowanus Canal at levels above its NYS action level for drinking water (15 mcg/L), as well as in surface sediment (highest level of 4200 mg/kg) above its restricted residential SCO (400 mg/kg). The presence of lead in surface water and sediment of the canal could result in increased lead exposure through incidental ingestion of surface water during swimming or recreational activities and through incidental ingestion of sediments. Based on the levels and likely nature of expected exposures, the sediment levels would be the primary contributor to potential increases in blood lead levels, which, when added to background lead exposures could be significant in light of the recent downward revision of the Centers for Disease Control and Prevention's blood lead reference value to the 97.5th percentile of the National Health and Nutrition Examination Survey (NHANES) generated blood lead level distribution in children 1-5 years old (currently 5 micrograms per deciliter of blood) to identify children with elevated blood lead levels (CDC, 2012). Whether or not the exposures would actually increase blood lead levels depends primarily on the actual sediment lead levels in the location they are contacted, the frequency and duration of exposure, and how much sediment the child ingests.

Biological/Pathogens from GEI data

Research suggests a direct relationship between the extent of exposure to contaminated water, the area of the body in contact with contaminated water and the

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[2] Sample calculation: Cancer risk for benzo(a)pyrene in surface sediments = [200 mg/kg_s/0.63 mg/kg_s] x 0.000001 = 3.2 in 10,000 (moderate). See Appendix B, Table 3 for specific exposure parameters used in the calculation of comparison values.

[3] Sample calculation: Noncancer hazard quotient for phenanthrene in surface sediments = [1100 mg/kg_s/960 mg/kg_s = 1.4 (low). See Appendix B, Table 3 for specific exposure parameters used in the calculation of comparison values.

risk of subsequent illness (WHO, 2003). Sample results in excess of 1000 colonies/100 milliliters suggest that pathogens are present at a concentration that will result in an increased risk of gastrointestinal illnesses through participating in swimming activities. This increase in risk in illness is based on an assumption that swimming includes submerging the face and head under the surface of the water. Pathogens that cause gastrointestinal illness are transmitted through the eating or drinking material contaminated with feces. Submersing the head during swimming can result in ingestion of contaminated water. Dufour et al. (2006) reported that the average amount of water swallowed by non-adults (6 to 18 years old) and adults during a 45 minute swimming session is 37 milliliters and 16 milliliters, respectively (Dufour et al., 2006). Ingestion volumes may be even higher for toddler age children (Dufour et al., 2006). While the average volume of water consumed by swimming may appear of little significance, several pathogens known to be found in sewage contaminated waters, such as *E.coli* O157:57, S*higella* spp., Hepatitis A, *Giardia* and *Cryptosporidium* have relatively low infective doses, which means that swallowing a very few number of these pathogens can result in illness. Submerging the head while swimming also increases the likelihood of infection through various organs, such as the eyes, ears, and nose.

Published reports also identify an increased risk of illness from water activities such as boating and fishing during exceedances of indicator bacteria standards. Because the head is not usually submerged during these activities, the presumed volume of incidental water consumption is lower than swimming. Subsequently, the risk of illness can also be assumed to be lower. Experimental data have demonstrated a positive correlation between the volumes of water contacted during recreational activities and a risk of gastrointestinal illness. For example, canoeing had a higher risk of illness than fishing or boating, respectively, reflecting estimated water ingestion rates for these activities (Rijal, 2009). Increased duration and frequency of water contact recreational activities also increases the risk of illness.

Water samples collected from the Gowanus Canal indicate that levels of fecal coliform bacteria exceeded standards on occasion. An increased risk of illness is likely from recreational contact with the water during these periods. The risk of illness would be increased in the presence of undertreated sewage or overflow events, but the extent of the increased risk would be dependent on the extent of effluent treatment, the volume of pathogens released, the extent of precipitation as well as other factors. Environmental factors such as sunlight, tides, currents and wind can also affect the fate and transport of pathogens in waters and require extensive site specific assessment, sampling and modeling to quantify indicator and pathogen concentrations and the risk of illness during varied conditions. A site specific assessment of this magnitude has not been performed for the Gowanus Canal.

D. Child Health Initiative

ATSDR and DOH consider children when evaluating exposure pathways and potential health effects for environmental contaminants. Children are of special concern because their behavior patterns, play activities, and physiology can result in more exposure than adults. Children sometimes differ from adults in their sensitivity to the effects of chemicals, but this depends on the chemical, and whether or not there is a difference can also change as the child gets older.

We considered the possibility that children may be more sensitive to the health effects of PAHs when we evaluated the sampling results for the Gowanus Canal. Benzo(a)pyrene, the primary PAH contaminant found at elevated levels in surface water and sediment samples, is identified by the EPA as a chemical that causes cancer by causing permanent changes in DNA (EPA, 2005; 2006). Such chemicals are considered to pose a higher risk for cancer if exposure occurs early in life compared to the risk from exposure during adulthood (EPA, 2005). Therefore, children may be more sensitive than adults to the carcinogenic effects of benzo(a)pyrene. We considered this possibility when evaluating the cancer risks to children who may come into contact with sediment in areas of the canal having the highest levels of benzo(a)pyrene. In addition, we evaluated exposure for a person from age 3 to 33 years to include the child portion of life during which relatively more sediment relative to body weight is ingested compared to adults. The potential increased cancer risk to children posed by benzo(a)pyrene would not change the conclusions and recommendations of this public health assessment.

