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Lina Letiecq, Manager, Environmental Site Assessments
Sue-Jin An, Senior Environmental Specialist
Public Works and Government Services of Canada
Environmental Services
4900 Yonge Street, 12th Floor
Toronto, ON M2N 6A6

KINGSTON INNER HARBOUR – SOURCE INVESTIGATION FOR SOUTHWEST TRANSPORT CANADA WATER LOT

Dear Ms. Letiecq and Ms. An:

Golder Associates Ltd. (Golder) is pleased to provide Public Works and Government Services Canada this review of potential sources of contaminants to the southwest portion of the Transport Canada (TC) water lot of the Kingston Inner Harbour (KIH) in the vicinity of Anglin Bay and Douglas Fluhrer Park. Emphasis in the review is placed on sediment contamination by polycyclic aromatic hydrocarbons (PAHs), which have been identified as contaminants that are plausibly linked to observed effects in environmental samples from this area. Our analysis was based on a combination of historical document reviews and interviews with Paul MacLatchy of the City of Kingston.

This review has been prepared as described in the proposal (P2-1122-0207) issued to PWGSC by Golder on November 26, 2012. A call-up against the Standing Offer EQ447-094076/021/TOR under Order 700241757 was issued for this work on December 13, 2012. The overall scope of work also included an evaluation of fish deformities, which has been issued under separate cover (Golder 2013).

1.0 CONTEXT FOR STUDY

This section provides a brief summary of the purpose and objectives for the study. Additional details are provided in the Final SOW issued by PWGSC (2012). Based on the weight-of-evidence from multiple investigations of sediment quality, some areas within the Transport Canada property (specifically those adjacent to Douglas Fluhrer Park and within Anglin Bay) may require management intervention based on the results of the Detailed Quantitative Assessment (DQRA) (Golder 2012a). The areas that contain sediments posing ecological risks include portions of management units MF-1, FF-0, and FF-1.

Prior to application of intrusive remediation (*i.e.*, dredging, capping, or other physical works), improved understanding of the contamination sources has been recommended adjacent to Douglas Fluhrer Park and within Anglin Bay. The guidance document Framework for Addressing and Managing Aquatic Contaminated Sites under the Federal Contaminated Sites Action Plan (FCSAP) (Chapman 2011, EC and OMOE 2008) documents three pre-requisites to remedial planning: (1) determine causation; (2) control on-going sources of contamination; and (3) ensure that remedial actions do not cause more environmental damage than they remedy. Evaluation of these three pre-requisites is recommended prior to the development of a risk management plan or implementation of remedial works.

Based on the weight-of-evidence from multiple investigations of sediment quality, some areas within the TC property (adjacent to Douglas Fluhrer Park and within Anglin Bay) may require management intervention on the basis of an "Adverse Effects Likely" designation. These areas include:

- The first area is adjacent to Douglas Fluhrer Park, defined by the three contiguous Stations 2010-3, 2011-C, and 2010-4. The higher risk level for this zone was determined based on elevated contamination for metals, PAHs, and polychlorinated biphenyls (PCBs) that was matched with moderate toxicity responses and some indications of benthic community alteration. The locations of these stations are adjacent to a municipal storm sewer that discharges to the Inner Harbour (**Figure 1)**.
- The second area is also adjacent to Douglas Fluhrer Park, but corresponds to the vicinity of a second storm sewer to the north of the one described above. The nearest sediment quality station (2010-5) exhibited moderate indications of sediment toxicity and benthic community impairment (**Figure 1)**.
- The third area of concern is the Dry Dock area found within Anglin Bay. The enclosed portion of Anglin Bay has exhibited multiple indications of sediment toxicity and altered benthic community structure. Although mechanical disturbance of sediments and lack of macrophyte beds may partially explain the observed biological assemblages, the sediment toxicity was observed in both 2010 and 2011 sampling events. Furthermore, the pattern of sediment chemistry indicates elevated concentrations of some substances (copper, lead, zinc, tributyltin and PAHs) that suggest incremental contamination from local industrial sources, storm sewers, and/or legacy contamination. Although the toxicity identification evaluation (TIE) was inconclusive for the 2011-A sample, the complex mixture of sediment contaminants at potentially toxic levels suggests that observed adverse effects are not false positives (**Figure 1)**.

Remaining areas of the TC property indicate low environmental risks, subject to the following caveats:

- Potential for human health effects (related to PCBs) remains for much of the TC water lot pending the refined evaluation of these pathways; and
- Potential to risks to fish for development of tumors or other abnormalities remains, related to PAHs and/or PCBs.

With respect to **causation**, there is evidence that PAHs have contributed to the toxicity of sediments adjacent to Douglas Fluhrer Park. Because PAHs are a key contaminant of concern for the health of both benthic communities and fish, the identification of sources (both historical and ongoing) is a key consideration in the application of the *Framework*. There is also potential for PCBs to have influenced the health of fish and/or recreational fishers, although conclusive evidence of harm has not been demonstrated. The pattern of contamination for PCBs and PAHs is similar in the southwest corner of KIH, suggesting that sources/pathways for the two groups of contaminants may be related.

