UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

REPLY TO THE ATTENTION OF:
SR-6J

March 6, 2013

Naren M. Prasad, P.E.
Senior Environmental Engineer
Integrys Business Support, LLC
130 East Randolph Drive, 22nd Floor
Chicago, Illinois 60601

Re: Administrative Order on Consent (V-W-08-917)
Technical Memorandum – Data Evaluation for North Branch Sediment Sampling (Rev. 2)
Willow Street/Hawthorne & Division Street Station Former MGP Sites

The U.S. Environmental Protection Agency (EPA), with assistance from the Illinois Environmental Protection Agency, has reviewed the subject document dated February 20, 2013. We have determined the changes made in the document satisfactorily addressed our December 13, 2012 comments and subsequent discussions on the subject. Based on this determination, the subject document is approved, in accordance with Section X, Paragraph 38 of the Administrative Order of Consent. Please proceed with Step 2 work on the affected north branch sites, including North Station.

Your attention on this matter is appreciated. If you have any questions, kindly bring it to my attention. I can be reached at 312-886-6195.

Sincerely,

R. del Rosario

Ross del Rosario
Remedial Project Manager

CC: Doyle Wilson, IEPA
David Klatt, CH2M Hill

NATURAL
RESOURCE
TECHNOLOGY
ENVIRONMENTAL CONSULTANTS

300 SOUTH WACKER DRIVE, SUITE 2050
CHICAGO, IL 60606
(P) 312.465.1740
(F) 262.523.9001

Mr. Ross del Rosario
USEPA Region 5 – SR-6J
77 W. Jackson Boulevard
Chicago, Illinois 60604-3590

February 20, 2013
(2069)

RE: Response to USEPA Comments on Technical Memorandum Step I Data Evaluation for North Branch Sediment Sampling, Revision 1
Willow Street/Hawthorne Avenue Station and Division Street Station Former MGPs, North Branch Site, Chicago, Illinois
The Peoples Gas Light and Coke Company

CERCLA Docket No. V-W-08-C-917
CERCLIS ID – ILN000510194 (Division)
Site Spill ID – B5FY (Willow) and B5HN (Hawthorne)
CERCLIS ID – ILD982074759 (Willow) and ILN000510195 (Hawthorne)

Dear Mr. del Rosario,

On behalf of Integrys Business Support, LLC (IBS), Natural Resource Technology, Inc. (NRT) is providing the enclosed two hard copies and two CD copies of the *Technical Memorandum Step I Data Evaluation for North Branch Sediment Sampling, Revision 2* (Technical Memorandum, Rev 2), for the Peoples Gas Light and Coke Company's (PGL) Willow Street/Hawthorne Avenue Station and Division Street Station Former Manufactured Gas Plants (MGP).

The enclosed document has incorporated USEPA's comment dated December 13, 2012 on the Technical Memorandum Step I Data Evaluation for North Branch Sediment Sampling, Revision 1. For ease of review, the comments received from USEPA is presented below in *italics*, followed by the response from IBS and summary of associated elements in the Technical Memorandum, Rev 2, where applicable.

Comments

USEPA Comment. *The total P AH (13) UTL should be recalculated and a re-evaluation of site-specific concentrations against background should be performed. EPA reviewed data found in Attachment B-2 to identify potential outliers in the total dataset. Our preliminary analysis using the Agency's ProUCL Version 4.0 indicated that a sample, designated as ACR-12, is a statistically significant outlier at the 1%, 5%, and 10% significance levels (see attached). Consequently, this sample should not be used to calculate ambient statistics, including the ambient PAH (13) UTL which initially yielded a value of 665 mg/kg. To assist Integrys, the ProUCL output included in this letter generated a value (472 mg/kg) which does not include ACR-12. We believe this revised calculated value to be a more accurate representation of the total P AH (13) UTL for this dataset.*

RESPONSE:
Revised UTLs with Outliers Removed

As requested, the upper tolerance limits (UTL) for total PAH (13) for the ambient data set have been updated by removing samples that were determined to be outliers at the 5% significance level. The attached Technical Memorandum, Rev 2, has been updated to include these revised total PAH (13) UTLs; the sample-by-sample comparison to the UTLs has been updated (Tables 9−12), and the comparison of the means between the ambient data set (with outliers removed) and the site-specific data sets have been updated (Enclosure C).

Surface Sample Grouping

Prior to performing the outlier evaluation for the total PAH (13) of the ambient data set, the surface sediment grouping of the data set was expanded from 0−0.5 ft below mudline to 0−1.5 ft below mudline. By expanding the depth range this way, the ambient data set groupings are now consistent with the site-specific data set groupings. As before, these groupings are used to compare the data sets. It should be noted that only one outlier was identified in the ambient surface sample grouping; the same outlier was noted whether the analysis was run on the original (0−0.5 ft below mudline) grouping or the expanded (0−1.5 ft below mudline) grouping.

Separate UTLs for Surface and Subsurface Samples

Statistical analysis of the total PAH (13) ambient data set concluded that concentrations of total PAH (13) in surface sediment (0- to 1.5-ft depth interval) were significantly lower than concentrations measured in subsurface sediment (> 1.5 ft below mudline). The comparison of total PAH (13) concentrations in surface and subsurface sediment is provided in Enclosure B of the Technical Memorandum, Rev 2. The comparison of surface and subsurface data was performed twice; once using all samples and once with the outliers removed. The conclusion that concentrations of total PAH (13) in surface sediment is significantly lower than in subsurface sediment was the same for each comparison. Because of this difference, separate total PAH (13) UTLs have been developed for surface and subsurface sediments. These UTLs were used to update the sample-by-sample comparison in Technical Memorandum, Rev 2 (Tables 9−12).

Step II Sediment Sampling Plan Updates

The lower total PAH (13) UTLs developed with the outliers removed have been used as the guide for the Step II sediment investigation proposed in Technical Memorandum, Rev 2. Two subsurface samples that previously did not exceed the total PAH (13) UTL, now exceed the revised total PAH (13) for subsurface sediment. Both samples were in boring PCA-20WHS (Table 12, Figure 5). This location had already been scheduled for resampling due to the depth of clay. Three additional borings will be advanced surrounding PCA-20WHS to further characterize the concentration of PAHs in that area (Figure 7).

Please contact Mr. Naren Prasad of IBS at 312.240.4569 if you should have any questions regarding the content of this letter or the enclosed document.

Sincerely,

NATURAL RESOURCE TECHNOLOGY, INC.

Sarah Meyer
Senior Scientist/Project Manager

Jennifer M. Kahler

Jennifer M. Kahler, PE
Senior Engineer

Enc: *Technical Memorandum Step I Data Evaluation for North Branch Sediment Sampling, Revision 2*

cc: Mr. D. Wilson, IEPA
Mr. Naren Prasad, IBS
Mr. David Klatt, CH2MHill

[File:\2069 Tech Memo R2 TRANSLTR]

TECHNICAL MEMORANDUM

Date: **February 20, 2013**

To: **Ross del Rosario, USEPA Region 5**

From: **Sarah Meyer and Jennifer Kahler, Natural Resource Technology, Inc.**

Subject: **Step I Data Evaluation for North Branch Sediment Sampling**
North Branch Chicago River
Willow Street/Hawthorne Avenue Station and Division Street Station Former MGPs
The Peoples Gas Light and Coke Company

CERCLA Docket No. V-W-08-C-917
CERCLIS ID – ILN000510194 (Division)
Site Spill ID – B5FY (Willow) and B5HN (Hawthorne)
CERCLIS ID - ILD982074759 (Willow) and ILN00510195 (Hawthorne)

This Technical Memorandum, Revision 2, presents a summary and analysis of data obtained during the surface water and Step I sediment sampling at the Division Street Station (Division) and Willow Street/Hawthorne Avenue Station (Willow/Hawthorne) Former Manufactured Gas Plant (MGP) Sites performed from December 12, 2011 through February 15, 2012. Sampling was conducted on behalf of Integrys Business Support, LLC (IBS) and The Peoples Gas Light and Coke Co. (PGL). A summary and analysis of data obtained during the North Branch Chicago River ambient sediment sampling is also included. In addition, this Technical Memorandum provides supplemental details for Step II sediment sampling at these sites.

The United States Environmental Protection Agency (USEPA) approved the Site-Specific Work Plans (SSWP) for the Division Street Station Former MGP (Revision 1, September 21, 2009) and Willow/Hawthorne (Revision 2, July 15, 2012) Sites that were used for this work. This technical memorandum is presented to provide the approach for Step II sediment sampling to further characterize sediment conditions at the Sites. The characterization activities will be performed in accordance with the USEPA-approved SSWPs and the Administrative Order on Consent (AOC) and Statement of Work (SOW), Comprehensive Environmental Response, and Compensation and Liability Act (CERCLA) Docket No. V-W-08-C-917, dated October 31, 2008. This document is not intended to provide a complete data summary; further data analysis will be conducted as the Remedial Investigation (RI)/Feasibility Study (FS) process continues.

Due to their proximity to each other and position on the North Branch of the Chicago River (River), Step I sampling was conducted for the Division and Willow/Hawthorne Sites concurrently. The North Station Former MGP Site, also nearby and on the River, did not have an approved SSWP at the time this work was conducted. Step I sediment and surface water sampling for the North Station Former MGP Site will be conducted during a future sampling event.

Step I Data Summary

Natural Resource Technology, Inc. (NRT) completed surface water and Step I sediment sampling at the Sites according to the approved SSWPs from December 12, 2011 through February 15, 2012. The purpose of the Step I sampling was to characterize the magnitude and extent of surface water and sediment potentially affected with MGP residuals and to provide data to support human and ecological risk evaluations. Surface water and sediment samples were submitted to Pace Analytical and Test America laboratories for analysis of the site-specific constituents of potential concern (COPC) per the SSWPs. Shepherd Technical Services validated the data packages.

Surface Water

Surface water samples were collected using a peristaltic pump with the tubing attached to a pole, and submitted for laboratory analysis in accordance with the approved SSWPs for the Division and Willow/Hawthorne Sites. Samples were collected adjacent to and upstream of the former MGP property boundaries (Figures 1-3) in December 2011. Samples designated SWA-#DVS (Division) and SWA-#WHS (Willow/Hawthorne) were collected in the site-specific ambient (or upstream) areas of the former MGP property boundaries. Samples designated SWS-#DVS (Division) and SWS-#WHS (Willow/Hawthorne) were collected adjacent to and immediately downstream of the former MGP property. Samples were analyzed for site-specific COPCs and results are compared to residential groundwater and ecological screening levels and presented in Tables 1 and 2.

Sediment

Sediment borings and samples were collected and analyzed in accordance with the approved SSWPs for the Division and Willow/Hawthorne Sites. Sediment borings were completed adjacent to, upstream, and downstream of the former MGP property boundaries in January and February 2012. Sediment borings were advanced to a maximum depth of 16.5 feet below mudline, the depth permitted for this work by the nationwide permit (U.S. Army Corps of Engineers, Illinois EPA and Illinois Department of Natural Resources), and the City of Chicago’s Office of Underground Coordination. Borings were advanced with a drill rig equipped with hollow-stem augers from a barge and continuously sampled from the mudline to native clay with split-spoon samplers. In general, sediment consisted of silt with varying amounts of coal pieces, wood debris, sand and gravel overlaying lean clay.

A summary of sediment field observations and analytical results are presented in this section and on Figures 4 and 5 and Tables 3 through 8. Boring logs are located in Enclosure A.

Location and Depth of Non-Aqueous Phase Liquid (NAPL):

- Division – NAPL in the form of oil-wetted or oil-coated sediment was observed in nine cores at locations no further downstream than STA-11DSS and the approximate downstream edge of the former MGP property boundary. At all nine locations (STA-2DSS, -5DSS, -6DSS, -7DSS, -8DSS, -9DSS, -11DSS, -24DSS and -30DSS), the oil-wetted or oil-coated sediment was observed on top of lean clay at depths ranging from 2.5 to 15.5 feet below mudline. The oil-wetted or oil-coated sediment thicknesses ranged from 0.1 to 4 feet, but generally 1 foot or less, and penetrated into the upper clay in some locations.

- Willow/Hawthorne - NAPL in the form of oil-wetted or oil-coated sediment was observed in one location (PCA-13WHS) near the shoreline adjacent to the former MGP property. The oil-wetted or oil-coated silt was observed from 8.5 to 14.5 below mudline, just above lean clay.

Depth of Clay:

- Division – Borings reached clay at depths ranging from 6.5 to 16.5 feet below mudline. At five locations (STA-1DSS, STA-4DSS, STA-19DSS, STA-21DSS, and STA-22DSS) the boring reached 16.5 feet below mudline, but did not terminate in clay. At five locations (STA-14ADSS, STA-23DSS, STA-25DSS, STA-26DSS, and STA-38DSS) the borings reached a maximum of 3.5 feet below mudline, but did not terminate in clay. Refer to the cross sections on Figure 4 and boring logs in Enclosure A.

- Willow/Hawthorne - Borings reached clay at depths ranging from 11.1 to 16.4 feet below mudline. At nine locations (PCA-3WHS, PCA-5WHS, PCA-11AWHS, PCA-15WHS, PCA-16AWHS, PCA-19WHS, PCA-20WHS, PCA-21WHS, and PCA-24WHS) the boring reached 12.5 to 16.5 feet below mudline, but did not terminate in clay. At another two locations (PCA-17WHS and PCA-22WHS) the borings reached a maximum of 3.5 feet below mudline, but did not terminate in clay. Refer to the cross sections on Figure 5 and boring logs in Enclosure A.