For biological contamination of surface water, hand-to-mouth contact during and after participating in water recreation will increase risk of illness. As a result, children can be at higher risk of gastrointestinal illness, even without submerging their heads. Increased duration and frequency of water contact recreational activities will also increase the risk of illness. Dufour et al. (2006) reported that the average amount of water swallowed by non-adults (6 to 18 years old) and adults during a 45 minute swimming session is 37 milliliters and 16 milliliters, respectively (Dufour et al., 2006). Ingestion volumes may be even higher for toddler age children (Dufour et al., 2006).

E. Chemical Interactions

Most hazardous waste sites contain multiple chemical contaminants. Therefore, the possibility for interactions among the chemicals detected in the Gowanus Canal was considered when evaluating the potential health risks. The three types of interactions that can take place among chemicals are additivity, synergy and antagonism. Additivity means that the combined effect of the chemicals of a mixture acting together is equal to the sum of the effects of the chemicals acting alone. Synergy takes place when the combined effect of the chemicals acting together is greater than the sum of the effects of the chemicals acting alone. Antagonism takes place when the combined effect of the chemicals acting together is less than the sum of the effects of the chemicals acting alone.

Human exposure to benzo(a)pyrene is invariably associated with exposure to mixtures of other PAHs. In general, additive interactions between chemicals are most likely to occur when the chemicals cause the same effect on the same body organ in the same manner (ATSDR, 2004; EPA, 2000b). The carcinogenic PAHs (the primary chemical contaminants detected at elevated levels in samples from the Gowanus Canal) cause adverse health effects by a common mode of action (EPA, 1993). Therefore in our assessment, the cancer risks for exposure to carcinogenic PAHs were considered to be additive after scaling the risks according to their carcinogenic potency relative to benzo(a)pyrene as described in DEC/DOH (2006). Assuming additive interactions means that the cancer risk associated with exposure to mixtures of carcinogenic PAHs would be higher than the cancer risk from exposure to any individual PAH in the mixture.

F. Health Outcome Data Evaluation

The DOH has not previously evaluated health outcome data specifically for the Gowanus neighborhood. Both DOH and NYCDOHMH provide health statistics for the Downtown – Heights – Slope neighborhood in Brooklyn which includes the Gowanus neighborhood. The DOH and NYCDOHMH maintain several health outcome databases, which could be used to generate health outcome data specifically for the Gowanus neighborhood, if appropriate. These databases include the Cancer Registry, the Congenital Malformations Registry, Vital Records (birth and death certificates) and hospital discharge information. In addition, the DOH and NYCDOHMH Environmental Public Health Tracking programs could be used to evaluate certain environmental health outcomes in the area. The programs extend traditional environmental and health surveillance by jointly tracking environmental hazards, exposures and health effects potentially related to environmental exposures.

Based on the exposure and toxicological evaluation presented elsewhere in this PHA, no evaluation of health outcome data is currently indicated. No significant community-wide exposures were identified and we do not have enough information for the limited population exposed through occasional swimming and boating to study the potentially exposed population. Although people may have consumed fish caught from the Canal, we do not have enough information about who may be eating the fish and what types of fish are being eaten to be able to study the potentially exposed population.

COMMUNITY HEALTH CONCERNS

We identified community health concerns from the EPA Gowanus Canal NPL Listing Support Document (EPA, 2010a), discussions with community members, and from subsequent media reports. These concerns and our responses are provided below.

Comment: Community members are concerned about people's exposure to both chemical and biological contaminants in the surface water and sediments by skin contact and the ingestion of locally caught fish and crabs.

Response: Potential and completed pathways for exposure exist for people who contact canal surface water during recreation, either through direct contact during swimming and scuba diving or by accidental splashing while boating or fishing. The DOH evaluated these exposures by comparing the levels of chemicals and biologicals (coliform bacteria) found in surface water and sediment samples to health-based public health comparison values.

DOH and ATSDR concluded that swimming in the Gowanus Canal could harm people's health because water in the Gowanus Canal contains levels of fecal coliform bacteria that indicate an increased risk of illness from contact with the water. Exposure to chemicals in accessible sediments is a potential health concern for people who might contact the sediments. DOH and ATSDR concluded that recreational boating in the Gowanus Canal is not expected to harm people's health, although there may be some physical hazards, such as large commercial boats. The DOH and ATSDR concluded that if people don't follow DOH's fish consumption advisories, and eat more fish and crabs from the Gowanus Canal than indicated in the advisory, their health could be harmed. This information is presented in more detail in other sections of this document.

Comment: Community members report that people have been seen fishing from several bridges that span the canal.

Response: The DOH issues yearly fish consumption advisories for New York State (DOH, 2013a) that cover the Upper Bay of New York Harbor, including the Gowanus Canal area.

To address the concerns about fishing and fish consumption in the Gowanus Canal during cleanup, the DOH will continue to distribute fish advisories (Chemicals in Sportfish and Game) that will include any new data on contaminant levels found in local fish. Additionally, the agencies will, where requested, provide technical assistance, such as suggestions for warning signs, to assist in outreach educational efforts to high risk groups. Signs can be used to warn about the hazards associated with eating contaminated sport fish from the Gowanus Canal (especially for women and children).