2.0 PAH SOURCES

2.1 Potential Ongoing Sources

PAHs occur in oil, coal, and tar deposits, and are produced as by-products of incomplete combustion of both natural and anthropogenic organic materials. PAHs are a ubiquitous contaminant in urban waterways, and PAHs in the bottom sediment of KIH may derive from numerous sources, including:

- Storm sewer discharges to the harbour from road run-off containing PAHs from road construction and use, as well as atmospheric fallout (automobile exhaust, furnace/stack emissions, *etc*.);
- Marine traffic; or
- Hydrocarbon spills from bulk fuel depots/marinas.

These sources are described in the following subsections, with reference to information collected for KIH on each source type.

2.1.1 Storm Sewers

One of the most prevalent sources of PAHs in the aquatic environment is urban runoff (Mackenzie and Hunter 1979). Urban streets act as repositories for particulate matter, and are therefore important sources of PAHs. Direct sources include, particulate automobile exhaust, lubricating oil residue, tire wear particles, abraded bitumen particles and coal tar used in road construction (Depree and Ahrens 2003; Rogge *et al*., 1993). Those derived from the combustion of fossil fuels and biomass are referred to as pyrogenic sources. Anthropogenic PAHs may also be derived from unburned petroleum, coal, and coal byproducts, and are referred to as petrogenic sources. Discrimination among these two broad categories of PAHs can yield valuable insights into potential sources.

Derry *et al*. (2003) conducted a review of storm sewer discharge from two storm sewers south of the Woollen Mill (nearest site 2010-5; Sites E1 and E2) and one storm sewer just north of the Kingston Marina (nearest to stations 2010-3, 2011-C, and 2010-4; Site F). These discharges are of interest due to their proximity to sediment PAH contamination and evidence for biological effects at several nearby stations (**Figure 1)**. Results of the analysis are presented in **Table 1**.

Concentrations of fluoranthene, pyrene and benzo(a)anthracene were found to exceed their respective Canadian Council of Ministers of the Environment (CCME) water quality guidelines (WQG; CCME 2011) by approximately five times at Site F, whereas stations closest to the Woollen Mill were found to have PCB and PAH concentrations below CCME WQGs. The results of Derry *et al*. (2003) indicate that PAHs may be a common constituent in the storm water entering the KIH but not likely at high enough concentrations to account for the concentrations of PAHs observed in the KIH sediment. THE CCME guidelines are highly conservative, and the minor exceedances observed at Site are not expected to result in sufficient mass loadings of PAHs to result in broad scale contamination above 15 mg/kg dw such has been observed in southwest KIH.

Table 1: Storm Sewer Samples Collected in 2001. Site E1 (storm sewer ST1200) and E2 (ST750) South of Woollen Mill and Site F North of Kingston Marina

	CCME WQG	Site E1	Site E2	Site F
Total PCBs	**0.001**		0.0005	0.0003
Phenanthrene	**0.4**	0.003	0.003	0.092
Fluoranthene	**0.04**	0.005	0.007	**0.174**
Pyrene	**0.025**	0.004	0.007	**0.133**
Benzo(a)anthracene	**0.018**	0.003	0.004	**0.080**
Chrysene		0.002	0.003	0.053
Benzo(b)fluoranthene		0.004	0.003	0.082
Benzo(k)fluoranthene		0.002	0.003	0.044
Benzo(e)pyrene		0.002	0.003	0.057
Benzo(a)pyrene	**0.015**	0.003	0.003	0.045
Perylene				0.018
Indeno(1,2,3-c,d)pyrene		0.005	0.004	0.072
Dibenzo(a,h)anthracene				0.021
Benzo(g,h,i)perylene		0.004	0.003	0.057
HPAH		0.035	0.039	0.837

Source: Derry *et al*. (2003)
All concentrations in µg/L

Recent improvements in the City sewer system have further decreased the potential for contamination to enter the harbour via storm sewers. Whereas combined sewer overflows occurred historically in Kingston, sewer upgrades have substantially decreased untreated flows to KIH. Combined sewers are a historical remnant located only in the older areas of the City, with all new development serviced by fully separated sewers (CH2M Hill 2010). In addition to local and trunk sewers, thirty-three pumping stations and two wastewater treatment plants (Cataraqui Bay and Ravensview) provide conveyance for sanitary and combined sewage, and nine combined sewage overflow facilities provide wet weather storage for combined sewage, reducing the volume of combined sewage discharged to receiving waters (CH2M Hill 2010).

2.1.2 Marine Traffic and Oil Spills

Marine traffic is unlikely to be a significant source of PAHs in southwest KIH, as it is not subject to heavy shipping traffic; however, Anglin Bay has historically been and continues to be used as a marina. The marina was also adjacent to two large bulk fuel depots that are no longer present in the area, one of which was known to be releasing petroleum products into the Bay (CH2M Hill 1991). While the date of the leakage is unknown, bulk fuel storage tanks have been in the area since the early 1900’s with the last of the tanks removed in the early 1990’s (MacLatchy 2013a, pers. comm.). It is possible that any number of unreported leakages could have occurred over this time period.

During operation of the Sowards Coal Company and Anglin Coal Company, the north shore of the bay was also used as an oiling dock (CH2M Hill 1991) and was a potential source of petrogenic PAHs.