Total PAHs (Sum of 13):

- In Surface Sediment (0-1.5 feet below mudline)
  - Division - Ranged from 4,800 to 878,000 µg/kg (arithmetic mean 53,000 µg/kg; geometric mean 36,000 µg/kg).
  - Willow/Hawthorne - Ranged from 4,290 to 207,000 µg/kg (arithmetic mean 77,000 µg/kg; geometric mean 63,000 µg/kg).
- In Subsurface Sediment (greater than 1.5 feet below mudline)
  - Division - Ranged from 430 to 23,400,000 µg/kg (arithmetic mean 400,000 µg/kg; geometric mean 40,000 µg/kg).
  - Willow/Hawthorne - Ranged from 540 to 12,900,000 µg/kg (arithmetic mean 400,000 µg/kg; geometric mean 65,000 µg/kg).
- Locations of Maximum Total PAHs in Surface Sediment (Tables 9 and 11)
  - Division - At location STA-3DSS on the west side of the channel and upstream of the former MGP property boundary and the Division Street Bridge, in silt at a depth of 0.5 to 1.5 feet below mudline.
  - Willow/Hawthorne - At location PCA-13WHS on the east side of the channel and adjacent to the former MGP property, in silt at a depth of 0 to 0.5 feet below mudline.

- Locations of Maximum Total PAHs in Subsurface Sediment (Tables 10 and 12)
    - Division - At location STA-24DSS on the east side of the channel, across from the former MGP property, in silt at a depth of 2.5 to 3.5 feet below mudline. MGP-like odor and NAPL in the form of oil-wetted/oil coated sediment was observed in from 2.5 to 6.5 feet below the mudline.
    - Willow/Hawthorne - At location PCA-15WHS on the east side of the channel and adjacent to the Site, in silt at a depth of 15.5 to 16.5 feet below mudline. Trace sheen and odor were noted at depths of 8.5 to 16.5 feet below mudline (End of Boring [EOB]) at this location.

Metals and Cyanide:

- Concentrations in Surface Sediment (0-1.5 feet below mudline)
    - Division - Detected concentrations of metals and cyanide ranged from 0.21 to 2,800 mg/kg.
    - Willow/Hawthorne - Detected concentrations of metals ranged from 0.28 to 32,300 mg/kg.
- Concentrations in Subsurface Sediment (greater than 1.5 feet below mudline)
    - Division - Detected concentrations of metals ranged from 0.024 to 2,480 mg/kg.
    - Willow/Hawthorne - Detected concentrations of metals ranged from 0.02 to 174,000 mg/kg.
- Locations of Maximum Concentrations in Surface Sediment – Division (Table 9)
    - Adjacent to Former MGP Property – Maximum beryllium, copper, cyanide, lead, nickel, and silver concentrations are at locations STA-6DSS through STA-9DSS and STA-31DSS. These borings, except STA-31DSS, contained oil-wetted/oil-coated sediment and are located on the west side of the channel.
    - Upstream of Former MGP Property and Division Street Bridge – Maximum barium, cadmium, chromium, mercury, selenium, and zinc concentrations are at locations STA-1DSS and STA-2DSS. These borings are located on the west side of the channel. Boring STA-2DSS contained oil wetted/oil coated sediment.
    - Downstream of Site – The maximum arsenic concentration is at location STA-19DSS. This boring is located on the west side of the channel.
- Locations of Maximum Concentrations in Surface Sediment - Willow/Hawthorne (Table 11)
    - Adjacent to Former MGP Property – Maximum arsenic, barium, cadmium, chromium, cyanide, iron, lead, mercury, selenium, and zinc concentrations are at locations PCA-10WHS, PCA-12WHS, and PCA-17WHS.
    - Upstream of Former MGP Property – Maximum antimony, copper, and manganese concentrations are at locations PCA-2WHS and PCA-4WHS. These borings are located on the west side of the channel.
    - Downstream of Former MGP Property – The maximum aluminum, nickel, silver and vanadium concentrations are at location PCA-22WHS, PCA-23WHS, and PCA-26WHS.

- Locations of Maximum Concentrations in Subsurface Sediment – Division (Table 10)
    - Adjacent to Former MGP Property – Maximum arsenic, barium, and nickel concentrations are at locations STA-4DSS, STA-6DSS, and STA-24DSS. Borings STA-4DSS and STA-6DSS are located on the west side of the channel and STA-24DSS is located on the east side of the channel. Oil-wetted/oil coated sediment was observed in boring STA-24DSS.
    - Upstream of Former MGP Property and Division Street Bridge – Maximum chromium, mercury, selenium, and silver concentration are at locations STA-1DSS, STA-2DSS, and STA-22DSS.
    - Downstream of Former MGP Property - Maximum beryllium and cyanide concentrations are at locations STA-36DSS and STA-18DSS.
    - Far downstream of Former MGP Property – Maximum cadmium, copper, lead, and zinc concentrations are at locations STA-41DSS and STA-42DSS. These borings are located on the east side of the channel.
- Locations of Maximum Concentrations in Subsurface Sediment - Willow/Hawthorne (Table 12)
    - Adjacent to Former MGP Property – Maximum arsenic cadmium, copper, cyanide, lead, nickel, and selenium concentrations are at locations PCA-5WHS, PCA-11AWHS, PCA-13WHS, and PCA-14WHS.
    - Downstream of Former MGP Property and North Avenue Bridge – Maximum aluminum, antimony, barium, chromium, iron, manganese, mercury, silver, vanadium, and zinc concentrations are at locations PCA-20WHS, PCA-23WHS, PCA-25WHS and PCA-26WHS.

Step I Data Analysis and Discussion

The purpose of the Step I sampling was to characterize the magnitude and extent of surface water and sediment potentially affected with MGP residuals and to provide data to support human and ecological risk evaluations. The Step I data analysis is presented prior to Step II sampling, which will be implemented to further delineate potential MGP residuals and focus on defining the incremental PAH contributions from MGP residuals at the sites.

Surface Water

Results from surface water sampling have been compared to residential groundwater screening levels (SL) and ecological benchmarks (Tables 1 and 2). Because there are no generic construction worker and recreational user SLs for surface water constituents, the residential groundwater SLs are used as a conservative screen. Ecological benchmarks were established in the USEPA-approved Multi-Site Risk Assessment Framework (Exponent, 2007).

No results exceed residential groundwater SLs in either the Division or Willow/Hawthorne data sets. Concentrations of two PAHs (i.e., benzo(a)anthracene and benzo(a)pyrene) exceed ecological benchmarks at both Sites. At Division, some samples both upstream and adjacent to the former MGP property exceed the ecological benchmarks for benzo(a)anthracene and benzo(a)pyrene. At Willow/Hawthorne, some upstream samples exceed the ecological benchmark for benzo(a)anthracene, and some samples both upstream and adjacent to the former MGP property exceed the ecological benchmark for benzo(a)pyrene.

No additional analysis of surface water data has been prepared at this time. Further analysis will be included as part of the RI Report.

Sediment

This section provides a preliminary analysis of the Step I sediment investigative data collected at the Division and Willow/Hawthorne Sites. The results of the data analysis are used in part to determine if additional Step II sediment investigations (e.g., additional sediment sampling or sediment toxicity testing) are necessary to fill data gaps from the Step I sediment investigation.

In 2011, an ambient sediment investigation was performed upstream of the North Branch MGP Sites to characterize ambient sediment quality in the River. The ambient sediment sampling approach was included as Appendix E of the Division Site SSWP and Appendix D of the Willow-Hawthorne Site SSWP. The results and analysis of the ambient sediment investigation data, including a discussion of ambient sediment toxicity, are provided in Enclosure B. The ambient investigation was performed to:

1) Characterize the ambient concentrations of potentially MGP-related COPCs in the River unrelated to influences of MGP activities.
2) Evaluate if sediment toxicity would be a useful tool for characterizing ecological risk zones at the downstream North Branch MGP Sites.

Results of the ambient investigation indicate that the River upstream of the North Branch MGP Sites, and away from the influence of the former MGPs, is polluted with relatively high concentrations of total PAHs and metals. The concentrations of total PAHs and many of the metals in sediment of the ambient study area are orders of magnitude above their respective screening-level ecological benchmarks used in the ecological risk assessment. For this reason, accounting for degraded ambient conditions of the River is an important point of comparison relative to conditions at the Sites. In addition, the sediments tested during the ambient investigation exhibited a moderate degree of aquatic toxicity based on the results of the sediment toxicity testing. This indicates that ambient conditions of the River are associated with some level of toxicity to ecological receptors. The details of the ambient investigation data analysis are summarized in Enclosure B.

Ambient Zone Evaluation

The ambient investigation was performed to establish ambient sediment conditions. As discussed in Enclosure B, results of the investigation are to be compared against the results of the Step I sediment sampling at the Sites and used to identify a zone of sediment at each of the Sites where COPC concentrations are clearly above those in ambient sediment. Furthermore, if this condition exists, then sediment toxicity testing as part of the Step II sediment investigation at the Sites is to be considered. The comparison of the results of the ambient investigation and Step I sampling at the Sites is provided in the next section.

Development of and Comparison to Upper Tolerance Limits

The ambient investigation results were used to develop upper tolerance limits (UTL) for the ambient data set. The UTLs are analyte-specific concentration limits above which analyte concentrations in samples collected at a downstream MGP site are more likely to be due to MGP sources (e.g., MGP residuals) than ambient conditions. Analyte concentrations above the UTL indicate a sample location where MGP-related residuals are potentially present. Conversely, if the analyte concentrations are below the UTL at a site location, the analyte concentrations are more likely to indicate ambient conditions rather than an influence from the former MGP. The UTLs were developed based on surface sediment samples for metals and surface and subsurface samples for total PAHs as specified in Enclosure B. It should be noted that for total PAHs, surface and subsurface sediment concentrations were statistically different, so a separate UTL was developed for each depth grouping. A summary of the UTLs is included as Table B-4 of Enclosure B.

UTLs developed for the ambient sediment data set for total PAHs and metals were used to identify samples at each Site with analyte concentrations above their respective UTL. Comparisons are divided into surface samples (0 to 1.5 feet below mudline) and subsurface samples (greater than 1. 5 feet below mudline) from the Sites. The surface and subsurface sample results above each UTL are summarized, respectively, in Tables 5 and 6 for the Division Site, and Tables 7 and 8 for the Willow/Hawthorne Site. Sample-by-sample comparisons to UTLs for each Site by depth category (surface or subsurface) are provided in Tables 9 through 12.

Based on the comparison of Step I site sediment data to the total PAH(13) UTLs (342 mg/kg [surface] and 410 mg/kg [subsurface]), there was a limited number of surface and subsurface samples that exceeded the surface or subsurface UTLs. At the Division Site, total PAH(13) in only 1 of 86 surface sediment samples and 7 of 105 subsurface sediment samples exceeded the UTL. At the Willow Hawthorne Site, no total PAH(13) in surface sediment samples exceeded the UTL and 9 of 80 subsurface sediment samples exceeded the total PAH(13) UTL. This indicates that surface sediment conditions at both Sites are representative of ambient conditions when compared to the total PAH(13) UTL, while there are isolated subsurface locations at both Sites that are potentially affected by MGP residuals. These results appear to parallel the presence of evidence of potential MPG residuals (e.g., NAPL in the form of oil-wetted/oil coated sediment) in subsurface samples at the Sites, but not in surface samples (Figures 4 and 5).

Based on Step I sediment sample comparison to metal and cyanide UTLs, there were some metals at each Site that exceeded their UTL in surface sediment samples (Tables 5 and 7). However, the distribution of the exceedances was rarely co-located with total PAH(13) UTL exceedances. In addition, there were many more exceedances of metals and cyanide UTLs at each Site in subsurface sediment samples. This indicates that the metal and cyanide UTLs developed based on the surface sediment ambient results likely do not adequately represent ambient conditions for the metals and cyanide found in the subsurface. Or, this may indicate that there are some historic metals influences within each Site area not found in the upstream ambient area. At the Division Site, there were exceedances of lead (5 of 86 samples), nickel (5 of 86 samples), and silver (21 of 86 samples) in surface sediment above their respective UTL. At the Willow/Hawthorne Site, there were exceedances of antimony (1 of 48 samples), chromium (1 of 48 samples), copper (1 of 48 samples), cyanide (3 of 48 samples), lead (3 of 48 samples), nickel (6 of 48 samples), silver (5 of 48 samples), vanadium (16 of 48 samples), and zinc (3 of 48 samples) in surface sediment above their respective UTL.

At both Sites, in the subsurface sediments, nearly all of the metals evaluated had one or more exceedances of a UTL (Tables 6 and 8). At both Sites, a few metals (e.g. silver) had a very high frequency of UTL exceedances in the subsurface environment. Many of the metals UTL exceedances were very close to the UTL.

Locations of metals and cyanide UTL exceedances are very infrequently co-located with total PAH(13) UTL exceedances. The lack of metals and cyanide UTL exceedances co-located with total PAH(13) UTL exceedances can be seen in the sample-by-sample UTL exceedance results in Tables 9 through 12. Considering that it appears the concentrations of metals above the ambient UTLs are unrelated to the former MGP operations at each Site and many metals UTL exceedances were very close to the UTL, additional statistical analyses of the data were performed.