Comment: Some community members raised concerns about other recreational uses of the canal during canal clean up, including boating and scuba diving.

Response: EPA released a Record of Decision for the site in September 2013 (http://www.epa.gov/region02/superfund/npl/gowanus/ri_docs/692106_gowanus_canal_rod_9_27_13_final.pdf). Major intrusive activities will be done with a project-specific Community Health and Safety Plan designed to prevent people from contacting contamination and avoiding physical hazards.

Comment: Community members reported knowledge of illnesses among the community that they believe are related to the Gowanus Canal contamination.

Response: People who are concerned about how their own health may be affected by the Gowanus Canal can contact DOH staff for further information.

For the community at large, no significant exposures were identified that would affect a large number of people in a specific community. DOH does not have enough information about who are the limited population exposed to biological or chemical hazards through occasional swimming and boating and where they live, to be able to study the potentially exposed population. Although people may have eaten fish and crabs caught from the canal, we do not have enough information about who may be eating the fish and what types of fish are being eaten to be able to study the potentially exposed population.

Comment: Community members raised concerns about other contaminated sites upland and along the canal.

Response: The EPA is assessing what contribution these other sites have had on the Gowanus Canal waterway and are addressing that contribution. The DOH and DEC will work with EPA to address any new site-specific potential exposure pathways that may be identified for the community.

Comment: The community raised concerns about redevelopment of formerly contaminated areas and the construction of new residential housing units, and wants to know what mechanisms would be in place to ensure that clean-up was adequate to protect public health.

Response: The DOH and DEC will work with the EPA, NYCDEP, NYCDOHMH and other agencies to assess cleanup levels for soils related to their intended reuse, in particular, for construction of residential units and related areas such as parks and playgrounds. This information will be shared with the community for review and comment as the Gowanus Canal cleanup proceeds and as other nearby contamination sites are addressed in the future.

CONCLUSIONS

DOH and ATSDR conclude that full body immersion recreation (e.g., swimming or scuba diving) in Gowanus Canal could harm people's health.

There are physical, biological and chemical hazards for swimmers in the Gowanus Canal. Large commercial boat traffic and in some places high bulkheads (marine retaining walls) represent physical safety concerns for swimming and other water recreation. Bulkheads may make it difficult to get out of the canal when necessary for safety. In addition, there are physical hazards that can cause injury, as well as drowning hazards (for example, steep slopes, drop offs and poor water clarity) that have not been assessed.

Water in the Gowanus Canal contains, at times, levels of fecal coliform bacteria that indicate an increased risk of illness from recreational contact with the water. Water from the Gowanus Canal contains microorganisms, such as coliform bacteria, and likely contains viruses and parasites that can make a person ill if they enter the body. There is increased risk of contracting diseases through swallowing or skin contact with these disease-causing agents.

In some locations, exposure to chemicals in the surface water is also a potential health concern for swimmers. While most water samples from the Gowanus Canal contain chemical levels that are estimated to pose a minimal or low risk for health effects, about 8% of the samples taken in 2007 contained PAHs, particularly benzo(a)pyrene, at levels that could pose a moderate to high increased cancer risk if people are exposed repeatedly over a long period of time (for example, 30 years) at those specific locations only. All but one of these samples were from the Middle Reach of the canal (from 2nd Street to the Brooklyn Queens Expressway). Benzo(a)pyrene contamination may be limited to specific areas of the canal where there is tar, creosote-treated bulkheads and petroleum sheens.

Also, exposure to chemicals in accessible sediments is a potential health concern for swimmers, as well as others, who might contact the sediments during fishing, boating, or wading. Repeated and long-term exposure to the highest level of benzo(a)pyrene detected in surface sediments is estimated to pose a moderate increased risk for cancer (i.e., the estimated increased cancer risk is between one in ten thousand and one in one thousand). Lead in some of the sediment locations could increase a child's blood lead level if the child frequently contacts sediments in these high lead locations.

DOH and ATSDR conclude that recreational boating (for example, canoeing or kayaking) or "catch and release" fishing from boats in the Gowanus Canal is not expected to harm people's health, although there may be some physical hazards, such as large commercial boats.

Certain precautions are recommended because accidental swallowing and skin contact with the water when boating or fishing in some areas of the canal would lead to increased exposure to chemical and biological contaminants, and these are discussed under general recommendations below.

There is an increased risk of illness from water contact while boating and fishing from boats when standards for indicator bacteria are exceeded. Because people do not usually submerge their heads during these activities, the presumed volume of incidental water consumption is lower than when swimming. Consequently, the risk of illness can also be assumed to be lower.

The DOH and ATSDR conclude that if people don't follow DOH's fish consumption advisories, and eat more fish and crabs from the Gowanus Canal than recommended in the advisory, their risk for adverse health effects will increase and their health could be harmed.

Based on the close association of the Upper Bay of New York Harbor and the Gowanus Canal, contaminant levels in fish and crabs are similar. DOH has extensive, restrictive fish advisories for the Upper Bay of New York Harbor that apply to the Gowanus Canal. People who are considering eating fish and crab caught in the canal should follow the DOH consumption advisories for fish (including crabs) taken from the Upper Bay of New York Harbor to reduce their exposures to chemical contaminants.