2.2 Historical Sources of PAHs

2.2.1 Coal Yards

A significant potential source of petrogenic PAH contamination is the coal stockpiles historically placed along the KIH shoreline, which were not carefully managed, along with spillage from the loading/unloading of ships within the harbour. Tinney (2006) conducted a review of potential PAH sources in KIH and noted that coal yards were once located along the shore line of the inner harbour. These coal yards were suspected to be the source of PAHs detected along the lower west side of the inner and outer harbour (Tinney 2006).

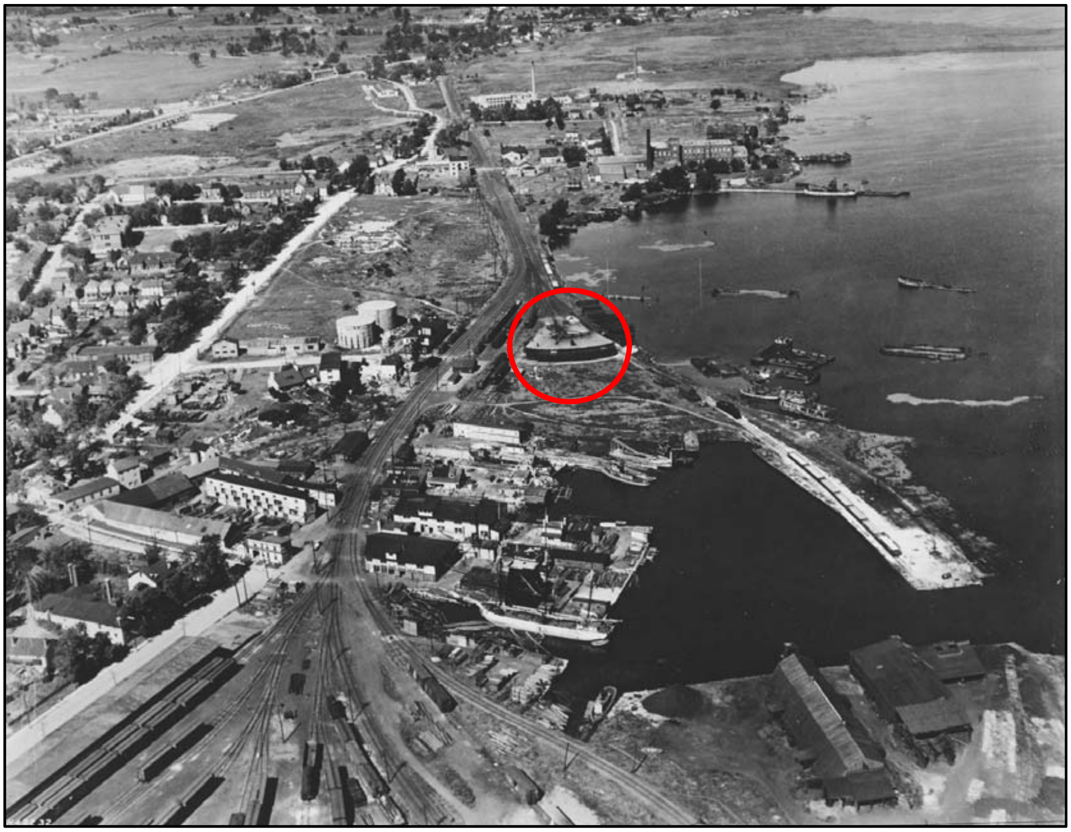
In 1908, the southern and western edges of Anglin Bay were reclaimed in order to install multiple rail lines and commercial buildings, including Anglin's Lumber Wood and Coal Yard (Osborne and Swainson 1988). The Canadian Dredge and Dock Company was the last major boat building company to operate in the area in operation until the 1980s. At that time, large oil storage tanks that had existed on the site were removed and the old coal yards were covered. Although these hydrocarbon sources would have included PAH contamination, they are not anticipated to be of a scale that would explain the broadly distributed PAH contamination in the southwestern KIH. Inferred sources of PAHs to the southwestern KIH are discussed further in Section 4.1.

2.2.2 Rail Yards

The waterfront near Anglin Bay served as a large rail yard for the Canadian National and Canadian Pacific railways (**Photograph 1**). The Canadian Pacific Railways built a four stall roundhouse at the foot of North Street (now part of Douglas Fluhrer Park) which served the rail yards (**Photograph 2**). The rail yard and roundhouse were located adjacent to the portions of the TC water lot that currently contain the highest PAH concentrations.

Water and Earth Science Associates Ltd. (WESA 2005) conducted a Phase I and Phase II environmental site assessment for a proposed development in the Kingston Marina and Douglas Fluhrer Park area. Results of groundwater and soil chemistry analyses indicated elevated concentrations of metals, petroleum hydrocarbons, PAHs and volatile organic compounds (VOCs), relative to Tables 1 and 3 of the Ontario Regulation 153/04, within the park area. It is believed that these contaminates are related to historical area uses, bulk fuel storage and the railway activities. Further evidence of railway impacts also includes petroleum impacted soils (below a depth of approximately 1.5 mbgs) and petroleum hydrocarbon and PAH contaminated groundwater along a portion of the former railway alignment in the vicinity of North Street and between Cataraqui and River Street (WESA 2003).