Supplemental Statistical Analysis

As a supplemental statistical analysis, a comparison of the means between the ambient data set and the Step I site data sets was performed for metals, cyanide, and total PAH(13). To perform the statistical comparison, all Step I site data were compared to all ambient data for a given depth interval (surface or subsurface). Since there is no apparent relationship between the metals UTL exceedances and the location of the former MGP, the ambient data set was compared to the entire Step I site data sets instead of just those site locations adjacent to and downstream of the former MPGs. A description of the methods used to perform the supplemental statistical evaluation and the results of the evaluation are provided in Enclosure C.

Based on results of the statistical analyses (Tables C-1 and C-2 of Enclosure C), there are four metals that have mean concentrations within the site areas that exceed those in the ambient study area. At the Division Site, only the mean silver concentration in surface sediments was statistically elevated above the mean concentration in the ambient study area. The silver UTL exceedances are distributed both upstream of the MGP, adjacent to the MGP, and downstream of the MGP, and so appear unrelated to the former MGP operations. At the Willow/Hawthorne Site, iron, nickel, and vanadium mean concentrations in surface sediments, and aluminum and vanadium concentrations in subsurface sediments were statistically elevated above mean concentrations in the ambient study area. The metals that are elevated above ambient conditions are common components of scrap metal, such as that currently processed at the scrap yard on the Willow/Hawthorne Site, but not major drivers associated with MGP operations. The metal with the greatest number of UTL exceedances is vanadium (16 of 48 surface samples and 50 of 80 subsurface samples). Vanadium UTL exceedances are distributed both upstream of the MGP, adjacent to the MGP, and downstream of the MGP, and so appear unrelated to the former MGP operations.

Considering the spatial distribution of the metal exceedances at both Sites, and the statistical assessment presented in Enclosure C, metals appear unrelated to the former MGP operations.

Consideration of Sediment Toxicity Testing

The specific conditions under which sediment toxicity would be considered a useful tool to define ecological risk zones at the North Branch MGP Sites is discussed in detail in Enclosure B. These conditions include:

1) There is an area where analyte concentrations exceed the UTLs at a Site and MGP-related effects likely exist.
2) That area is physically contiguous and large enough to consider for sampling and sediment toxicity testing.
3) The concentrations within an area defined by conditions 1 and 2 are not so high as to be considered clearly toxic with a reasonable amount of certainty without actual sediment toxicity testing.

If these three conditions are satisfied, then sediment toxicity testing could be considered at a particular North Branch MGP Site. However, as noted in Enclosure B, the concentrations of total PAHs in the ambient investigation area of the Chicago River upstream of the North Branch MGP Sites are within the range where sediments are considered toxic to benthic invertebrates. For this reason, if sediment toxicity is performed in another similar area of the Chicago River (i.e., at a specific North Branch MGP Site), it will mostly likely serve the purpose of differentiating between different degrees of toxicity, rather than determining if there is toxicity or not affecting benthic invertebrates.

Based on the initial data analysis of the sediment sample results at the Division and Willow/Hawthorne Sites, MGP-related effects (as defined by UTL exceedances of total PAH(13)) are primarily located in the subsurface environment well below the biologically active zone, where ecological receptors would be present. There were no total PAH(13) UTL exceedances at Willow/Hawthorne Site in surface sediment and only a single exceedance in surface sediment at Division Site. In addition, the mean concentration of total PAH(13) in the surface sediments at both Sites are lower than the mean total PAH(13) concentrations in the ambient investigation area of the River. For this last reason alone, and considering

Condition 1 (previously described in this section), there is no compelling reason to perform sediment toxicity testing at either of these two Sites.

In addition, Condition 3 does not appear to be satisfied based on review of the investigative sediment data collected at these two MGP Sites. While there are more total PAH(13) UTL exceedances in the subsurface sediment at each Site (i.e., 7 samples atDivision and 9 samples at Willow/Hawthorne), approximately half of these sample locations at each Site (4 of 7 samples at Division and 4 of 9 samples at Willow/Hawthorne) are associated with total PAH(13) concentrations at or above approximately 1,000 mg/kg. Above a concentration of 1,000 mg/kg total PAH, the sample would be expected to be toxic to benthic invertebrates and potentially associated with areas of NAPL or oil-wetted/oil-coated sediment. Toxicity testing would not be conducted on sediments with such high total PAH concentrations or presence of potential MGP residuals (NAPL or oil-wetted/oil-coated sediment) because of the great degree of certainty that the material would be toxic. In addition, IBS includes areas containing NAPL or oil-wetted/oil-coated sediment for further consideration in the RI/FS.

Considering the sediment conditions at these two Sites, as previously described in this section, sediment toxicity testing would not help to better define ecological risk zones that depart from ambient conditions. Therefore, no sediment toxicity testing will be performed as part of the Step II sediment investigation at these two Sites.

Additional Data Needs

Additional sampling will be conducted at the Sites to further define the vertical and horizontal extent of potential MGP residuals and provide data to be used in support of the FS. The following data needs will be addressed in Step II sampling:

1) Depth to clay will be determined for those areas where it was not possible during Step I sampling.
2) Horizontal extent of NAPL/oil-wetted/oil-coated sediment will be refined by advancing additional cores within the site areas.
3) Vertical and horizontal extent of total PAH(13) exceedences of the UTL will be refined by:
    a. Analyzing selected discreet Step I samples that have been stored in archive for total PAHs
    b. Advancing additional cores within the site areas and analyzing samples from those cores for total PAHs

Details of the Step II sampling plan are described in the following section.

Step II Sediment Sampling Plan

The purpose of the Step II sampling is to further define the vertical and horizontal extent of potential MGP residuals and provide additional data for future evaluation of potential remediation areas. To address the additional data needs outlined in the previous section, the following sampling will be conducted.

Depth of Clay

Lean clay was observed at maximum depths of 16.5 feet below mudline at Division Site and 16.4 feet below mudline at the Willow/Hawthorne Site. Based on borings conducted during Step I sampling, depth of clay has been extrapolated on cross sections shown on Figures 4 and 5. The estimated deepest depth of clay at those locations where it was not encountered at the Division Site is 23.5 feet below mudline; at Willow/Hawthorne Site the depth is 24 feet below mudline. During Step II sampling, borings will be advanced approximately 24 feet below mudline to reach the estimated elevation of clay. Borings will be advanced using a barge-mounted drill rig using hollow stem augers and continuously sampled using split spoons according to the procedures outlined in the USEPA-approved SSWPs.

Ten borings will be advanced during Step II sampling for this purpose at Division Site; 10 borings will be advanced at Willow/Hawthorne Site. These borings are described as “revisit” samples on Figures 6 and 7 and identified with the suffix “RVT.”

Horizontal Extent of NAPL

NAPL or oil-coated/oil-wetted sediment was identified at both Sites during Step I sampling. Additional borings will be advanced surrounding observations of NAPL or oil-coated/oil-wetted sediment to define the extent of visually-observed potential MGP residuals. Borings will be located according to the following protocol:

- New borings will be advanced at locations half the distance between the boring where NAPL was observed and its nearest neighbor borings where NAPL was not observed.
- If the new boring contains NAPL or oil-coated/oil-wetted sediment and is at an upstream or downstream end of the investigation area, an additional boring will be advanced 50 feet further away from the Site (upstream or downstream) from the original boring.
- If the new boring does not contain NAPL or oil-coated/oil-wetted sediment, then an additional boring may be advanced between the new boring and the original boring to further refine the area of potential residuals.

In addition, at Willow/Hawthorne Site, additional borings will be advanced near the shoreline along the former MGP property boundary to further delineate potentially affected sediment in that area.

Seventeen borings will be advanced during Step II sampling for this purpose at Division Site; nine at Willow/Hawthorne Site (Figures 6 and 7). Additional borings will be advanced to refine areas of potential residuals based on field observations to be made during Step II sampling and the protocol previously described in this section.

Vertical and Horizontal Extent of Elevated PAHs

Concentrations of total PAH(13) in sediment that exceed the UTL were identified at both Sites during Step I sampling (Figures 4 and 5). Additional pre-design borings will be advanced surrounding observations of elevated concentrations of total PAH(13). Borings will be located according to the following protocol:

- Additional borings will be advanced at locations half the distance between the boring where concentrations of total PAH(13) exceed the UTL and its nearest neighbor borings where concentrations of total PAH(13) did not exceed the UTL.
- If the boring with concentrations of total PAH(13) exceeds the UTL, and is at an upstream or downstream end of the investigation area, an additional boring will be advanced 50 feet further away from the Site (upstream or downstream) from the original boring.

Two borings will be advanced during Step II sampling for this purpose at Division Site; five borings will be advanced at Willow/Hawthorne (Figures 6 and 7).

To further refine the extent of elevated concentrations of total PAHs, select Step I samples that were frozen in archive at the laboratory will be run for total PAHs. Samples collected above the elevation of clay in Step I cores will be selected for this purpose according to the following protocol:

- Within the same core where Step I sampling results indicated the potential presence of MGP residuals (NAPL or oil-coated/oil-wetted sediment, and/or concentrations of total PAH(13) exceeding the UTL) - Sample intervals directly above and below the interval containing potential residuals will be analyzed for total PAHs.
- In cores adjacent to a core where Step I sampling results indicated the potential presence of MGP residuals - Sample intervals at the same elevation, and directly above and below the elevation of potential residuals will be analyzed for total PAHs.

A total of 77 Division Site samples and 27 Willow/Hawthorne Site samples were removed from archive on October 4, 2012 and analyzed for total PAHs using methods described in the USEPA-approved SSWPs for these Sites (Table 13).

All borings will be advanced and logged, and samples will be collected and analyzed in accordance with the USEPA-approved SSWPs for these Sites.

Schedule

Step II sediment sampling is tentatively planned for spring 2013, pending USEPA's concurrence with the sampling approach, permits procurement, and contractor availability. Analytical and field observation data will be presented in full as part of the Division and Willow/Hawthorne RI Reports.

Attachments:

Figures

Figure 1: Step I Sediment and Surface Water Sampling Locations December 2011 – February 2012, Division Street Station
Figure 2: Step I Sediment and Surface Water Sampling Locations December 2011 – February 2012, Willow/Hawthorne Street Station
Figure 3: Step I Ambient Surface Water Sampling Locations December 2011 – February 2012, North of Division Street and Willow/Hawthorne Street Stations
Figure 4: Cross Sections – Division Street Station
Figure 5: Cross Sections – Willow/Hawthorne Street Station
Figure 6: Proposed Step II Boring Locations – Division Street Station
Figure 7: Proposed Step II Boring Locations – Willow/Hawthorne Street Station

Tables

Table 1a: Surface Water Data Compared to Residential Groundwater Screening Levels – Division Street Station (on CD)
Table 1b: Surface Water Data Compared to Ecological Benchmarks – Division Street Station (on CD)
Table 2a: Surface Water Data Compared to Residential Groundwater Screening Levels – Willow/Hawthorne Street Station (on CD)
Table 2b: Surface Water Data Compared to Ecological Benchmarks – Willow/Hawthorne Street Station (on CD)
Table 3a: Step I Sediment Data – Division Street Station (on CD)
Table 3b: Step I Sediment QC Data – Division Street Station (on CD)
Table 4a: Step I Sediment Data – Willow/Hawthorne Street Station (On CD)
Table 4b: Step I Sediment QC Data – Willow/Hawthorne Street Station (On CD)
Table 5: Summary Statistics for Surface Sediment Samples Above MDL – Division Street Station
Table 6: Summary Statistics for Subsurface Sediment Samples Above MDL – Division Street Station
Table 7: Summary Statistics for Surface Sediment Samples Above MDL – Willow/Hawthorne Street Station
Table 8: Summary Statistics for Subsurface Sediment Samples Above MDL – Willow/Hawthorne Street Station
Table 9: Sample-by-Sample Comparison of Surface Sediment Sample Results to UTLs – Division Street Station (On CD)
Table 10: Sample-by-Sample Comparison of Subsurface Sediment Sample Results to UTLs – Division Street Station (On CD)
Table 11: Sample-by-Sample Comparison of Surface Sediment Sample Results to UTLs – Willow/Hawthorne Street Station (On CD)
Table 12: Sample-by-Sample Comparison of Subsurface Sediment Sample Results to UTLs – Willow/Hawthorne Street Station (On CD)
Table 13: Sediment Samples Retrieved from Archive and Submitted for PAH Analysis on October 4, 2012

Enclosure A: Division and Willow/Hawthorne Sediment Boring Logs – January/February 2012 (On CD)
Enclosure B: Summary of Ambient Area Sediment Investigation Toxicity Test Results and Related Sediment Chemistry Results
Enclosure C: Supplemental Statistical Sediment Analysis

FIGURES

Report Figures were removed to reduce file size for this transmittal

TABLES 5-8, 13

(TABLES 1-4, 9-12 INCLUDED ON CD)

Report Tables were removed to reduce file size for this transmittal

ENCLOSURE A

DIVISION AND WILLOW/HAWTHORNE SEDIMENT BORING LOGS – JANUARY/FEBRUARY 2012

Enclosure A was removed to reduce file size for this transmittal

ENCLOSURE B

SUMMARY OF AMBIENT AREA SEDIMENT INVESTIGATION TOXICITY TEST RESULTS AND RELATED SEDIMENT CHEMISTRY RESULTS

Enclosure B:
Summary of Ambient Area Sediment Investigation Toxicity Test Results and Related Sediment Chemistry Results

Background Concerning the Need for the Ambient Investigation

Because of the history of industrial and urban activity along the Chicago River (River), it was recognized that the ambient sediments could exhibit some toxicity to benthic invertebrates. Considering that toxicity measurements and predictions are used to evaluate the risks associated with exposure to sediments influenced by former manufactured gas plants (MGP), the presence of toxicity in the ambient locations could be a confounding factor. Therefore, it was important to evaluate the level of toxicity that may be present in the ambient samples. Depending upon the ambient investigation results, one of the following outcomes and associated assessment decisions was anticipated:

1. The ambient sediments do not exhibit significant toxicity compared to the control samples used in the laboratory. This outcome indicates that toxicity tests will be useful for determining whether the North Branch MGP sites are contributing to toxicity, and that sediment samples collected off MGP sites can be evaluated by comparing them with both the ambient samples and laboratory controls.
2. The ambient sediments exhibit some toxicity and many of the samples may be significantly different from the laboratory control samples. This outcome indicates that there is some level of toxicity associated with ambient conditions and that the level of toxicity needs to be factored into the evaluation of toxicity for sediments at the MGP sites. The information can also be used to determine the test sample size needed to detect a specified degree of increasing toxicity (e.g., 20 percent) for sediments potentially influenced by the MGP sites.