DOH and ATSDR conclude that breathing contaminants from the Gowanus Canal in outdoor air near the canal is not expected to harm people's health.

The health risks from long-term exposure to the concentrations of benzene, chloroform, ethyl benzene, methylene chloride and naphthalene detected in outdoor air near the canal (at street or canal level) are similar to those associated with the concentrations of these chemicals in typical urban air. Long-term exposure to total xylenes, which were measured near the canal or at street level at concentrations higher than those in typical urban air, poses a minimal risk for adverse health effects.

RECOMMENDATIONS

For those people using the Gowanus Canal for recreation, the DOH and ATSDR recommend measures to reduce exposures to the biological and chemical hazards at the site. People recreating in and around the canal can reduce the risk of becoming ill by avoiding the canal water after periods of effluent discharge, rainfall, when the water is cloudy or turbid, or when pollution is clearly visible (for example, petroleum sheens). People should avoid any activity that would result in swallowing canal water. People should wash their hands after contacting the water and sediments, especially before eating and at the end of the day. If people get water or sediments on more than just their hands, it would be prudent to take a shower to wash off canal water and sediments.

ATSDR and DOH will, where requested, assist in providing materials, such as warning signs, to assist in outreach efforts to high risk groups, such as subsistence anglers. These signs would warn about the hazards associated with eating contaminated sport fish from the Gowanus Canal, especially for women and children.

PUBLIC HEALTH ACTION PLAN

The ATSDR and DOH will coordinate with EPA and the NYCDEP on postings of public health protective messages regarding recreational use (e.g. swimming, boating and fishing) of Gowanus Canal.

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APPENDIX A
Figure

Figure 1. Overview map of the Gowanus Canal site, Brooklyn, New York.

APPENDIX B
Tables

Table 1. Surface Water Analytical Results - Gowanus Canal - Brooklyn, New York (GEI, 2007 Data).

	NYSDEC HFC[1]	NYSDOH MCL[2]	Lower Reach of Canal (30 Samples) Number of detects	Range of detects	Number over MCL	Middle Reach of Canal (85 Samples) Number of detects	Range of detects	Number over MCL	Upper Reach of Canal (30 Samples) Number of detects	Range of detects	Number over MCL
BTEX (mcg/L) [3]											
Benzene	10	5	9	0.43 - 3.9	0	79	0.42 - 6.1	2	23	0.48 - 6.1	1
Toluene	6000	5	24	0.33 - 31	3	81	0.3 - 13	12	26	0.34 - 18	5
Ethylbenzene	-	5	3	1.2 - 4.9	0	32	1 - 12	5	6	1.1 - 2.7	0
Xylene, total	-	5	11	1.2 - 20	1	62	1 - 12	12	19	1 - 12	3
Other VOCs (mcg/L) [3]											
Bromodichloromethane	-	80[a]	0	0 - 0	0	0	0 - 0	0	2	0.52, 0.6	0
Bromoform	-	80[a]	6	1.5 - 7.9	0	13	0.86 - 62	0	10	1.2 - 98	3
Butanone, 2-	-	50	3	1.2 - 1.8	0	5	1.4 - 2.8	0	0	0 - 0	0
Chloroform	-	80[a]	0	0 - 0	0	0	0 - 0	0	1	1.7	0
Chloromethane	-	5	0	0 - 0	0	1	3.5	0	2	1.3, 4.3	0
Dibromochloromethane	-	80[a]	0	0 - 0	0	8	0.59 - 3.4	0	7	1.6 - 6.7	0
Methyl tert-butyl ether	-	10	12	0.45 - 20	1	64	0.32 - 11	1	26	0.43 - 26	2
Tetrachloroethene	1	5	0	0 - 0	0	0	0 - 0	0	1	0.67	0
Other SVOCs (mcg/L) [3]											
Bis(2-ethylhexyl)phthalate	-	6	0	0 - 0	0	6	2 - 8	2	7	2 - 5	0
Butyl benzyl phthalate	-	50	0	0 - 0	0	4	1 - 5	0	0	0 - 0	0
Dibenzofuran	-	50	0	0 - 0	0	4	1 - 14	1	0	0 - 0	0
Diethyl phthalate	-	50	0	0 - 0	0	2	1, 1	0	5	2 - 4	0
Methylphenol, 4-	-	50	0	0 - 0	0	1	0.5	0	7	0.4 - 3	0
Phenol	-	50	0	0 - 0	0	0	0 - 0	0	1	0.4	0
PAHs (mcg/L) [3]											
Acenaphthene	-	50	2	1, 1	0	26	0.8 - 56	1	2	1, 2	0
Acenaphthylene	-	50	0	0 - 0	0	23	0.8 - 94	1	2	0.9, 0.9	0
Anthracene	-	50	0	0 - 0	0	18	1 - 110	1	1	1	0
Benzo[g,h,i]perylene	-	50	0	0 - 0	0	15	1 - 46	0	0	0 - 0	0
Fluoranthene	-	50	0	0 - 0	0	25	1 - 220	2	2	1, 2	0
Fluorene	-	50	0	0 - 0	0	12	0.8 - 52	1	1	1	0
Methylnaphthalene,2-	-	50	0	0 - 0	0	11	0.7 - 41	0	6	0.8 - 8	0
Naphthalene	-	50	2	0.8, 0.9	0	11	0.9 - 24	0	14	0.7 - 4	0
Phenanthrene	-	50	0	0 - 0	0	28	0.8 - 450	5	6	0.7 - 4	0
Pyrene	-	50	0	0 - 0	0	30	1 - 320	3	5	1 - 3	0
Benzo[a]anthracene	-	50	0	0 - 0	0	19	1 - 110	1	1	1	0
Benzo[a]pyrene	-	0.2	0	0 - 0	0	16	1 - 85	16	1	1	**1**
Benzo[b]fluoranthene	-	50	0	0 - 0	0	13	2 - 50	1	0	0 - 0	0
Benzo[k]fluoranthene	-	50	0	0 - 0	0	14	2 - 54	**1**	0	0 - 0	0
Chrysene	-	50	0	0 - 0	0	25	1 - 130	**1**	2	1, 1	0
Indeno[1,2,3-cd]pyrene	-	50	0	0 - 0	0	12	2 - 39	0	0	0 - 0	0