The main sources of PAHs in railway areas derive from substances used for rolling stock (locomotives, cars, *etc*.) such as machine grease, fuel and transformer oils, as well as from substances (most commonly creosote) used for the impregnation of wooden structures, including railway ties (Wilkomirski *et al*. 2012). Creosote is a complex mixture of over 200 compounds, predominantly PAHs, with phenolic and aromatic nitrogen and sulphur compounds, obtained by fractional distillation of crude coal tar. It can contain over 30 different PAHs with a possible total PAH content of 85% by weight (WHO 2004). Historical leakage due to poor housekeeping and spills of oils, hazardous materials, paints, solvents, and creosote from railroad ties, account for the majority of the contamination incurred in rail yards (US EPA 2013). It is likely that PAHs found within the sediments in front of Douglas Fluhrer Park are influenced by previous rail activity, either by direct deposit or by discharge through the storm sewers.



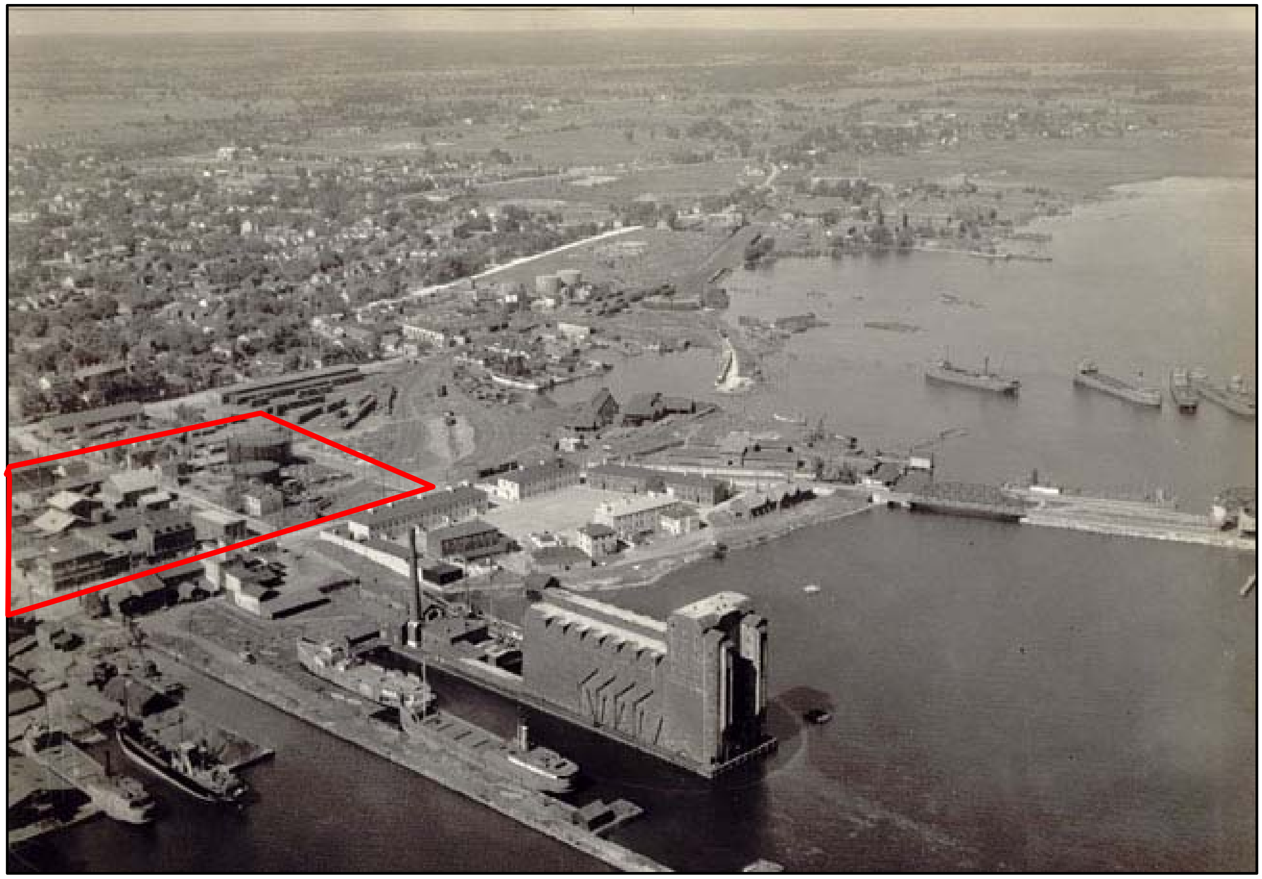
Photograph 1: Aerial photograph looking north showing Kingston Inner Harbour with the rail yard in the foreground and the roundhouse (circled in red) in the middle of the photo (c. 1924).

Photograph 2: Aerial photograph looking west showing large coal piles surrounding Anglin Bay, bulk fuel storage facilities (center right and top right), the edge of the rail yard to the left and the roundhouse to the right (c. 1951).

2.2.3 Coal Gasification Plant

A large coal gasification plant operated in the City of Kingston southwest of Anglin Bay from 1848 to the early 1950s (**Photograph 3**). The plant's principal function was to carbonize coal and oil to produce gas. A by-product of the gas extraction process was a thick black coal tar, some of which was used as a preservative for railway ties (CH2M Hill 1991). It is suspected that improperly managed coal tar may be a potential source of the PAH contamination in the KIH sediments within the area; however, contamination from this source does not explain the spatial extent of PAH contamination observed.