3. The ambient sediments exhibit substantial toxicity and it would be difficult to detect incremental increases in toxicity. This outcome suggests that toxicity testing at downstream sites may not be able to detect an added influence associated with the MGP sites. With this outcome, the need to conduct toxicity testing should be re-evaluated, because the testing may provide little value.

It was anticipated in the ambient conditions work plan (Exponent 2009) that Outcome 2 was most likely followed by Outcome 1. Outcome 3 was a possibility. In fact, based on the results of the sediment toxicity testing, an outcome somewhere between Outcome 2 and 3 appears to be the reality. Careful consideration of the Step I sediment investigation's chemistry results collected at each North Branch MGP site will need to be reviewed in combination with the ambient investigation results, to make a site-specific judgment of whether Outcome 2 or 3 applies to a particular site. The reason for this is explained more fully below, based on a combination of the ambient sediment chemistry and toxicity test data, and the experience gained from the earlier MGP investigations at other Integrys Business Support, LLC (IBS) sites (i.e., Campmarina and Manitowoc).

Summary of Sampling and Testing Performed

The ambient and source sediment sample locations investigated within the ambient zone in the spring of 2011 are shown on Figure 1. During the ambient area sediment investigation, 20 ambient sample locations were sampled for a total of 59 ambient sediment samples. At each of the 20 ambient sample locations, a surface sediment sample was attempted, and at 19 sample locations a surface sample (0–0.5 ft below mudline) was recovered. At sample location ACR11, a surface sample could not be collected because of rocky conditions. At 5 of the 20 ambient sediment sample locations, a vertical profile of sediment samples was collected. A subgroup of surface ambient sediment samples (10 of 19 collected) was tested using a sediment toxicity test (described further below). None of the source samples were submitted for toxicity testing.

Within the ambient area another nine sample locations were pre-selected as potential source areas and sampled. These nine source sediment samples were all collected at the sediment surface (0–0.5 ft below mudline).

The sediment samples were analyzed for polycyclic aromatic hydrocarbons (PAHs), petroleum volatile organic compounds, target analyte list metals, and a series of indicator parameters, a summary of which is provided in Table B-1.

Summary of Sediment Chemistry Data Analysis

The concentrations of total PAHs and many of the metals analyzed in ambient sediments were orders of magnitude over the sediment ecological benchmarks that are used to screen the sediment results as part of the IBS Multi-Site program. Table B-1 provides summary statistics of the chemistry results for the entire set of ambient sediment samples collected at all depths. Within Table B-1, summary statistics of the chemistry data are also provided for surface ambient sediment samples (0–0.5 ft below mudline) and the source samples collected within the ambient area at the same depth interval. Source samples were not collected at depths greater than 0.5 ft below the mudline.

As part of the ambient sediment investigation, 10 of the 20 ambient surface sediment samples (0–0.5 ft below mudline) were submitted for both chemistry (Table B-2) and toxicity testing (Table B-3) using a specific test organism (i.e., *Hyalella azteca*) that is sensitive to MGP-related constituents. This group of 10 samples was evaluated to determine if sediment toxicity testing could be used as a tool to evaluate ecologically relevant risk zones on a site-specific basis at each of the North Branch MGP sites.

Results of Toxicity Testing for Select Ambient Samples

Ten sediment samples were tested using the 28-day chronic sediment toxicity testing protocol that utilizes *Hyalella azteca* as the test species by Coastal Bioanalysts, Inc. The full sediment toxicity laboratory report from Coastal Bioanalysts, Inc. is provided as Attachment B-1 to this enclosure (on CD). The sediment toxicity test measures percent survival and growth at the termination of the test. Growth is measured both as the mean weight of the test organisms, and the mean length of the test organisms. Generally the weight index is used to address whether there are effects on growth to the test species, so the weight index was focused upon for this evaluation. In addition to the 10 ambient surface sediment samples tested, a laboratory control sediment sample was evaluated for quality control purposes as part of the assay. A number of the 10 ambient surface sediment samples (3 samples based on survival and 5 based on growth endpoints using organism weight) were statistically different from the laboratory control samples indicating that these sediments were somewhat toxic to the test organisms (Table B-3). Among the ambient sediment samples, average percent survival for *H. azteca* ranged from 95% to 63.75%, compared to the laboratory control sample, which had an average survival of 97.5%. Samples with survival of 70% or less were statistically different than the laboratory control. Growth, as measured by average dry weight of an individual organism, ranged from 0.563 mg to 0.275 mg, compared with individuals in the laboratory control group (0.465 mg). Samples with an average weight of 0.396 mg or less were statistically different than the laboratory control. Figure 2 presents the percent survival and average organism weight by sample location. As is apparent from the figure, those sediment samples with survival or growth (as measured by organism weight) less than the laboratory control where not clustered in one segment of the ambient area, but rather distributed throughout the ambient area tested.

Characterization of the Ambient Conditions in the North Branch Chicago River

One of the primary objectives of the ambient investigation was to characterize sediment quality in the ambient area. This characterization was to include summarizing the concentrations of constituents of potential concern in the sediment to calculate the upper tolerance limits (UTLs) for the ambient data set. The UTLs are concentration limits above which the individual sample result collected at a downstream former MGP site is more likely to be due to MGP sources (e.g., MGP residuals) than ambient conditions, and so would represent a sample location where MGP-related impacts are considered potentially present. Conversely, if the concentration of an analyte is below the UTL at an investigative location, it is more likely to represent ambient conditions, rather than indicate an influence from the former MGP site. The UTLs developed for the ambient sediment data set for total PAHs and metals analyzed in the ambient area are summarized in Table B-4. The UTLs were developed using the approach described in

Section 3.3 of the ambient investigation work plan (Exponent 2009), and considering comments on the UTL approach provided by USEPA specific to total PAHs concentrations. The data used to develop the UTLs along with the statistical output from the UTL analysis are provided as Attachment B-2 to this enclosure (on CD).

At the request of USEPA, a supplemental outlier analysis and revised UTL analysis was performed on the total PAH-13 dataset.[1] Prior to performing this outlier analysis, the surface sediment ambient data set was expanded to include a broader depth range (0–1.5 ft below mudline) to be consistent with the data grouping for performing comparisons between the ambient and investigative datasets (refer to Enclosure C). Rosner's test in USEPA's ProUCL software was used to assess whether the highest concentration ambient samples could be identified as anomalous in comparison to the distribution of concentrations measured in the other samples. Based on separate outlier analyses of the samples collected within the expanded surface range (samples from 0–1.5 ft in depth) and from the subsurface depth (below 1.5 ft depth), three outliers were identified at a 0.05 significance level, specifically one surface ambient sample (ACR-12, 725 mg/kg), one ambient source sample (SC-R5, 875 mg/kg), and one ambient subsurface sample (ACR-11 4.5-5.5 ft, 803 mg/kg). For total PAH-13, a separate UTL estimate was developed for surface and subsurface sediment concentrations because total PAH-13 concentrations were significantly different between these two depth intervals (refer to analysis provided in Attachment B-2). The UTLs presented in Table B-4 for total PAH-13 were estimated for surface and subsurface samples, excluding the identified outlier samples.

If sediment sample concentrations are identified above these UTLs for one or more analytes at one of the three North Branch MGP sites under investigation (i.e., Division, Willow/Hawthorne, and North Station), then additional statistical comparisons of the ambient and investigative data sets may be performed as described in the work plan.

The magnitude of the UTLs based on the ambient data set clearly demonstrate the degraded conditions of the River, and that ambient conditions for the River would be considered heavily

---

[1] No outlier tests have been performed for the ambient metals datasets to date, if further evaluation of the ambient metals data becomes necessary, it will be performed during the preparation of the remedial investigation report.

polluted conditions for many other rivers. For example, the UTL for total PAHs-13 for the ambient reach of the River is 342 mg/kg, based on the ambient surface sediment sample results, and 410 mg/kg based on the subsurface sample results.

Correlation Analysis of Ambient Toxicity Test and Chemistry Data Set

To evaluate whether the range of survival and growth observed in the 10 ambient samples submitted for toxicity testing was potentially related to the concentrations of any particular analyte (e.g., PAH or metal), a correlation analysis was performed (Table B-5). Using a standard significance level (i.e., P-value less than 0.05), survival was negatively correlated to two specific groups of alkylated PAHs (C3-chrysene and C4-naphthalene); a group of metals (arsenic, barium, mercury, nickel and zinc); total petroleum hydrocarbon diesel, oil and grease; and total organic carbon (TOC). Growth was negatively correlated at the same significance level to ammonia; a group of metals (aluminum, arsenic, mercury, selenium, silver, and vanadium); oil and grease; and TOC. If the significance level (i.e., P-values less than 0.05) was adjusted to account for the multiple comparisons performed (e.g., Bonferroni adjustment or P-values less than 0.000685) only two metals (aluminum and selenium) were negatively correlated with growth, and none were correlated with survival. Noticeably absent from either comparison was any negative correlation to total PAHs, which has been a good indicator of toxicity to benthic invertebrates at other IBS MGP sites (e.g., Campmarina, Manitowoc).

It should be noted that the maximum and mean total PAH concentrations tested in the toxicity testing (i.e., 188 and 86 mg/kg, respectively) was much lower than the maximum and mean of total PAHs encountered in all surface ambient samples (i.e., 725 to 155 mg/kg). In contrast, the maximum concentrations of most of the metals detected in any surface ambient samples were represented in the 10 sediment samples tested for toxicity. The mean concentration of each metal was comparable for those samples submitted for toxicity testing and those that were not. Therefore, the metals tested were very representative of the ambient metals concentrations, whereas the total PAH concentrations were underrepresented.

General Observations Considering Both Ambient Investigation Test Results and Past IBS Site Experience

Some general observations can be made based on the toxicity test and chemistry results when considering 1) the generic sediment screening levels that are used to evaluate the IBS Multi-Site Program sites, and 2) the range of threshold effect concentrations for PAHs that have been developed at previous IBS former MGP sites to define the limits of the ecological risk zones.

- **There are high concentrations of total PAHs and many metals within the ambient area that could be potentially toxic to benthic invertebrates.** For example, the maximum and average total PAHs-13 concentrations in the surface sediment samples were 725 mg/kg and 155 mg/kg, respectively. In addition, the maximum and average cadmium concentrations in the surface sediment samples were 101 mg/kg and 29 mg/kg, respectively. These concentrations are orders of magnitude above their respective sediment ecological screening levels (e.g., threshold effect concentrations or TECs). In addition, the maximum and average total PAH-13 concentrations in the surface ambient area data set are higher than those concentrations (e.g., 45 mg/kg total PAH-13 at Campmarina) developed at other IBS Multi-Site Program sites to serve as the threshold concentrations where sediments begin to be considered toxic to benthic invertebrates. The correlation analysis performed for the ambient study did not show a relationship between total PAHs and the toxicity observed in a subset of the ambient area sediment samples, but rather it was more related to metals concentrations. However, the total PAH sediment concentrations tested for toxicity under-represented the upper end of the concentration range detected in the ambient area, so the sediment toxicity test results are not fully representative of the ambient area conditions.

- **There are not large differences in the concentration ranges for most analytes between the surface ambient sediment samples and the source sediment samples within the ambient area.** For example, the maximum and mean total PAHs-13 concentrations in the source sediment samples collected in the ambient area were 875 mg/kg and 192 mg/kg, respectively. This is in comparison to the maximum and average total PAHs-13 concentrations in the surface ambient sediment samples of 725 mg/kg and 155 mg/kg, respectively. This indicates that while potential source areas were identified and evaluated as part of the ambient investigation, the contribution of any one source area to the contamination in the ambient area would be nearly impossible to ascertain from a spatial evaluation of the chemistry results alone. Rather, the ambient area appears to represent the combined influences of multiple sources that have contributed to the contamination within the ambient area over the many years of industrial use of the River. Forensic techniques may be helpful in fingerprinting the general type of PAH contamination found in the ambient area to help distinguish that PAH fingerprint from former MGP sources. This will be evaluated once site-specific MGP sediment data is available from the North Branch site sediment evaluations as described in the ambient investigation work plan (Exponent 2009).