Table 1 Cont. - Surface Water Analytical Results - Gowanus Canal - Brooklyn, New York (GEI, 2007 Data).

			Lower Reach of Canal (30 Samples)			Middle Reach of Canal (85 Samples)			Upper Reach of Canal (30 Samples)		
	NYSDEC HFC[1]	NYSDOH MCL[2]	Number of detects	Range of detects	Number over MCL	Number of detects	Range of detects	Number over MCL	Number of detects	Range of detects	Number over MCL
Herbicides (ug/L) [3]											
2,4-D	-	50	0	0 - 0	0	1	0.47	0	1	0.52	0
PCBs (ug/L) [3]											
Aroclor 1248	$1x10^{-6}$ [b]	0.5	0	0 - 0	0	1	0.2	0	0	0 - 0	0
Aroclor 1254	$1x10^{-6}$ [b]	0.5	0	0 - 0	0	2	0.2, 0.35	0	0	0 - 0	0
Aroclor 1260	$1x10^{-6}$ [b]	0.5	0	0 - 0	0	6	0.11 - 0.28	0	0	0 - 0	0
Pesticides (ug/L) [3]											
Aldrin	0.001	5	0	0 - 0	0	1	0.16	0	0	0 - 0	0
BHC, Alpha-	0.002	5	0	0 - 0	0	2	0.067, 0.02	0	1	0.053	0
BHC, Beta-	0.007	5	2	0.029, 0.045	0	4	0.025 - 0.092	0	0	0 - 0	0
BHC, Gamma- (Lindane)	0.008	0.2	0	0 - 0	0	4	0.013 - 0.15	0	1	0.013	0
Chlordane, Alpha-	$2x10^{-5}$	2	0	0 - 0	0	4	0.04 - 0.29	0	0	0 - 0	0
Chlordane, trans-	$2x10^{-5}$	2	0	0 - 0	0	1	0.13	0	0	0 - 0	0
DDD,4,4-	$8x10^{-5}$	5	0	0 - 0	0	3	0.035 - 0.15	0	0	0 - 0	0
DDE,4,4-	$7x10^{-6}$	5	0	0 - 0	0	2	0.035, 0.15	0	0	0 - 0	0
DDT,4,4-	$1.1x10^{-5}$ [c]	5	0	0 - 0	0	2	0.08, 0.088	0	0	0 - 0	0
Endrin ketone	-	2	0	0 - 0	0	1	0.031	0	0	0 - 0	0
Heptachlor	$2x10^{-4}$	0.4	0	0 - 0	0	2	0.03, 0.08	0	0	0 - 0	0
Heptachlor epoxide	$3x10^{-4}$	0.2	0	0 - 0	0	1	0.11	0	0	0 - 0	0
Inorganic Constituents (ug/L) [3]											
Aluminum	-	None	1	486	-	0	0 - 0	-	2	2380, 4820	-
Barium	-	2000	17	15.9 - 23.7	0	55	15.1 - 48.3	0	25	15.7 - 128	0
Chromium	-	100	1	10	0	4	24.7 - 57.3	0	0	0 - 0	0
Copper	-	1300 [d]	0	0 - 0	0	4	21.7 - 46.2	0	0	0 - 0	0
Iron	-	300	2	303, 502	2	4	421 - 2070	4	1	4870	1
Lead	-	15 [d]	0	0 - 0	0	3	17.3 - 36.2	3	1	99.3	1
Magnesium	-	None	30	596,000 - 920,000	-	85	586,000 - 839,000	-	30	657,000 - 870,000	-
Manganese	-	300	2	49.5, 59.2	0	41	35.1 - 142	0	1	37.6	0
Mercury	$7x10^{-4}$ [e]	2	6	0.08 - 0.25	0	3	0.071 - 0.12	0	2	0.071, 0.28	0
Nickel	-	None	0	0 - 0	0	3	19.1 - 28.1	0	0	0 - 0	0
Thallium	-	2	0	0 - 0	0	4	50.1 - 57	4	0	0 - 0	0
Zinc	-	5000	1	68.2	0	4	61.4 - 2750	0	0	0 - 0	0
Cyanide (ug/L) [3]											
Cyanide, Total	9000	200	9	1.5 - 22.6	0	22	1 - 12	0	3	1.4 - 1.7	0

Table 1 Cont. - Surface Water Analytical Results - Gowanus Canal - Brooklyn, New York (GEI, 2007 Data).