In 1999, the City of Kingston undertook a $2.2 million clean-up of the former coal gasification site by removing huge quantities of contaminated soil and groundwater as well as some unexpected pure coal tar. Early site investigations conducted by Intera Technologies Ltd. (1988) identified several areas on former plant site with coal tar waste. This included free coal tar and contaminated groundwater within the fractured limestone bedrock. It was concluded that groundwater in the bedrock would be sufficiently diluted upon reaching the receiving environment as to not be impacting the surface water or sediment quality in Anglin Bay or Lake Ontario. Subsequent study of the property indicated that contaminant concentrations in groundwater were unlikely to represent a significant environmental concern and that concentrations had been decreasing steadily since the 1988 study (Golder 1999).



Photograph 3: Aerial photograph looking northwest showing Kingston Inner Harbour with coal gasification plan (highlighted in red; c. 1925).

To confirm the assumptions from Intera (1988), CH2M Hill (1991) conducted an investigation to determine if coal tar was present in the sediment of Anglin Bay and the Queen Street Harbour. In both areas, significant quantities of coal tar were found in sediment at depths between 30 cm and 100 cm, with the highest total PAH concentrations (4,121 mg/kg in Anglin Bay; 9,979 ppm in Queen Street Harbour) found in close proximity to storm sewer discharges. The coal tar was found underlying soft, loosely consolidated sediment and appeared to be weathered, indicating that the coal tar had likely been deposited during the operation of the plant and was not associated with more recent discharges (CH2M Hill 1991). It was determined that the mostly likely pathway to explain the presence of the coal tar was direct deposit into Anglin Bay and the Queen Street Harbour via the storm sewers surrounding the plant during its operation. This finding indicates that there is a significant source of pyrogenic PAHs within sediments of Anglin Bay and the Queen Street Harbour.

Although discharge of coal tar contamination occurred in Anglin Bay, discharges into the sewers from the gasification plant area would not reach the drains north of Anglin Bay (MacClatchy 2013, pers. comm). The elevations of the drains in the catchment area north of Anglin Bay (*i.e.*, near Douglas Fluhrer Park) would have prevented contamination from reaching these locations.

2.3 Characteristics of PAH Contamination in Southwest KIH

Chemical fingerprinting (*i.e.*, chemometric analysis) is an environmental research method designed to reveal distinctive characteristics or patterns in environmental chemistry data. With respect to PAH contamination, the ratios and patterns among components can be used as an indicator of potential sources, degree of weathering, and type (pyrogenic versus petrogenic). Sediment PAH distributions typical of pyrogenic sources tend to show common molecular features including a dominance of four and five ring PAHs, whereas common characteristics of petrogenic sources are a series of two and three ringed parental and alkylated compounds (Abrajano *et al*. 2003). Individual PAH ratios such as those listed in **Table 2** may also be used to determine the PAH sources.

Table 2: Characteristic Values of Diagnostic PAH Ratios and KIH Sediment Results

			Anglin Bay (FFO)				Douglas Fluhrer Park -South			-North
Ratio	Pyrogenic	Petrogenic	2011-A	STATION 1	2011-B	STATION 2	STATION 3	2011-C	STATION 4	STATION 5
Phenanthrene/ Anthracene	<10	<15	3.1	2.9	1.4	1.2	2.5	1.6	1.0	5.6
Fluoranthene/pyrene	<1	<1	0.9	0.8	0.8	0.7	0.8	0.7	0.7	1.2
Benzo(a)anthracene/ Chrysene	<0.9	<0.4	0.8	0.7	0.8	0.9	0.8	0.9	0.9	0.6

Sediment PAH distributions of KIH sediment within the areas of interest tend to have higher concentrations of four and five-ringed PAHs as compared two and three ringed PAHs (**Figure 2**). The phenanthrene/anthracene ratio of sediment at stations closest to the shoreline (Anglin Bay Stations 2011-A and Station 1; Douglas Fluhrer Park-South Station 3; Douglas Fluhrer Park-South Station 5) range from 2.5 to 5.6. Using the diagnostic ratios from Abrajano *et al*. 2003 these data are indicative of PAHs of pyrogenic origin. The phenanthrene/anthracene ratio is somewhat reduced at stations further from the shoreline to ratios between 1.2 and 1.6; **Table 2**). The fluoranthene/pyrene ratios for most sites were less than one; however, because degradation and/or re-partitioning may result in significant post-depositional changes in 2 and 3-ring PAH compounds, benzo(a)anthracene/chrysene ratios considered a more useful indicator (McCready *et al*. 2000; Depree and Ahrens 2003). Benzo(a)anthracene/chrysene ratios were between 0.6 and 0.9 for all sites, suggesting either a pyrogenic or mixed source of PAHs. Overall, the evidence indicates that PAHs in sediment are mainly the result of pyrogenic sources.