Ramifications of the Ambient Investigation Test Results on the Site-Specific Sampling Strategy

Considering the results of the ambient sediment toxicity and these general observations, it is likely there will be a zone of sediments that are toxic to benthic invertebrates at each of the individual MGP sites being evaluated on the River. However to determine what portion of that ecological risk zone is attributable to the MGP site will require careful consideration of the ambient chemistry results, and at times the use of forensic chemistry techniques to differentiate MGP sources from ambient sources.

The first suggested step in the site-specific MGP investigation process before any sediment toxicity is performed would be to compare the Step 1 sediment investigation results collected adjacent to each North Branch MGP site to the ambient sediment results. To facilitate this comparison, UTLs were developed for the ambient sediment data set (Table B-4) for total PAHs and the metals analyzed in the ambient investigation area. If sediment samples are identified with analyte concentrations above these UTLs for one or more analytes, then additional statistical comparisons may be performed as described previously (Exponent 2009) to determine if analyte concentrations in sediments at the former MGP sites are greater than those in the ambient investigation area. The UTL analysis and additional statistical analyses (if required) will be used to determine which investigative samples depart from ambient conditions at each MGP site. The results of this analysis will be used to evaluate the zone of ambient conditions at each MGP site. If toxicity testing is considered necessary, the results of the toxicity testing will be used to develop ecological risk zones.

The magnitude of the ambient area UTLs clearly demonstrates the degraded conditions of the River. The total PAH concentrations in the ambient area of the River are above the concentration thresholds that have been used at other IBS Multi-Site Program sites to demark toxic versus non-toxic sediment ecological risk zones to benthic invertebrates. Therefore, very specific conditions would have to exist near a particular North Branch former MGP site before sediment toxicity testing would be a useful tool for refining the ecological risk zones.

Whether it will make sense to perform site-specific sediment toxicity testing at a North Branch former MGP site (e.g., Division Street Station, Willow-Hawthorne Street Station, or North Station) will depend upon a few key factors including the following:

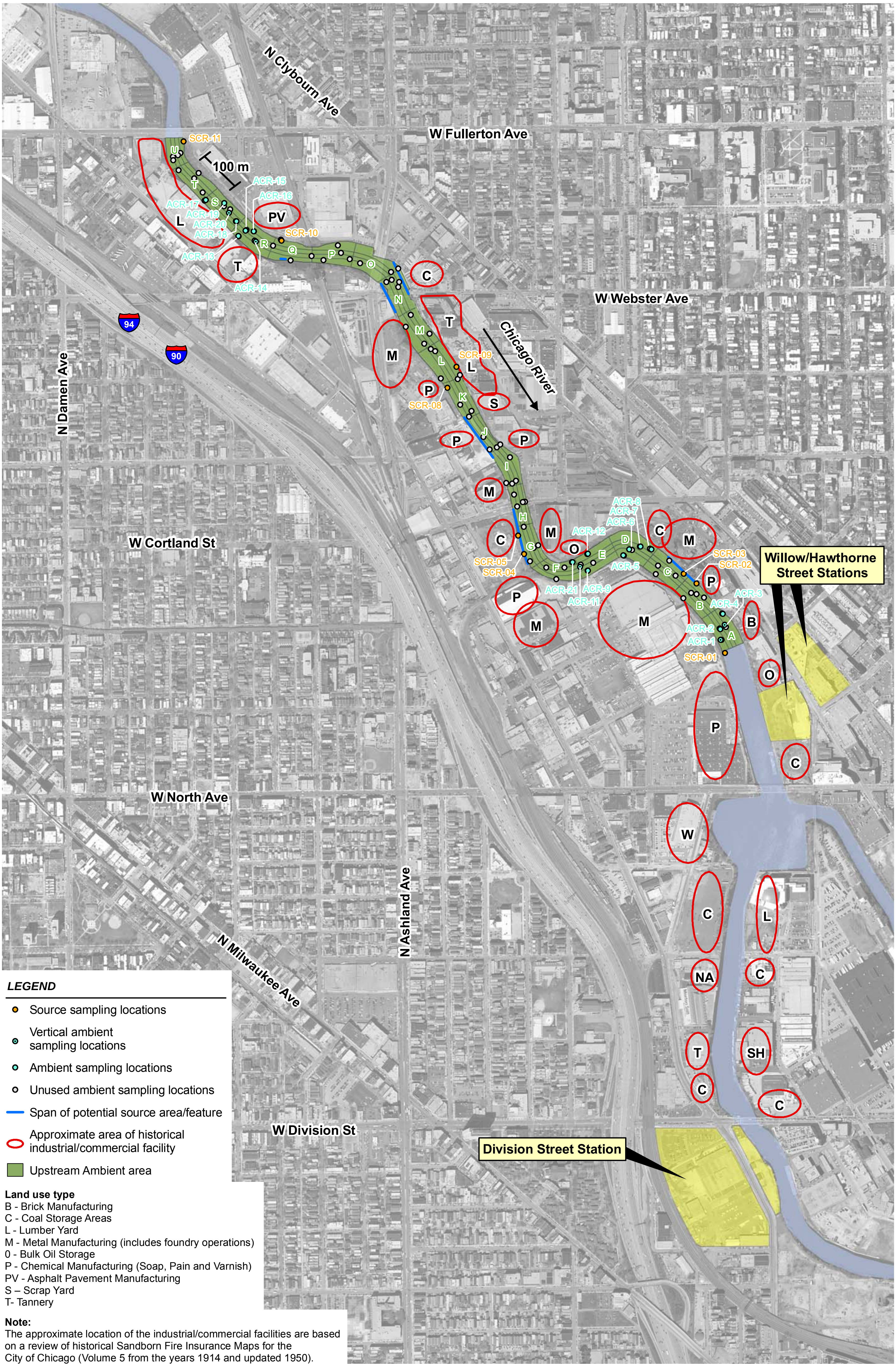
1. Whether there is an area where analyte concentrations exceed the UTLs at a site and MGP-related effects likely exist
2. Whether that area is physically contiguous and large enough to consider for sampling and sediment toxicity testing
3. The concentrations within an area defined by Conditions 1 and 2 (described above) are not so high as to be considered clearly toxic with a reasonable amount of certainty without actual sediment toxicity testing.

If these three conditions are satisfied, then sediment toxicity testing could be considered at a particular North Branch former MGP site. However as noted, the concentrations of total PAHs in the ambient area are within the range where sediments are considered toxic to benthic invertebrates. For this reason, if sediment toxicity is performed at a specific MGP site on the River, it will mostly likely serve the purpose of differentiating between different degrees of toxicity, rather than determining if there is toxicity or not occurring to benthic invertebrates. Lastly, at the former MGP sites evaluated thus far using sediment toxicity testing within the Multi-Site Program, there has not been significant metals contamination that has been present in sediments along with the MGP-related PAHs. It is clear from the North Branch Chicago River ambient data that the sediments are heavily polluted with a number of different metals in the ambient region, many with concentrations much higher than ecological sediment benchmarks developed for the protection of benthic invertebrates, and some correlated with survival and growth. For this reason, any site-specific evaluation of the toxicity of sediment will need to include an evaluation of the full suite of metals that were analyzed for in the ambient sediment investigation, to address this potential confounding factor.

References

Exponent. 2009. Characterization of ambient conditions in the Chicago River upstream of the North Branch MGP Sites, Revision1. August 2009. Prepare for Integrys Business Support, LLC. Exponent, Maynard, MA.

Figures



LEGEND

- ● Source sampling locations
- ● Vertical ambient sampling locations
- ● Ambient sampling locations
- ○ Unused ambient sampling locations
- — Span of potential source area/feature
- ○ Approximate area of historical industrial/commercial facility
- 🟩 Upstream Ambient area

Land use type
B - Brick Manufacturing
C - Coal Storage Areas
L - Lumber Yard
M - Metal Manufacturing (includes foundry operations)
0 - Bulk Oil Storage
P - Chemical Manufacturing (Soap, Pain and Varnish)
PV - Asphalt Pavement Manufacturing
S – Scrap Yard
T- Tannery

Note:
The approximate location of the industrial/commercial facilities are based on a review of historical Sandborn Fire Insurance Maps for the City of Chicago (Volume 5 from the years 1914 and updated 1950).

Exponent®

Source: Aerial photograph form USGS (2006).

0 750 1,500 Feet
0 250 500 Meters

Figure 1. Sampling locations characterization of ambient conditions North Branch Chicago River

MY03195 | May 2011 | M:\MY03195_ChicagoMGP\projects\Figure 2 2010 proposed locations - updated.mxd

LEGEND

Ambient sampling locations
● Sample ID
Average Survival (%)
Average Weight (mg dry)

Samples with a statistically significant difference from the laboratory control
Sample ID
Average Survival (%)
Average Weight (mg dry)

● Source sampling locations

○ Unused ambient sampling locations

— Span of potential source area/feature

⭕ Approximate area of historical industrial/commercial facility

🟩 Upstream Ambient area

Land use type
B - Brick Manufacturing
C - Coal Storage Areas
L - Lumber Yard
M - Metal Manufacturing (includes foundry operations)
0 - Bulk Oil Storage
P - Chemical Manufacturing (Soap, Pain and Varnish)
PV - Asphalt Pavement Manufacturing
S - Scrap Yard
T- Tannery

Note:
The approximate location of the industrial/commercial facilities are based on a review of historical Sandborn Fire Insurance Maps for the City of Chicago (Volume 5 from the years 1914 and updated 1950).

Exponent®

Source: Aerial photograph form USGS (2006).

0 750 1,500 Feet

0 250 500 Meters

Figure 2. Summary of sediment toxicity test results

MY03195 | May 2011 | M:\MY03195_ChicagoMGP\projects\Figure 2 2010 proposed locations - SedTox.mxd

Tables

Table B-1. Summary of Chicago River ambient zone investigation sediment sample results (ambient and source samples)

		Ambient Sediment Samples (all depths)					Ambient Sediment Samples (0–0.5 ft depth interval)					Source Sediment Samples (0–0.5 ft depth interval)[a]				
Analyte	Concentration units	Number of Analyses	Number of Detected Values	Minimum Detected Value	Mean Detected Value	Maximum Detected Value	Number of Analyses	Number of Detected Values	Minimum Detected Value	Mean Detected Value	Maximum Detected Value	Number of Analyses	Number of Detected Values	Minimum Detected Value	Mean Detected Value	Maximum Detected Value
Total PAHs sum of 13	mg/kg	51	51	0.775	188	803	19	19	5.95	155	725	9	9	2.27	192	875
Total PAHs sum of 34	mg/kg	51	51	3.08	400	1,240	19	19	11.5	270	1,040	9	9	6.99	320	1,380
Nitrogen, Ammonia Total	mg/kg	10	10	17.7	405	912	10	10	17.7	405	912					
Aluminum	mg/kg	51	51	2,220	9,700	16,200	19	19	2,220	8,800	14,100	9	9	3,850	7,200	12,900
Antimony	mg/kg	51	50	0.28	3.9	9.7	19	19	0.98	3.6	9.7	9	9	0.43	2.92	5.5
Arsenic	mg/kg	51	51	3.8	20.1	46.1	19	19	5.1	11.3	29.6	9	9	3.9	14	65.6
Barium	mg/kg	51	51	31.6	339	738	19	19	80.4	263	498	9	9	46.4	300	730
Cadmium	mg/kg	51	51	0.21	29	185	19	19	1.9	29	101	9	9	1.1	14.5	42.3
Chromium	mg/kg	51	51	12.4	390	2,120	19	19	69.1	242	736	9	9	27.9	250	1,150
Copper	mg/kg	51	51	9.9	370	977	19	19	97.5	380	977	9	9	53.8	271	530
Iron	mg/kg	51	51	10,800	25,700	71,400	19	19	14,800	24,100	71,400	9	9	12,800	22,000	34,500
Lead	mg/kg	51	51	18.3	570	1,190	19	19	115	419	704	9	9	31.6	550	1,310
Manganese	mg/kg	51	51	120	362	648	19	19	211	352	648	9	9	231	338	432
Nickel	mg/kg	51	51	19.7	78	227	19	19	42.4	81	227	9	9	31	63	120
Selenium	mg/kg	51	51	1.5	3.49	6.7	19	19	1.5	3.04	4.8	9	9	1.6	2.42	3.8
Silver	mg/kg	51	50	0.17	9.3	25	19	19	0.26	7.1	14.2	9	9	0.48	7.5	31.7
Vanadium	mg/kg	51	51	15.5	41	165	19	19	15.5	30.7	71.5	9	9	12.7	23.7	51.1
Zinc	mg/kg	51	51	57.7	1,250	2,990	19	19	146	940	1,930	9	9	78.8	870	1610
Mercury	mg/kg	51	51	0.028	4.9	22.5	19	19	0.074	2.12	8.1	9	9	0.039	2.07	5.9
TPH, Diesel	mg/kg	10	10	26.8	2,420	8,700	10	10	26.8	2420	8700					
TPH, Total	mg/kg	10	7	6.7	29.2	64.4	10	7	6.7	29.2	64.4					
1,2,4-Trimethylbenzene	mg/kg	20	11	0.137	0.221	0.45	19	10	0.167	0.23	0.45	9	3	0.0715	0.158	0.213
1,3,5-Trimethylbenzene	mg/kg	20	8	0.071	0.174	0.295	19	7	0.071	0.182	0.295	9	2	0.164	0.168	0.171
Benzene	mg/kg	20	6	0.0132	0.0275	0.0522	19	5	0.0201	0.0304	0.0522	9	0			
Ethylbenzene	mg/kg	20	8	0.021	0.0353	0.0673	19	7	0.0234	0.0373	0.0673	9	2	0.0262	0.0302	0.0341
Methyl-tert-butyl-ether	mg/kg	20	0				19	0				9	0			
Toluene	mg/kg	20	20	0.0174	0.49	3.63	19	19	0.0174	0.5	3.63	9	9	0.0883	1.61	9.5
Xylenes, O	mg/kg	20	11	0.0201	0.062	0.251	19	10	0.0201	0.065	0.251	9	3	0.0331	0.0365	0.0405
Xylenes, m + p	mg/kg	20	11	0.0325	0.105	0.318	19	10	0.0325	0.108	0.318	9	3	0.0225	0.0625	0.0876
Xylenes, Total	mg/kg	20	11	0.053	0.167	0.569	19	10	0.053	0.173	0.569	9	2	0.113	0.121	0.128
2,4-Dimethylphenol	mg/kg	20	0				19	0				9	0			
2-Methylphenol	mg/kg	20	0				19	0				9	0			
3 & 4-Methylphenol	mg/kg	20	8	0.217	1.24	4.12	19	8	0.217	1.24	4.12	9	7	0.221	3.5	15.5
Phenol	mg/kg	20	0				19	0				9	0			
Cyanide	mg/kg	22	22	0.33	2.1	12.9	19	19	0.33	2.4	12.9	9	8	0.59	1.02	1.9
Reactive Sulfide	mg/kg	10	1	27.1	27.1	27.1	10	1	27.1	27.1	27.1					
Oil and grease	mg/kg	10	10	86.7	1,720	3,370	10	10	86.7	1,720	3,370					
Carbon, black	mg/kg	10	10	2,920	30,200	42,900	10	10	2,920	30,200	42,900					
Carbon, Total Organic	mg/kg	10	10	44,500	81,000	129,000	10	10	44,500	81,000	129,000					
Solids	%	9	9	36.9	54.2	81.1	9	9	36.9	54.2	81.1					