			Lower Reach of Canal (30 Samples)			Middle Reach of Canal (85 Samples)			Upper Reach of Canal (30 Samples)		
	NYSDEC HFC[1]	NYSDOH MCL[2]	Number of detects	Range of detects	Number over MCL	Number of detects	Range of detects	Number over MCL	Number of detects	Range of detects	Number over MCL
Other (mg/L) [3]											
Biochemical Oxygen Demand	-	None	26	2.2 - 101.4	-	29	1.6 - 84	-	9	0.36 - 14	-
Nitrate and Nitrite as N	10	10	20	0.076 - 1.8	0	70	0.11 - 16	1	30	0.26 - 3	-
Sulfate	-	250	30	1530 - 2280	30	85	1460 - 1930	85	30	1320 - 1590	30
Fecal Coliform (number per 100mL) [3]											
Fecal Coliform		1000 [g]	19	25 - 600	0	72	33 - 2900	10	20	75 - 2500	3

[1] DEC water quality standard for surface waters 6NYCRR Part 703 Class SD Saline, Human Consumption of Fish (HFC).
[2] DOH drinking water standards maximum contaminant levels (MCL) Part 5-1 of the New York State Sanitary Code.
[3] Units include micrograms per liter (mcg/L), milligrams per liter (mg/L) and number of coliform bacteria per 100 milliliters of water (100 mL).
[a] MCL for total trihalomethanes.
[b] Standard for total PCBs in a sample.
[c] Applies to the total of DDD, DDE and DDT.
[d] MCLs are not available for aluminum, magnesium and nickel.
[e] Copper and lead are action levels.
[f] Applies to dissolved form of mercury.
[g] Not an MCL, but the standard for regulated bathing beaches, one-time sample.

Table 2. Contaminant Levels in Surface Water and Public Health Assessment Comparison Values Based on Swimming for Gowanus Canal Contaminants Selected for Further Evaluation

All values in micrograms per liter (mcg/L).

Contaminant	Contaminant Level	Comparison Value			
		Cancer[1]	Basis	Noncancer[2]	Basis
benzene	11	79	CA EPA CPF	1028	ATSDR MRL
bromoform	98	4570	EPA CPF	116,000	EPA RfD
ethyl benzene	12	730	DOH CPF	75,700	EPA RfD
methyl-*tert*-butyl ether	26	540	DOH CPF	18,200	DOH RfD
tetrachloroethene	40	75	EPA CPF	107,800	EPA RfD
toluene	31	--	--	91,000	EPA RfD
xylene, total	20	--	--	141,000	EPA RfD
acenaphthene	56	--	--	47,200	EPA RfD
acenaphthylene	94	--	--	47,200	EPA RfD[3]
anthracene	110	--	--	25,800	EPA RfD
benzo(a)pyrene	85	0.02	DEC CPF	98	CA EPA RfD
benz(a)anthracene	110	0.3	DEC CPF[4]	146	CA EPA RfD[5]
benzo(b)fluoranthene	50	0.18	DEC CPF[4]	98	CA EPA RfD[5]
benzo(k)fluoranthene	54	1.8	DEC CPF[4]	98	CA EPA RfD[5]
bis(2-ethylhexyl)phthalate	8	350	EPA CPF	27,300	EPA RfD
chrysene	130	2.7	DEC CPF[4]	146	CA EPA RfD[5]
dibenz(a,h)anthracene	0.11	0.009	DEC CPF[4]	46	CA EPA RfD[5]
indeno(1,2,3-c,d)pyrene	1.1	0.13	DEC CPF[4]	69	CA EPA RfD[5]
fluoranthene	220	--	--	7250	EPA RfD
fluorene	52	--	--	7250	EPA RfD
phenanthrene	450	--	--	480	CA EPA RfD[5]
pyrene	320			8440	EPA RfD
arsenic	26.2	36	EPA CPF	2100	EPA RfD
chromium	99.7	77	CA EPA CPF	5980	ATSDR MRL
cobalt	3.9	--	--	2100	EPA PPRTV
iron	4870	--	--	4,902,000	EPA PPRTV
nitrate/nitrite	16,000	--	--	700,000	EPA RfD[6]
selenium	64.6	--	--	35,000	EPA RfD
thallium	57	--	--	70	EPA PPRTV

[1]Cancer comparison values are based on the dose corresponding to a one in one million risk level and calculated for a 71.8 kg adult who swims one hour per day, 2 days per week, 3 months per year for 30 years, and ingests 0.025 liters of surface water (EPA, 2003) and absorbs surface water contaminants through the skin during each event. Calculation: Comparison value = [1 mg/L x 0.000001/cancer potency factor $(mg/kg/day)^{-1}$]/total dose x 1000 mcg/1 mg. Total dose is the sum of oral and dermal dose. Oral dose = 1 mg/L x 0.025 L/day x 1/71.8 kg x 2 days/7 days x 3 months/12 months x 30 years/70 years. Dermal dose = [1 mg/L x 18,200 cm^2 x (dermal permeability coefficient (cm/hour)) x 1 hour/day x 26 d/year x 30 year x 1 L/1000 cm^3] /71.8 kg x 25,550 days. Dermal permeability coefficients are from Appendix B of EPA (2004). The dermal permeability value for

benzo(b)fluoranthene was used for benzo(k)fluoranthene; the default value of 0.001 cm/hour was used for metals in the absence of a chemical-specific value.