3.0 PCB SOURCES

Contamination of sediments by PCBs has been documented in the Parks Canada waterlot of KIH, associated with leachate from the former Belle Landfill. Golder (2011b) provides a review of pathways for this portion of the harbour. However, the Parks Canada water lot is located well to the north of the southwest corner of KIH where elevated PCBs have been observed in sediment. Furthermore, the pattern of PCB contamination in surface sediment indicates that the contamination in the southwest zone is separated from the Parks Canada water lot by an area of lower PCB concentrations. This suggests that the two areas are influenced by different PCB sources.

The City of Kingston and OMEE (2005) conducted investigations (*i.e.*, PCB Trackdown Study) along the western shore of KIH to determine if PCBs are present within the groundwater. The project included installation of monitoring wells, well development, hydraulic conductivity testing, and groundwater sampling and analyses.

Overall, PCB concentrations within the shallow groundwater zone were observed to be low. Average PCB results were highest from wells at Davis Tannery (2.4 ng/L) and the River Street Pumping Station/Rowing Club area (2.3 ng/L). These areas are located north of the zone of sediment in southwest KIH with elevated sediment chemistry. PCB concentrations were observed to be lowest from the vicinity of the Woollen Mill (0.74 ng/L). An infra-red thermal imagery survey of the Inner Harbour did not identify areas of obvious and significant groundwater discharge. Overall, the PCB Trackdown Study did not identify any significant on-going source of PCBs to the Inner Harbour due to groundwater discharging into the TC water lots, and PCBs in river sediment were concluded to be the result of historical sources.

Aside from the landfill, there are two additional properties that may have contributed to the PCBs found in the KIH sediment (MacLatchy 2013b, pers. comm.):

- Cohen and Company Ltd. operated a scrap yard and steel distributorship on Montreal Street that dismantled transformers and batteries; and
- Harold’s Demolition located south of the Woollen Mill that dismantled transformers.

While exact dates of these activities are unavailable, it is most likely that recycling transformers at both of these properties took place between the 1970’s up to the early 1980’s.

It is possible that poor PCB handling practices at both sites may have led to the discharge of PCBs through the storm sewer system. Storm sewer discharge from the Cohen property would have entered KIH through the Kingscourt outfall north of the study area, whereas discharge from Harold’s Demolition would have entered KIH in the vicinity of Douglas Fluhrer Park (**Figure 1)**.

Aside from the above, no point sources of PCBs were identified that would explain the observed distribution of PCBs in sediment. It is unlikely that storm sewers would contribute significant masses of PCBs to KIH sediment because PCBs are not associated with vehicle sources of other street runoff constituents.

4.0 STUDY CONCLUSIONS

4.1 Inferred Sources

Historical sources from the rail yard and coal gasification plant have likely contributed to the majority of PAHs observed. Although the overall contribution of sediment PAHs from the rail yard and roundhouse areas are unknown, the spatial extent of contamination, PAH composition, and type of industrial activity all suggest that rail yard activities played a significant role in contaminating the adjacent water lots of KIH. Within Anglin Bay, migration of PAHs from the large deposits of weathered coal tar historically transported via storm sewers are also expected to be responsible for the PAH concentrations found in nearby sediments. These historical contributions are expected to represent the bulk of the observed PAH contamination, with ongoing sources representing only a minor component.

Despite the historical presence of coal activities adjacent to the foreshore of southwest KIH, the chemometric analysis of sediment chemistry data does not support the hypothesis of these sources being the dominant pathway for PAH contamination currently observed in southwest KIH. Of the potential sources identified, only urban run-off, creosote/coal tar contributions from the historical rail activities, and coal tar from the coal gasification plant are pyrogenic sources. Urban runoff through storm sewers is not expected to result in major contributions to the sediments within KIH. Although some contamination would be captured in municipal storm drains that are not connected to the municipal sanitary system, the concentrations observed in previous monitoring do not implicate these point sources as the cause of the broad-scale PAH contamination observed in the harbour. PAH contamination is also observed in the west-central zone of KIH (Parks Canada water lot) adjacent to the Orchard Street marsh and the Kingscourt storm sewer discharge point; however, the spatial extent of PAH contamination is not as large as in the southwest corner of KIH, suggestive of different sources.

4.2 Implications for Management

The results of this investigation indicate that historical (legacy) sources, rather than ongoing sources, are primarily responsible for the observed pattern of sediment contamination in the Transport Canada water lots of KIH. Accordingly, the next steps are:

1) Develop risk-based sediment benchmarks associated with different levels of environmental impairment in southwest KIH. These benchmarks should consider lines of evidence from the following risk assessment components:

    a. Risk to invertebrates from PAHs as indicated in the DQRA (Golder 2012a);

    b. Risk to fish from PAHs and/or PCBs as indicated in the evaluation of fish lesions (Golder 2013); and

    c. Human health risks from consumption of PCB contaminated fish by recreational fishers – this assessment should incorporate simultaneous consideration of exposures from Parks Canada and Transport Canada water lots, as both properties contain elevated PCBs and would influence exposure to fish that forage throughout KIH. Our understanding is that the risk assessment and remedial options evaluations for the Parks Canada zone (RMC 2011a,b) are currently under revision based on recent data collections and feedback from Expert Support.