Note: All results reported on a dry weight basis
All field replicates are averaged before developing overall mean of data set.

[a] All source samples were collected at the surface (0–0.5 ft depth interval), and so there are no deeper source samples.

Table B-2. Summary of Chicago River ambient zone investigation sediment sample results (ambient samples only)

		Ambient Sediment Samples (all depths)					Ambient Sediment Samples (0–0.5 ft depth interval)					Ambient Sediment Toxicity Test Samples[a]				
Analyte	Concen-tration units	Number of Analyses	Number of Detected Values	Minimum Detected Value	Mean Detected Value	Maximum Detected Value	Number of Analyses	Number of Detected Values	Minimum Detected Value	Mean Detected Value	Maximum Detected Value	Number of Analyses	Number of Detected Values	Minimum Detected Value	Mean Detected Value	Maximum Detected Value
Total PAHs sum of 13[b]	mg/kg	51	51	0.775	188	803	19	19	5.95	155	725	10	10	5.95	86	188
Total PAHs sum of 34[b]	mg/kg	51	51	3.08	400	1,240	19	19	11.5	270	1,040	10	10	11.5	158	375
Nitrogen, Ammonia Total	mg/kg	10	10	17.7	405	912	10	10	17.7	405	912	10	10	17.7	405	912
Aluminum	mg/kg	51	51	2,220	9,700	16,200	19	19	2,220	8,800	14,100	10	10	5,960	9,000	12,200
Antimony	mg/kg	51	50	0.28	3.9	9.7	19	19	0.98	3.6	9.7	10	10	0.98	4.08	9.7
Arsenic	mg/kg	51	51	3.8	20.1	46.1	19	19	5.1	11.3	29.6	10	10	5.1	12.4	29.6
Barium	mg/kg	51	51	31.6	339	738	19	19	80.4	263	498	10	10	80.4	277	498
Cadmium	mg/kg	51	51	0.21	29	185	19	19	1.9	29	101	10	10	1.9	36	101
Chromium	mg/kg	51	51	12.4	390	2,120	19	19	69.1	242	736	10	10	70.8	274	736
Copper	mg/kg	51	51	9.9	370	977	19	19	97.5	380	977	10	10	97.5	413	977
Iron	mg/kg	51	51	10,800	25,700	71,400	19	19	14,800	24,100	71,400	10	10	15,000	25,900	71,400
Lead	mg/kg	51	51	18.3	570	1,190	19	19	115	419	704	10	10	115	402	704
Manganese	mg/kg	51	51	120	362	648	19	19	211	352	648	10	10	211	355	622
Nickel	mg/kg	51	51	19.7	78	227	19	19	42.4	81	227	10	10	53.3	84	227
Selenium	mg/kg	51	51	1.5	3.49	6.7	19	19	1.5	3.04	4.8	10	10	1.5	3.01	4.8
Silver	mg/kg	51	50	0.17	9.3	25	19	19	0.26	7.1	14.2	10	10	0.26	7.8	14.2
Vanadium	mg/kg	51	51	15.5	41	165	19	19	15.5	30.7	71.5	10	10	16	32.7	71.5
Zinc	mg/kg	51	51	57.7	1,250	2,990	19	19	146	940	1,930	10	10	146	960	1,930
Mercury	mg/kg	51	51	0.028	4.9	22.5	19	19	0.074	2.12	8.1	10	10	0.074	2.11	8.1
TPH, Diesel	mg/kg	10	10	26.8	2,420	8,700	10	10	26.8	2,420	8,700	10	10	26.8	2,420	8,700
TPH, Total	mg/kg	10	7	6.7	29.2	64.4	10	7	6.7	29.2	64.4	10	7	6.7	29.2	64.4
1,2,4-Trimethylbenzene	mg/kg	20	11	0.137	0.221	0.45	19	10	0.167	0.23	0.45	10	4	0.167	0.174	0.18
1,3,5-Trimethylbenzene	mg/kg	20	8	0.071	0.174	0.295	19	7	0.071	0.182	0.295	10	2	0.16	0.161	0.162
Benzene	mg/kg	20	6	0.0132	0.0275	0.0522	19	5	0.0201	0.0304	0.0522	10	2	0.0201	0.0213	0.0224
Ethylbenzene	mg/kg	20	8	0.021	0.0353	0.0673	19	7	0.0234	0.0373	0.0673	10	1	0.0259	0.0259	0.0259
Methyl-tert-butyl-ether	mg/kg	20	0				19	0				10	0			
Toluene	mg/kg	20	20	0.0174	0.49	3.63	19	19	0.0174	0.5	3.63	10	10	0.0174	0.243	0.826
Xylenes, O	mg/kg	20	11	0.0201	0.062	0.251	19	10	0.0201	0.065	0.251	10	4	0.0201	0.0273	0.0401
Xylenes, m + p	mg/kg	20	11	0.0325	0.105	0.318	19	10	0.0325	0.108	0.318	10	4	0.0325	0.0517	0.0806
Xylenes, Total	mg/kg	20	11	0.053	0.167	0.569	19	10	0.053	0.173	0.569	10	4	0.053	0.079	0.121
2,4-Dimethylphenol	mg/kg	20	0				19	0				10	0			
2-Methylphenol	mg/kg	20	0				19	0				10	0			
3 & 4-Methylphenol	mg/kg	20	8	0.217	1.24	4.12	19	8	0.217	1.24	4.12	10	5	0.26	0.98	1.65
Phenol	mg/kg	20	0				19	0				10	0			
Cyanide	mg/kg	22	22	0.33	2.1	12.9	19	19	0.33	2.4	12.9	10	10	0.33	2	12.3
Reactive Sulfide	mg/kg	10	1	27.1	27.1	27.1	10	1	27.1	27.1	27.1	10	1	27.1	27.1	27.1
Oil and grease	mg/kg	10	10	86.7	1,720	3,370	10	10	86.7	1,720	3,370	10	10	86.7	1,720	3,370
Carbon, black	mg/kg	10	10	2,920	30,200	42,900	10	10	2,920	30,200	42,900	10	10	2,920	30,200	42,900
Carbon, Total Organic	mg/kg	10	10	44,500	81,000	129,000	10	10	44,500	81,000	129,000	10	10	44,500	81,000	129,000
Solids	%	9	9	36.9	54.2	81.1	9	9	36.9	54.2	81.1	9	9	36.9	54.2	81.1

Notes: All results reported on a dry weight basis
All field replicates are averaged before developing overall mean of dataset

[a] The data set represents the subset of 10 surface sediment samples submitted for toxicity testing.

[b] Total PAHs results are presented for simplicity. Refer to Table 4 for the full list of PAHs that were analyzed.

Table B-3. Summary of sediment toxicity test results

Survey Station	Average Percent Survival	Average Weight (mg dry)	Average Length (mm)	Total PAHs Sum of 13 (µg/kg dry)
ACR-1	86.25	0.563	3.71	175,000
ACR-15	93.75	0.444	3.38	50,900
ACR-16	83.75	**0.363**	3.27	56,000
ACR-17	**63.75**	**0.302**	**3.04**	43,500
ACR-18	95.00	0.443	3.38	73,300
ACR-21	78.75	0.525	3.55	68,500
ACR-3	**70.00**	**0.275**	**2.97**	188,000
ACR-5	92.50	**0.396**	**3.31**	92,700
ACR-7	**66.25**	**0.367**	3.37	107,000
ACR-9	91.25	0.410	3.40	5,950
LABCTRL	97.50	0.465	3.50	NA

Note: 🟨 Samples that are statistically different from laboratory controls at P-value equal to or less than 0.05.

LABCTRL - laboratory control sediment sample
NA - not applicable

Table B-4. Summary of upper tolerance limits of the ambient sediment data by analyte

						Distribution Tests			UTL$_{95,95}$	
Parameter	Sample Type	N	Min	Max	Mean	Norm	Lnorm	Gamma	Concentration	Method
Sum of 13 PAHs (mg/kg)—Surface[a]										
	Ambient only	23	6	326	126	Yes	No	Yes	342	Normal
	Ambient+Source	31	2.3	326	121	No	No	Yes	446	Gamma
Sum of 13 PAHs (mg/kg)—Subsurface[b]										
	Ambient only	26	1	389	199	Yes	No	No	410	Normal
Aluminum (mg/kg)										
	Ambient only	19	2,220	14,100	8,834	Yes	No	Yes	16,118	Normal
	Ambient+Source	28	2,220	14,100	8,320	Yes	Yes	Yes	15,288	Normal
Antimony (mg/kg)										
	Ambient only	19	1.0	10	3.6	No	Yes	Yes	13	Gamma
	Ambient+Source	28	0.43	10	3.4	No	Yes	Yes	11	Gamma
Arsenic (mg/kg)										
	Ambient only	19	5.1	30	11	No	No	No	30	Non-parametric
	Ambient+Source	28	3.9	66	12	No	No	No	66	Non-parametric
Barium (mg/kg)										
	Ambient only	19	80	498	263	Yes	Yes	Yes	555	Normal
	Ambient+Source	28	46	730	276	Yes	Yes	Yes	615	Normal
Cadmium (mg/kg)										
	Ambient only	19	1.9	101	29	No	Yes	Yes	133	Gamma
	Ambient+Source	28	1.1	101	24	No	Yes	Approx.	101	Gamma
Chromium (mg/kg)										
	Ambient only	19	69	736	242	No	Yes	Yes	829	Gamma
	Ambient+Source	28	28	1,150	245	No	Yes	Approx.	869	Gamma
Copper (mg/kg)										
	Ambient only	19	98	977	380	No	Yes	Yes	1,048	Gamma
	Ambient+Source	28	54	977	345	No	Yes	Yes	918	Gamma
Cyanide (mg/kg)										
	Ambient only	19	0.33	13	2.4	No	No	No	13	Non-parametric
	Ambient+Source	28	0.33	13	1.9	No	No	No	8.8	Non-parametric

Table B-4. (cont.)