[2]Noncancer comparison values are based on the reference dose or similar value and calculated for a 30.2 kg child who swims one hour per day, 2 days per week, 3 months per year, and ingests 0.05 liters of surface water (EPA, 2003) and absorbs surface water contaminants through the skin during each event. Calculation: Comparison value = 1 mg/L x reference dose (mg/kg/day)/total dose x 1000 mcg/1 mg. Total dose is the sum of oral and dermal dose. Oral dose = 1 mg/L x 0.05 L/day x 1/30.2 kg x 2 days/7 days x 3 months/12 months. Dermal dose = [1 mg/L x 10,400 cm^2 x (dermal permeability coefficient (cm/hour)) x 1 hour/day x 26 d /year x 1 year x 1 L/1000 cm^3] /30.2 kg x 365 days. The following surrogate dermal permeability values were used: benzo(b)fluoranthene for benzo(k)fluoranthene; benz(a)anthracene for anthracene; fluoranthene for fluorene; naphthalene for acenaphthene and acenaphthylene; phenanthrene for pyrene; the default value of 0.001 cm/hour was used for metals in the absence of a chemical-specific value.

[3]The reference dose for acenaphthene was used in the absence of a chemical specific value.

[4]Relative potency factors were applied to the carcinogenic PAHs as described in DEC/DOH (2006).

[5]The reference dose for benzo(a)pyrene is used as a surrogate in the absence of a chemical-specific value.

[6]The reference dose for nitrite (0.1 mg/kg/day) was used to calculate the comparison value. Toxicity values for sulfate are not available, and therefore a comparison value is not calculated. Incidental ingestion by a 30.2 kg child of 0.05 L of canal water containing sulfate at the highest level detected (2280 mg/L) results in an estimated sulfate dose (3.8 mg/kg) that is about 17 times lower than the estimated dose associated with short-term, reversible health effects (diarrhea) in infants (63 mg/kg, Chien *et al*, 1968).

ATSDR MRL: Agency for Toxic Substances and Disease Registry Minimal Risk Level
CA EPA CPF: California Environmental Protection Agency Cancer Potency Factor
CA EPA RfD: California Environmental Protection Agency Reference Dose
DEC CPF: New York State Department of Environmental Conservation Cancer Potency Factor
DOH CPF: New York State Department of Health Cancer Potency Factor
DOH RfD: New York State Department of Health Reference Dose
EPA CPF: United States Environmental Protection Agency Integrated Risk Information System
EPA PPRTV: United States Environmental Protection Agency Provisional Peer Reviewed Toxicity Value
EPA RfD: United States Environmental Protection Agency Integrated Risk Information System Reference Dose

Table 3. Contaminant Levels in Surface Sediment and Public Health Assessment Comparison Values Based on Ingestion and Dermal Exposure to Gowanus Canal Contaminants Selected for Further Evaluation.

All values in milligrams per kilogram of sediment or soil (mg/kg_s).

Contaminant	Contaminant Level	Comparison Value			
		Cancer[1]	Basis	Noncancer[2]	Basis
acenaphthene	580	--	--	33,900	EPA RfD
acenaphthylene	150	--	--	33,900	EPA RfD[3]
anthracene	610	--	--	169,600	EPA RfD
benz(a)anthracene	490	6.3	DEC CPF[4]	960	CA EPA RfD[5]
benzo(a)pyrene	200	0.63	DEC CPF	960	CA EPA RfD
benzo(b)fluoranthene	210	6.3	DEC CPF[4]	960	CA EPA RfD[5]
benzo(k)fluoranthene	120	63	DEC CPF[4]	960	CA EPA RfD[5]
bis(2-ethylhexyl) phthalate	57	490	EPA CPF	11,800	EPA RfD
chrysene	490	63	DEC CPF[4]	960	CA EPA RfD[5]
dibenz(a,h)anthracene	14	0.63	DEC CPF[4]	960	CA EPA RfD[5]
fluoranthene	630	--	--	22,600	EPA RfD
fluorene	540	--	--	22,600	EPA RfD
indeno(1,2,3-c,d)pyrene	120	6.3	DEC CPF[4]	960	CA EPA RfD[5]
2-methyl naphthalene	870	--	--	2360	EPA RfD
naphthalene	1600	--	--	11,800	EPA RfD
phenanthrene	1100	--	--	960	CA EPA RfD[5]
pyrene	670	--	--	17,000	EPA RfD
Aroclor 1248	2.2	3.1	EPA CPF[6]	11	ATSDR MRL[7]
Aroclor 1254	0.59	3.1	EPA CPF[6]	11	ATSDR MRL[7]
Aroclor 1260	3.4	3.1	EPA CPF[6]	11	ATSDR MRL[7]
Total PCBs	15.1	3.1	EPA CPF	11	ATSDR MRL[7]
aluminum	18,900	--	--	689,100	EPA PPRTV
arsenic	44.7	6.0	EPA CPF	200	EPA RfD
barium	631	--	--	137,800	EPA RfD
cadmium	20.2	--	--	490	DEC RfD
chromium	139	20	CA EPA CPF	690	ATSDR MRL
cobalt	14.8	--	--	200	EPA RfD
copper	790	--	--	96,500	CA EPA RfD
iron	87,000	--	--	482,400	EPA PPRTV
mercury	2.3	--	--	110	CA EPA RfD
vanadium	61.2	--	--	6200	EPA RfD