2) Delineate surface sediment contamination for PCBs and PAHs in southwest KIH at a scale suitable for preliminary remedial design. Currently, the spatial resolution of sediment samples adjacent Douglas Fluhrer Park is coarse, precluding specification of a zone for which intrusive management is required. The historical sources, including rail yard operations, appear to have extended over a large section of shoreline, without clear indications of “hotspots.” The storm sewer discharge points could be elevated relative to outlying areas, in the event that historical dumping of wastes entered the storm sewer system; accordingly these areas should be sampling at higher density.

3) Conduct core sampling for a subset of locations to indicate the depth of dredging required, and to evaluate whether contaminants at depth could be exposed through mechanical disturbance and/or bioturbation.

4) Evaluate the stability of surface sediments in the area of potential dredging, both through natural processes (erosion/deposition) and disturbance through marine activities.

5) Develop a preliminary remedial options analysis, in various remediation scenarios are explored in terms of absolute risk and degree of risk reduction, suitable for consideration by risk managers.

5.0 CLOSURE

We trust that this documentation is sufficient for your current needs. Should you have any questions or concerns, please do not hesitate to contact the undersigned at 604-296-4200.

Yours very truly,

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

Shawn Seguin, B.Sc., R.P.Bio.
Environmental Scientist

ORIGINAL SIGNED

Gary Lawrence, M.R.M., R.P.Bio.
Associate, Senior Environmental Scientist

SRS/GSL/syd

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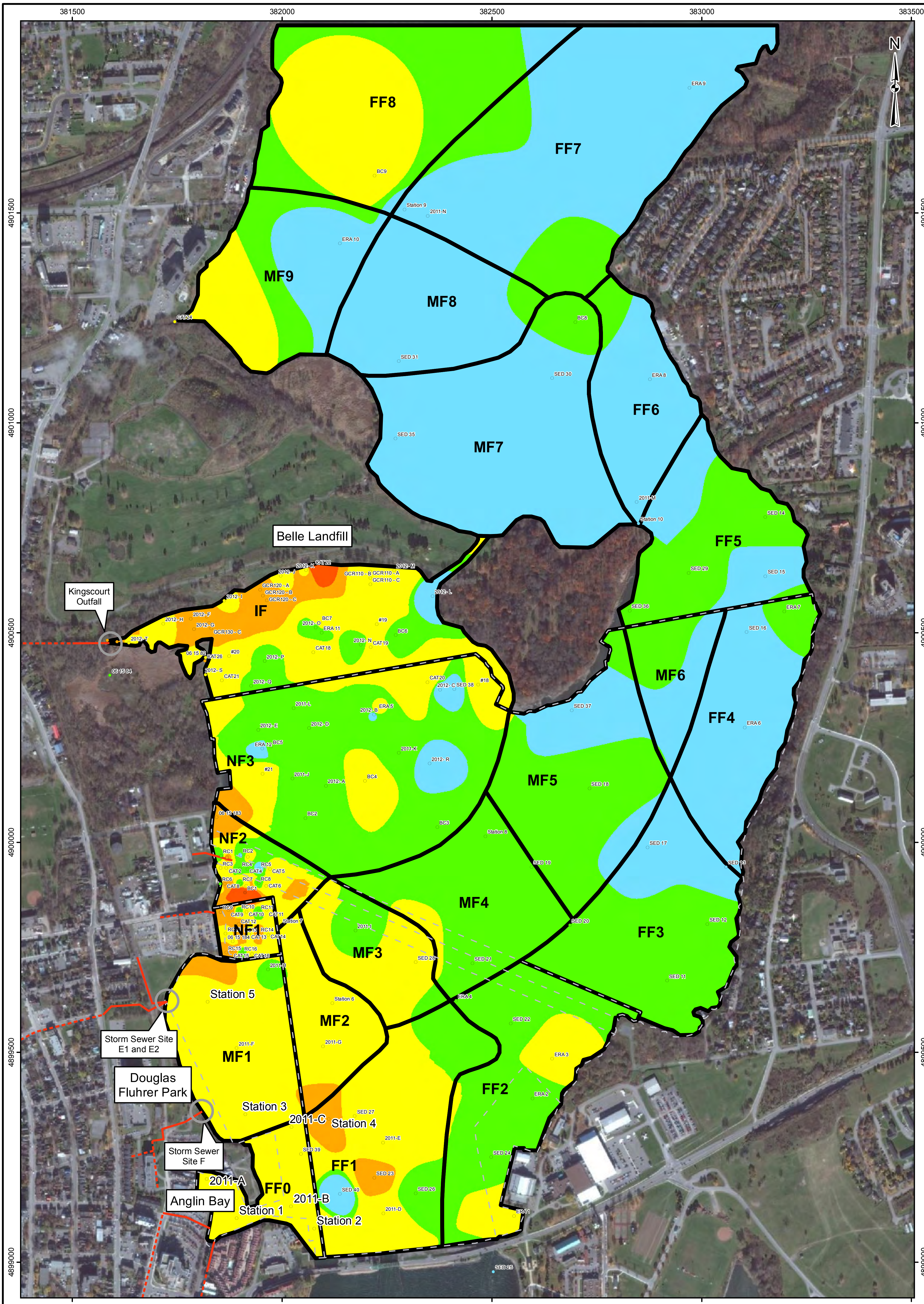

LEGEND

- Harbour Grid
- Transport Canada Property Boundary
- Approximate Storm Sewer Alignment

Total PAH

- 0 - 1.61 mg/kg
- 1.61 - 4 mg/kg (<LEL)
- 4 - 15 mg/kg
- 15 - 50 mg/kg
- 50 - 740 mg/kg (<SEL)
- > 740 mg/kg

200 0 200

SCALE 1:8,500 METRES

NOTE

IF Inner Field
NF Near Field
MF Mid Field
FF Far Field

REFERENCE

Water features obtained from Natural Resources Canada. Orthophoto obtained from Bing Maps for ArcGIS published by Microsoft Corporation, Redmond, WA, May 2009.
Projection: UTM Zone 18 Datum: NAD 83

PROJECT

PWGSC
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE

TOTAL PAH BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2003-2012)

Golder Associates
Greater Vancouver Office, B.C.