Parameter	Sample Type	N	Min	Max	Mean	Distribution Tests Norm	 Lnorm	 Gamma	$UTL_{95,95}$ Concentration	 Method
Iron (mg/kg)										
	Ambient only	19	14,800	71,400	24,116	No	No	No	71,400	Non-parametric
	Ambient+Source	28	12,800	71,400	23,429	No	No	No	71,400	Non-parametric
Lead (mg/kg)										
	Ambient only	19	115	704	419	Yes	Yes	Approx.	863	Normal
	Ambient+Source	28	32	1,310	460	Yes	No	Yes	1,059	Normal
Manganese (mg/kg)										
	Ambient only	19	211	648	352	No	Yes	Yes	690	Gamma
	Ambient+Source	28	211	648	347	No	Yes	Yes	617	Gamma
Mercury (mg/kg)										
	Ambient only	19	0.074	8.1	2.1	No	Yes	Approx.	9.7	Gamma
	Ambient+Source	28	0.039	8.1	2.1	No	No	No	8.1	Non-parametric
Nickel (mg/kg)										
	Ambient only	19	42	227	81	No	Yes	Approx.	190	Gamma
	Ambient+Source	28	31	227	75	No	Yes	Yes	168	Gamma
Selenium (mg/kg)										
	Ambient only	19	1.5	4.8	3.0	Yes	Yes	Yes	5.2	Normal
	Ambient+Source	28	1.5	4.8	2.8	Yes	Yes	Yes	4.8	Normal
Silver (mg/kg)										
	Ambient only	19	0.26	14	7.1	Yes	No	Yes	18	Normal
	Ambient+Source	28	0.26	32	7.2	No	Yes	Yes	28	Gamma
Vanadium (mg/kg)										
	Ambient only	19	16	72	31	No	Yes	Yes	70	Gamma
	Ambient+Source	28	13	72	28	No	Yes	Yes	63	Gamma
Zinc (mg/kg)										
	Ambient only	19	146	1,930	935	Yes	Yes	Yes	2,112	Normal
	Ambient+Source	28	79	1,930	913	Yes	No	Yes	1,985	Normal

[a] The maximum total PAH (13) concentrations in source (875 mg/kg) and ambient (725 mg/kg) surface sediment samples were identified as statistical outliers and excluded from the data set before estimating the UTL. If all data were retained, the UTLs would be higher (i.e., 626 mg/kg for ambient only and 659 mg/kg for ambient + source).

[b] The maximum total PAH (13) concentration in ambient subsurface sediment samples (803 mg/kg) was identified as a statistical outlier and excluded from the data set before estimating the UTL. If all data were retained, the UTL would be higher (i.e., 722 mg/kg).

Table B-5. Summary of relationships between toxicity endpoints and sediment parameter concentrations

				Survival		Growth	
Parameter	N	# ND	% ND	Correlation	*P* -value	Correlation	*P* -value
Acenaphthene	10	0	0	-0.04	0.9074	0.14	0.7009
Acenaphthylene	10	1	10	-0.58	0.0816	-0.27	0.4458
Anthracene	10	0	0	-0.09	0.8028	0.08	0.8287
Benz[a]anthracene	10	0	0	-0.09	0.8028	0.08	0.8287
Benzo[a]pyrene	10	0	0	-0.26	0.4657	-0.07	0.8413
Benzo[b]fluoranthene	10	0	0	-0.30	0.4047	-0.08	0.8287
Benzo[e]pyrene	10	0	0	-0.18	0.6261	-0.07	0.8544
Benzo[ghi]perylene	10	0	0	0.12	0.7514	-0.04	0.9074
Benzo[k]fluoranthene	10	0	0	-0.07	0.8548	-0.03	0.9338
C1-Chrysenes	10	0	0	-0.46	0.1854	-0.25	0.4874
C1-Fluoranthenes/pyrenes	10	0	0	-0.50	0.1383	-0.30	0.4047
C1-Fluorenes	10	0	0	-0.36	0.3104	-0.27	0.4458
C1-Naphthalenes	10	0	0	-0.19	0.6032	0.05	0.8810
C1-Phenanthrenes/anthracenes	10	0	0	-0.55	0.0984	-0.37	0.2931
C2-Chrysenes	10	0	0	-0.60	0.0667	-0.49	0.1497
C2-Fluorenes	10	0	0	-0.62	0.0537	-0.35	0.3282
C2-Naphthalenes	10	0	0	-0.62	0.0537	-0.35	0.3282
C2-Phenanthrenes/anthracenes	10	0	0	-0.62	0.0537	-0.35	0.3282
C3-Chrysenes	10	0	0	-0.68	**0.0289**	-0.39	0.2600
C3-Fluorenes	10	0	0	-0.54	0.1076	-0.31	0.3848
C3-Naphthalenes	10	0	0	-0.62	0.0537	-0.35	0.3282
C3-Phenanthrenes/anthracenes	10	0	0	-0.62	0.0537	-0.35	0.3282
C4-Chrysenes	10	1	10	-0.25	0.4888	-0.26	0.4671
C4-Naphthalenes	10	0	0	-0.65	**0.0425**	-0.37	0.2931
C4-Phenanthrenes/anthracenes	10	0	0	-0.39	0.2600	-0.16	0.6515
Chrysene	10	0	0	-0.13	0.7261	-0.03	0.9338
Dibenz[a,h]anthracene	10	10	100	-0.25	0.4888	-0.58	0.0816
Fluoranthene	10	0	0	-0.13	0.7261	-0.03	0.9338
Fluorene	10	0	0	-0.09	0.8028	0.13	0.7261
Indeno[1,2,3-cd]pyrene	10	0	0	0.08	0.8287	-0.03	0.9338
Naphthalene	10	3	30	-0.15	0.6761	-0.16	0.6515
Perylene	10	0	0	-0.13	0.7261	0.01	0.9867
Phenanthrene	10	0	0	-0.04	0.9074	0.14	0.7009
Pyrene	10	0	0	-0.13	0.7261	-0.03	0.9338
Total PAHs sum of 13	10	0	0	-0.13	0.7261	-0.03	0.9338
Total PAHs sum of 34	10	0	0	-0.27	0.4458	-0.12	0.7514
Nitrogen, ammonia	10	0	0	-0.50	0.1383	-0.66	**0.0376**
Aluminum	10	0	0	-0.35	0.3282	-0.89	**0.0005**
Antimony	10	0	0	-0.22	0.5334	-0.07	0.8548
Arsenic	10	0	0	-0.68	**0.0289**	-0.65	**0.0425**
Barium	10	0	0	-0.81	**0.0049**	-0.54	0.1076
Cadmium	10	0	0	-0.62	0.0537	-0.32	0.3655
Chromium	10	0	0	-0.43	0.2145	-0.43	0.2145
Copper	10	0	0	-0.25	0.4888	-0.19	0.6032
Iron	10	0	0	-0.31	0.3848	-0.62	0.0537
Lead	10	0	0	-0.48	0.1615	-0.60	0.0667
Manganese	10	0	0	0.01	0.9867	-0.27	0.4458
Nickel	10	0	0	-0.65	**0.0425**	-0.36	0.3104
Selenium	10	0	0	-0.55	0.0984	-0.90	**0.0003**
Silver	10	0	0	-0.45	0.1869	-0.83	**0.0029**
Vanadium	10	0	0	-0.39	0.2600	-0.70	**0.0251**

Table B-5. (cont.)

				Survival		Growth	
Parameter	N	# ND	% ND	Correlation	*P*-value	Correlation	*P*-value
Zinc	10	0	0	-0.70	**0.0251**	-0.59	0.0739
Mercury	10	0	0	-0.79	**0.0061**	-0.75	**0.0133**
TPH, Diesel	10	0	0	-0.64	**0.0479**	-0.52	0.1276
TPH, Total	10	3	30	-0.59	0.0739	-0.50	0.1383
1,2,4-Trimethylbenzene	10	6	60	-0.21	0.5563	0.28	0.4250
1,3,5-Trimethylbenzene	10	8	80	-0.31	0.3848	0.15	0.6761
Benzene	10	8	80	-0.20	0.5796	-0.77	**0.0092**
Ethylbenzene	10	9	90	-0.20	0.5796	-0.77	**0.0092**
m&p-Xylene	10	6	60	-0.03	0.9338	-0.42	0.2291
Methyl-tert-butyl ether	10	10	100	-0.24	0.5109	-0.73	**0.0158**
o-Xylene	10	6	60	-0.10	0.7770	-0.43	0.2145
Toluene	10	0	0	-0.45	0.1869	0.04	0.9074
Xylene (total)	10	6	60	-0.03	0.9338	-0.42	0.2291
2,4-Dimethylphenol	10	10	100	-0.03	0.9338	0.01	0.9867
2-Methylphenol(o-cresol)	10	10	100	-0.03	0.9338	0.01	0.9867
3&4-Methylphenol(m&p cresol)	10	5	50	0.27	0.4458	0.18	0.6272
Phenol	10	10	100	-0.03	0.9338	0.01	0.9867
Cyanide	10	0	0	-0.37	0.2931	-0.62	0.0537
Reactive sulfide	10	9	90	-0.15	0.6761	-0.41	0.2443
Oil and grease	10	0	0	-0.73	**0.0158**	-0.66	**0.0376**
Carbon, black	10	0	0	-0.07	0.8548	-0.44	0.2004
Carbon, total organic	10	0	0	-0.71	**0.0227**	-0.67	**0.0323**

Notes: Spearman non-parametric rank order correlation method was used.

P-values less than 0.05 are indicated in bold. To obtain an overall 0.05 significance level, an adjustment for the multiple comparisons should be made (e.g., Bonferroni adjustment).

P-values less than 0.000685 (overall 0.05 level after Bonferroni adjustment) are indicated in red.

PAH - polycyclic aromatic hydrocarbon
TPH - total petroleum hydrocarbon

Attachment B-1

Coastal Bioanalysts, Inc. Sediment Toxicity Test Report

The Toxicity lab report was removed to reduce file size for this transmittal

Attachment B-2

Excel Workbooks—Statistical Outlier Tests for PAH Data, Comparison of Surface and Subsurface Sediment Total PAH Data, UTL Calculations for Total PAHs, and UTL Calculations for Metals (on CD)

ENCLOSURE C

SUPPLEMENTAL STATISTICAL SEDIMENT ANALYSIS

Enclosure C:
Supplemental Statistical Sediment Analysis

A supplemental statistical analysis was performed to compare the mean concentrations of analytes in ambient sediment samples to those in investigative sediment samples at each Site (Division and Willow/Hawthorne). A separate comparison was made for surface and subsurface data.

At the request of USEPA, total-PAH concentrations identified as outliers were excluded from the ambient sediment dataset prior to comparisons with site samples. These included surface samples SCR-5 (875,000 µg/kg) and ACR-12 (725,000 µg/kg); and subsurface sample ACR-11-4 (803,000 µg/kg).

The statistical analysis used was Levene's test to evaluate whether the variability in concentrations was similar across all locations. Homogeneity of variance is an underlying assumption of the standard parametric analysis of variance (ANOVA) method which is more powerful for detecting differences than the non-parametric equivalent method, Kruskal-Wallis test. If the variability was similar (i.e., P-value >0.05), then ANOVA based on log-transformed concentrations was used to compare mean concentrations between locations, otherwise the Kruskal-Wallis test was used. Specific comparisons between individual locations were only evaluated if the overall assessment (ANOVA or Kruskal-Wallis test) was significant (P-value<0.05). If the ANOVA indicated a significant difference between locations, then multiple comparison methods evaluated specifically whether either site had significantly elevated concentrations compared to the ambient data set. When the Kruskal-Wallis test indicated significance, it was followed by pairwise Wilcoxon tests to evaluate the specific differences between site and ambient locations. All pairwise comparisons between each site and ambient conditions used an overall 0.05 significance level either through the multiple comparison method or a Bonferroni adjustment to the significance level of the Wilcoxon tests. No evaluation of beryllium concentrations could be performed because it was not measured in the ambient investigation. Results of the statistical comparisons of surface and subsurface sediment concentrations for both sites are summarized in Tables C-1 and Table C-2, respectively.

Tables

Table C-1. Summary of statistical comparison of means for surface sediment samples (0–1.5 ft depth)

	Summary of Measured Concentrations						Summary of Statistical Assessment							
Area	N	Min	Max	Arithmetic Mean	Geometric Mean	Median	Levene	ANOVA	Kruskal-Wallis	Comparison to ACR+SCR	Levene	ANOVA	Kruskal-Wallis	Comparison to ACR
Sum of 13 PAHs (µg/kg dry)							0.0486		0.0000		0.0817	0.0000	0.0000	
DSS	86	4,800	878,000	52,985	35,758	33,750			no	No Diff		no	no	No Diff
WHS	48	4,290	207,000	77,269	63,160	62,150			no	No Diff		no	no	No Diff
ACR[a]	23	5,950	326,000	126,430	87,771	96,000								
ACR+SCR[b]	31	2,270	326,000	121,447	81,513	92,700								
Aluminum (mg/kg dry)							0.3624	0.6798	0.7915		0.6512	0.8468	0.6759	
WHS	48	1,760	14,500	8,663	8,111	8,470		--	--	No Diff		--	--	No Diff
ACR	24	2,220	16,200	8,999	8,277	9,265								
ACR+SCR	33	2,220	16,200	8,518	7,797	8,700								
Antimony (mg/kg dry)							0.0416		1.0000		0.0000		0.9666	
WHS	48	1.6	18.5	3.3	3.0	2.9			--	No Diff			--	No Diff
ACR	24	0.98	9.7	3.9	3.0	3.1								
ACR+SCR	33	0.43	9.7	3.7	2.8	3.3								
Arsenic (mg/kg dry)							0.0000		0.0858		0.0000		0.0647	
DSS	86	6.1	15.9	8.3	8.2	8.1			--	No Diff			--	No Diff
WHS	48	2.8	17.6	8.0	7.6	7.4			--	No Diff			--	No Diff
ACR	24	3.8	35.0	12.9	10.6	8.8								
ACR+SCR	33	3.8	65.6	13.2	10.2	8.7								
Barium (mg/kg dry)							0.0000		0.2145		0.0000		0.2067	
DSS	86	60.1	431	272	265	264			--	No Diff			--	No Diff
WHS	48	122	545	304	291	293			--	No Diff			--	No Diff
ACR	24	31.6	738	288	240	294								
ACR+SCR	33	31.6	738	292	239	291								
Cadmium (mg/kg dry)							0.0006		0.7746		0.0005		0.4967	
DSS	86	0.96	87.7	19.7	15.0	11.5			--	No Diff			--	No Diff
WHS	48	4.4	77.4	20.3	15.9	13.2			--	No Diff			--	No Diff
ACR	24	0.75	185	35.5	18.1	17.8								
ACR+SCR	33	0.75	185	29.8	15.2	14.0								
Chromium (mg/kg dry)							0.0002		0.0754		0.0009		0.0497	
DSS	86	73.8	560	180	159	138			--	No Diff			no	No Diff
WHS	48	57.2	890	238	196	167			--	No Diff			no	No Diff
ACR	24	12.4	2120	320	197	183								
ACR+SCR	33	12.4	2120	301	181	170								
Copper (mg/kg dry)							0.0002		0.5572		0.0012		0.1143	
DSS	86	36.2	579	305	291	275			--	No Diff			--	No Diff
WHS	48	95.8	1420	339	308	287			--	No Diff			--	No Diff
ACR	24	9.9	977	393	309	371								
ACR+SCR	33	9.9	977	360	285	304								

Table C-1. (cont.)