[1]Cancer comparison values are based on the dose corresponding to a one in one million risk level and calculated for an individual who contacts sediment 2 days per week, 3 months per year for 30 years from ages 3 to 33, and is exposed to sediment contaminants by incidental ingestion and dermal absorption. A soil to skin adherence factor of 0.2 mg_s/cm^2-day, and time-weighted parameters for body weight (56.6 kg), daily sediment ingestion (180 mg_s/day), and surface area for upper and lower extremities (4347 cm^2) are assumed. Calculation: Comparison value = [1 mg/kg_s x 0.000001/cancer potency factor $(mg/kg/day)^{-1}$]/total dose. Total dose is the sum of oral and dermal doses. Oral dose = 1 mg/kg_s x 180 mg_s/day x 1/56.6 kg x 10^{-6} kg_s/mg_s x 26 days/365 days x 30 years/70 years. Dermal dose = [1 mg/kg_s x 4347 cm^2 x 0.2 mg_s/cm^2-day x dermal absorption factor x 10^{-6} kg_s/mg_s x 26

days/year x 30 years]/56.6 kg x 25,550 days. Dermal absorption factors are from Chapter 3 (Exhibit 3-4) of EPA (2004) or from EPA (2011c).

[2]Noncancer comparison values are based on the reference dose or similar value and calculated for a 15 kg child who contacts sediments 2 days per week, 3 months per year and is exposed to sediment contaminants by incidental ingestion and dermal absorption. A soil to skin adherence factor of 0.2 mg_s/cm^2-day, a daily sediment ingestion rate of 300 mg_s/day, and a surface area value for upper and lower extremities of 2792 cm^2) are assumed. Calculation: Comparison value = 1 mg/kg_s x reference dose (mg/kg/day)/total dose. Total dose is the sum of oral and dermal doses. Oral dose = 1 mg/kg_s x 300 mg_s/day x 1/15 kg x 10^{-6} kg_s/mg_s x 26 days/365 days. Dermal dose = [1 mg/kg_s x 2792 cm^2 x 0.2 mg_s/cm^2-day x dermal absorption factor x 10^{-6} kg_s/mg_s x 26 days/year x 1 year]/15 kg x 365 days. Dermal absorption factors are from Chapter 3 (Exhibit 3-4) of EPA (2004) or from EPA (2011c).

[3]The reference dose for acenaphthene is used as a surrogate in the absence of a chemical-specific value.

[4]Relative potency factors were applied to the carcinogenic PAHs as described in DEC/DOH (2006).

[5]The reference dose for benzo(a)pyrene is used as a surrogate in the absence of a chemical-specific value.

[6]Based on upper-bound cancer potency factor for high risk and persistence (EPA, 2013d).

[7]The ATSDR value is used to evaluate unspecified mixtures of polychlorinated biphenyls (PCBs) and is based on Aroclor 1254.

ATSDR MRL: Agency for Toxic Substances and Disease Registry Minimal Risk Level
CA EPA CPF: California Environmental Protection Agency Cancer Potency Factor
CA EPA RfD: California Environmental Protection Agency Reference Dose
DEC CPF: New York State Department of Environmental Conservation Cancer Potency Factor
DEC RfD: New York State Department of Environmental Conservation Reference Dose
EPA CPF: United States Environmental Protection Agency Integrated Risk Information System
EPA PPRTV: United States Environmental Protection Agency Provisional Peer Reviewed Toxicity Value
EPA RfD: United States Environmental Protection Agency Integrated Risk Information System Reference Dose

APPENDIX C

Conclusion Categories and Hazard Statements

Conclusion Categories and Hazard Statements

ATSDR has five distinct descriptive conclusion categories that convey the overall public health conclusion about a site or release, or some specific pathway by which the public may encounter site-related contamination. These defined categories help ensure a consistent approach in drawing conclusions across sites and assist the public health agencies in determining the type of follow-up actions that might be warranted. The conclusions are based on the information available to the author(s) at the time they are written.

1. Short-term Exposure, Acute Hazard "ATSDR concludes that...could harm people's health."

This category is used for sites where short-term exposures (e.g. < 1 yr) to hazardous substances or conditions could result in adverse health effects that require rapid public health intervention.

2. Long-term Exposure, Chronic Hazard "ATSDR concludes that...could harm people's health."

This category is used for sites that pose a public health hazard due to the existence of long-term exposures (e.g. > 1 yr) to hazardous substance or conditions that could result in adverse health effects.

3. Lack of Data or Information "ATSDR cannot currently conclude whether...could harm people's health."

This category is used for sites in which data are insufficient with regard to extent of exposure and/or toxicologic properties at estimated exposure levels to support a public health decision.

4. Exposure, No Harm Expected "ATSDR concludes that ... is not expected to harm people's health."

This category is used for sites where human exposure to contaminated media may be occurring, may have occurred in the past and/or may occur in the future, but the exposure is not expected to cause any adverse health effects.

5. No Exposure, No Harm Expected "ATSDR concludes that ...will not harm people's health."

This category is used for sites that, because of the absence of exposure, are not expected to cause any adverse health effects.