PROJECT NO. 13-1421-0002			PHASE No.	
DESIGN	SS	21 Mar. 2013	SCALE AS SHOWN	REV. 0
GIS	DSC	25 Mar. 2013	**FIGURE 1**	
CHECK				
REVIEW				

N:\Bur-Graphics\Projects\2013\1421\13-1421-0002\GIS\Mapping\MXD\WaterQuality\figure-1_total-pah.mxd

FIGURE 2

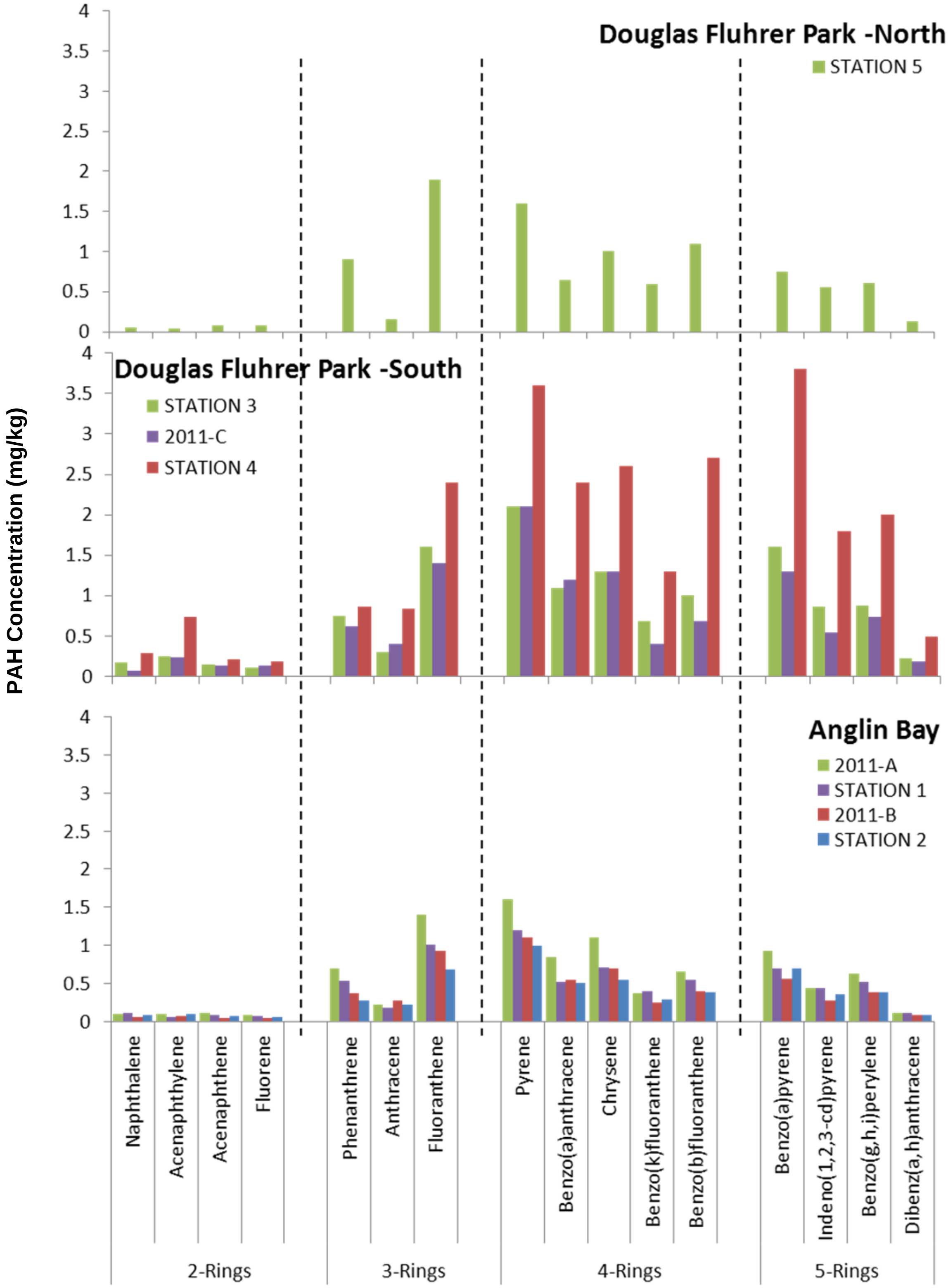

Figure 2: Distribution of PAHs with Douglas Fluhrer Park North and South Sediment and Anglin.