	Summary of Measured Concentrations						Summary of Statistical Assessment							
Area	N	Min	Max	Arithmetic Mean	Geometric Mean	Median	Levene	ANOVA	Kruskal-Wallis	Comparison to ACR+SCR	Levene	ANOVA	Kruskal-Wallis	Comparison to ACR
Iron (mg/kg dry)							0.0071		0.0062		0.0085		0.0141	
WHS	48	11,600	32,300	23,717	23,464	23,550			YES	Elevated			YES	Elevated
ACR	24	10,800	71,400	23,342	21,767	20,950								
ACR+SCR	33	10,800	71,400	22,970	21,634	21,200								
Lead (mg/kg dry)							0.0015		0.0000		0.0167		0.0000	
DSS	86	53.8	2,280	395	346	309			no	No Diff			no	No Diff
WHS	48	312	1,130	543	515	500			no	No Diff			no	No Diff
ACR	24	26.4	1,190	459	373	525								
ACR+SCR	33	26.4	1,310	483	374	526								
Manganese (mg/kg dry)							0.0069		0.0671		0.0080		0.0591	
WHS	48	121	593	363	355	366			--	No Diff			--	No Diff
ACR	24	120	648	335	314	301								
ACR+SCR	33	120	648	336	319	303								
Mercury (mg/kg dry)							0.0000		0.9211		0.0000		0.9566	
DSS	86	0.21	4.9	1.6	1.4	1.4			--	No Diff			--	No Diff
WHS	48	0.28	6.7	1.8	1.5	1.3			--	No Diff			--	No Diff
ACR	24	0.074	10.1	2.6	1.4	1.6								
ACR+SCR	33	0.039	10.1	2.4	1.3	1.4								
Nickel (mg/kg dry)							0.8421	0.0001	0.0000		0.8419	0.0004	0.0000	
DSS	86	36.5	270	84.9	74.1	58.4		no	no	No Diff		no	no	No Diff
WHS	48	56.4	248	114	104	91.6		YES	YES	Elevated		YES	YES	Elevated
ACR	24	19.7	227	84.4	75.2	75.2								
ACR+SCR	33	19.7	227	78.5	70.0	73.3								
Selenium (mg/kg dry)							0.0000		0.0002		0.0000		0.0000	
DSS	86	1.6	3.9	2.8	2.8	2.9			no	No Diff			no	No Diff
WHS	48	0.89	4.1	2.3	2.2	2.1			no	No Diff			no	No Diff
ACR	24	1.5	6.7	3.3	3.1	3.1								
ACR+SCR	33	1.5	6.7	3.1	2.9	2.8								
Silver (mg/kg dry)							0.0020		0.0000		0.0096		0.0000	
DSS	86	0.35	28.2	13.2	11.5	12.1			YES	Elevated			YES	Elevated
WHS	48	0.68	22.7	8.9	7.1	7.2			no	No Diff			no	No Diff
ACR	24	0.17	23.3	7.7	5.0	7.6								
ACR+SCR	33	0.17	31.7	7.7	4.8	6.2								
Vanadium (mg/kg dry)							0.4275	0.0000	0.0000		0.4998	0.0000	0.0000	
WHS	48	15.4	392	77.9	61.9	54.2		YES	YES	Elevated		YES	YES	Elevated
ACR	24	15.5	165	35.8	30.0	28.5								
ACR+SCR	33	12.7	165	32.5	27.5	26.2								

Table C-1. (cont.)

	Summary of Measured Concentrations						Summary of Statistical Assessment							
Area	N	Min	Max	Arithmetic Mean	Geometric Mean	Median	Levene	ANOVA	Kruskal-Wallis	Comparison to ACR+SCR	Levene	ANOVA	Kruskal-Wallis	Comparison to ACR
Zinc (mg/kg dry)							0.0000		0.3529		0.0000		0.5204	
DSS	86	92.3	1,970	991	942	911			no	No Diff			--	No Diff
WHS	48	380	3,090	1,105	1,021	971			no	No Diff			--	No Diff
ACR	24	57.7	2,990	1,043	809	939								
ACR+SCR	33	57.7	2,990	995	771	896								
Cyanide (µg/kg dry)							0.2616	0.0622	0.0365		0.2779	0.0784	0.0601	
DSS	86	155	4,500	1,306	1,016	945		--	no	No Diff		--	--	No Diff
WHS	48	190	30,400	3,033	1,460	1,350		--	YES	No Diff		--	--	No Diff
ACR	20	330	12,900	2,240	1,161	1,100								
ACR+SCR	29	295	12,900	1,837	1,050	980								

Notes: Levene's test evaluated whether the variabilty in concentrations was similar across all locations. ANOVA was not used if variances were not similar, as homogenenity of variance is an underlying assumption of ANOVA.

ANOVA evaluates whether any difference exists between any locations. Specific comparisons of interest were only evaluated if the ANOVA was significant (*P* -value<0.05). Multiple comparison methods were used to evaluate specifically whether DSS or WHS had significantly elevated concentrations compared to the ambient locations.

Kruskal-Wallis test is a non-parametric overall assessment similar to the ANOVA. If this test indicated any significant difference (P-value<0.05) then Wilcoxon tests were used to evaluate the specific differences between DSS and WHS and ambient locations.

ACR - ambient samples
ANOVA - analysis of variance
DSS - Division site samples
SCR - source ambient samples
WHS - Willow Hawthorne site samples

[a] Highest concentration sample was excluded (ACR-12 at 725,000 µg/kg).

[b] Two highest concentration samples were excluded (SCR-5 at 875,000 µg/kg and ACR-12 at 725,000 µg/kg).

Table C-2. Summary of statistical comparison of means for subsurface sediment samples (>1.5 ft depth)

	Summary of Measured Concentrations						Summary of Statistical Assessment			
Area	N	Min	Max	Arithmetic Mean	Geometric Mean	Median	Levene	ANOVA	Kruskal-Wallis	Comparison to ACR
Sum of 13 PAHs (µg/kg dry)							0.0383		0.0000	
DSS	105	430	23,400,000	440,314	39,422	32,900			no	No Diff
WHS	80	540	12,900,000	378,425	64,779	69,500			no	No Diff
ACR[a]	26	775	389,000	198,899	153,045	203,000				
Aluminum (mg/kg dry)							0.0733	0.0034	0.0028	
WHS	80	3,400	18,000	12,124	11,830	12,300		YES	YES	Elevated
ACR	27	3,780	15,000	10,363	9,847	10,800				
Antimony (mg/kg dry)							0.1903	0.0665	0.2337	
WHS	80	0.19	9.2	3.0	2.0	3.2		--	--	No Diff
ACR	27	0.28	8.3	3.8	3.1	3.2				
Arsenic (mg/kg dry)							0.0124		0.0000	
DSS	105	6.7	118	13.2	11.5	9.8			no	No Diff
WHS	80	6.0	38.7	18.4	16.3	16.6			no	No Diff
ACR	27	6.7	46.1	26.6	23.4	26.8				
Barium (mg/kg dry)							0.3776	0.1201	0.0037	
DSS	105	34.2	834	295	235	294		--	no	No Diff
WHS	80	39.7	582	320	249	371		--	no	No Diff
ACR	27	32.7	652	384	336	408				
Cadmium (mg/kg dry)							0.0232		0.0531	
DSS	105	0.12	212	38.5	15.6	22.4			--	No Diff
WHS	80	0.12	152	28.7	8.3	13.6			--	No Diff
ACR	27	0.21	147	22.7	9.6	10.6				
Chromium (mg/kg dry)							0.1114	0.3289	0.3923	
DSS	105	18.9	2,400	395	216	276		--	--	No Diff
WHS	80	21.3	1,230	375	238	361		--	--	No Diff
ACR	27	19.4	1,740	444	315	328				
Copper (mg/kg dry)							0.2693	0.4443	0.7315	
DSS	105	29.8	740	325	241	302		--	--	No Diff
WHS	80	25.5	638	325	228	365		--	--	No Diff
ACR	27	32.1	661	358	299	379				
Iron (mg/kg dry)							0.3476	0.1843	0.0259	
WHS	80	13,800	174,000	26,793	25,388	24,900		--	no	No Diff
ACR	27	20,900	50,700	27,756	27,216	26,800				

Table C-2. (cont.)

	Summary of Measured Concentrations						Summary of Statistical Assessment			
Area	N	Min	Max	Arithmetic Mean	Geometric Mean	Median	Levene	ANOVA	Kruskal-Wallis	Comparison to ACR
Lead (mg/kg dry)							0.0881	0.0553	0.0075	
DSS	105	15.3	2,480	485	294	381		--	no	No Diff
WHS	80	13.0	1,570	592	353	673		--	no	No Diff
ACR	27	18.3	1,040	672	569	709				
Manganese (mg/kg dry)							0.0102		0.9657	
WHS	80	190	785	370	362	361			--	No Diff
ACR	27	246	603	387	371	342				
Mercury (mg/kg dry)							0.3265	0.0003	0.0000	
DSS	105	0.024	13.4	2.0	1.1	1.8		no	no	No Diff
WHS	80	0.020	152	5.9	2.0	3.9		no	no	No Diff
ACR	27	0.028	22.5	7.0	4.3	6.4				
Nickel (mg/kg dry)							0.0017		0.1232	
DSS	105	30.7	273	107	86.5	71.2			--	No Diff
WHS	80	25.4	323	105	79.7	71.1			--	No Diff
ACR	27	29.0	205	72.4	64.1	57.7				
Selenium (mg/kg dry)							0.0528	0.0002	0.0001	
DSS	105	1.2	5.0	2.7	2.6	2.9		no	no	No Diff
WHS	80	0.79	17.8	2.9	2.6	2.7		no	no	No Diff
ACR	27	1.9	5.8	3.7	3.5	3.5				
Silver (mg/kg dry)							0.2714	0.2269	0.0063	
DSS	105	0.024	31.2	14.4	6.8	15.5		--	YES	No Diff
WHS	80	0.030	28.8	10.6	4.4	10.0		--	no	No Diff
ACR	27	0.245	25.0	10.3	7.1	9.1				
Vanadium (mg/kg dry)							0.0002		0.0000	
WHS	80	25.8	502	128	89.6	87.3			YES	Elevated
ACR	27	20.3	138	46.1	42.5	40.5				
Zinc (mg/kg dry)							0.2568	0.2498	0.1512	
DSS	105	53.6	3,410	1,140	758	989		--	--	No Diff
WHS	80	53.8	3,510	1,245	758	1,195		--	--	No Diff
ACR	27	60.9	2,640	1,426	1,133	1,540				

Table C-2. (cont.)

	Summary of Measured Concentrations						Summary of Statistical Assessment			
Area	N	Min	Max	Arithmetic Mean	Geometric Mean	Median	Levene	ANOVA	Kruskal-Wallis	Comparison to ACR
Cyanide (µg/kg dry)							Insufficient samples from ambient location			
DSS	104	210	17,900	2,472	1,395	1,100				
WHS	80	200	33,000	3,627	1,896	2,450				
ACR	2	610	705	658	656	658				

Notes: Levene's test evaluated whether the variabilty in concentrations was similar across all locations. ANOVA was not used if variances were not similar, as homogenenity of variance is an underlying assumption of ANOVA.

ANOVA evaluates whether any difference exists between any locations. Specific comparisons of interest were only evaluated if the ANOVA was significant (*P* -value<0.05). Multiple comparison methods were used to evaluate specifically whether DSS or WHS had significantly elevated concentrations compared to the ambient location.

Kruskal-Wallis test is a non-parametric overall assessment similar to the ANOVA. If this test indicated any significant difference (P-value<0.05) then Wilcoxon testswere used to evaluate the specific differences between DSS and WHS and the ambient location.

ACR - ambient samples
ANOVA - analysis of variance
DSS - Division site samples
WHS - Willow Hawthorne site samples

[a] Highest concentration sample was excluded (ACR-11-4 at 803,000 µg/kg).