NIAGARA POWER PROJECT

RELICENSING

EXTENT OF SEDIMENTATION AND QUALITY OF SEDIMENT IN THE LEWISTON RESERVOIR AND FOREBAY

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Prepared by:

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ABBREVIATIONS

2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
COC	Chain of Custody
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
EP	Equilibrium Partitioning
FSP	Field Sampling Plan
HASP	Health and Safety Plan
K_{OC}	Organic Carbon Partition Coefficient
K_{OW}	Octanol-Water Partition Coefficient
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NRTMP	Niagara River Toxics Management Plan
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyl

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PCE	Tetrachloroethylene, aka perchloroethylene
PEC	Probable Effect Concentration
PID	Photoionization Detector
QAPP	Quality Assurance Project Plan
TEC	Threshold Effect Concentration
TOC	Total Organic Carbon
VOC	Volatile Organic Compound

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EXECUTIVE SUMMARY

Introduction

The New York Power Authority (NYPA) is in the process of relicensing the Niagara Power Project, located in Lewiston, Niagara County, New York (Project). As part of the relicensing process, NYPA is developing information related to various aspects of the Project, including assessment of the quality of sediment at various locations within the Lewiston Reservoir and forebay. This report presents investigation activities and findings of the 2002 sediment quality assessment.

In order to document the extent of sedimentation (including depth and location) in the Lewiston Reservoir and forebay and to assess the physical/chemical quality of sediment in these two water bodies, a sediment quality investigation was conducted. The investigation program called for the collection of five sediment samples from the Lewiston Reservoir and two samples from the forebay. The program also called for the collection of two sediment samples from the upper Niagara River and two sediment samples from the lower Niagara River. The data from these samples provided additional information that was used to (1) assess potential impacts to sediment quality from upstream sources and (2) compare sediment quality results obtained from the Lewiston Reservoir and forebay to the upstream and downstream samples collected.

Existing Data

A bathymetric survey was conducted in May 2001 (TVGA and C&C 2002) to provide current, accurate bottom contour data and mapping of the Lewiston Reservoir and forebay. Estimated deposits of sediment in some areas of the Reservoir and forebay were greater than 4 feet, based on the results of survey data. Sampling locations were biased to sediment deposits that were believed to be sufficiently thick and where grain size and organic content would allow the sediment to be properly collected and characterized.

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Investigation Activities

The field sampling program was conducted in accordance with the following project control documents, all prepared by Environmental Standards: the Field Sampling Plan (FSP), Quality Assurance Project Plan (QAPP), and Site-Specific Health and Safety Plan (HASP).

Sediment sampling activities were conducted at the Project from October 1 through October 3, 2002. Sample collection activities were completed in one area before advancing to the next.

Upper Niagara River

On October 1, 2002, Environmental Standards collected two sediment samples in the upper Niagara River, near the Project intakes. Sonar was used to measure river depth at various locations in the river. By measuring river depths, likely areas of sediment accumulation could be predicted. A sediment corer was used to collect the two sediment samples at sampling locations where sediment deposits were believed to be sufficiently thick and where grain size and organic content would allow the sediment to be properly collected and characterized.

Lower Niagara River

On October 1, 2002, Environmental Standards collected two sediment samples in the lower Niagara River. One sediment sample was collected upstream of the tailrace and one sample was collected downstream of the tailrace. Sonar and visual observations were used to evaluate likely areas of sediment accumulation in the lower Niagara River.

Lewiston Reservoir

On October 2, 2002, Environmental Standards collected five sediment samples (SED05 through SED09) and a field duplicate (SED12) in the Lewiston Reservoir. The 2001 bathymetric survey (TVGA

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and C&C 2002) coupled with the construction elevations allowed for the determination of areas of sediment accumulation in the Lewiston Reservoir and forebay. Using this mapping and GIS technology, latitude and longitude were obtained for each sampling location.

Forebay

Bathymetric survey maps (TVGA and C&C 2002) were used to determine areas of sediment accumulation in the forebay. On October 3, 2002, sampling activities were conducted in the forebay using a crane with a 220-foot reach to access the sampling locations. Various techniques were used in numerous attempts to collect samples in the forebay, as detailed in Section 2.2.4. Limited amounts of coarse-grained sediments (cobbles and gravel) were obtained during some sampling attempts, but this type of material was not the targeted sediment type because it does not readily adsorb chemical constituents being investigated and its coarse size is not suitable for chemical analysis. Sampling efforts in the forebay were not successful in obtaining fine-grained sediments suitable for laboratory analysis.

Findings

Analytical Results

Sediment samples were analyzed at approved (10 NYCRR Part 55, Subpart 55-2) laboratories for multiple constituents, including 18 priority toxic pollutants identified in the Niagara River Toxics Management Plan (NRTMP) and five additional parameters of interest to the New York State Department of Environmental Conservation (NYSDEC). The NRTMP priority toxics were selected based on their history of exceeding water, fish, or sediment criteria values in the Niagara River or Lake Ontario. A summary of the analytical constituents and the number of sampling locations where the constituents were detected is provided below.

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NRTMP Priority Toxic Pollutants

- tetrachloroethylene (PCE) (one location).
- polynuclear aromatic hydrocarbons (PAHs) - reported individually as benzo(a)anthracene (six locations), benzo(a)pyrene (seven locations), benzo(b)fluoranthene (seven locations), benzo(k)fluoranthene (six locations), chrysene (seven locations).
- octachlorostyrene (none)
- total polychlorinated biphenyls (PCBs) (comprising Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260) (seven locations).
- pesticides (technical chlordane [none], total mirex [includes mirex and photomirex] [two], dieldrin [none], hexachlorobenzene [two], DDD [none], DDE [none], DDT [none], and toxaphene [none]).
- metals – mercury (seven locations), arsenic (nine locations), and lead (nine locations).
- dioxin (2,3,7,8-TCDD) (one location).

Additional Constituents

- total PAHs (reported as a total concentration of acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene) (seven locations).
- cadmium (none).
- total organic carbon (TOC) (nine location).
- total volatile solids (nine locations).

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- grain size

The sample collected in the lower Niagara River, upstream of the tailrace, was impacted by the highest number of constituents at generally the highest concentrations. The reservoir samples had detections at similar concentrations of PAHs, PCBs, and various metals. TOC was present at low levels in each of the samples.

Physical Data

Generally, the sediments in the upper and lower Niagara River were coarse materials (coarse to fine sand with varying amounts of fine gravel, silt, and clay). The sediments in the reservoir consisted primarily of silt and clay, with varying amounts of medium to fine sand. The limited volume of sediment obtained in the forebay allowed for only visual (not laboratory) classification. The forebay sediments consisted predominantly of cobbles and coarse to fine gravel.

Assessment of Findings

Chemical Data

To evaluate site-specific sediment sample analytical results, detected values for the parameters measured were compared to four sets of sediment values. The first set of values was the most conservative (i.e., protective of human health from toxic effects of bioaccumulation), as presented in the NYSDEC Technical Guidance for Screening Contaminated Sediments (NYSDEC 1999). These NYSDEC guidance values were organic-carbon-normalized (using the TOC data from the samples collected during this investigation) in accordance with the Technical Guidance document. The second and third sets of values consisted of sediment quality assessment values used by NYSDEC that are described in a paper by MacDonald et al. 2000. These sediment quality assessment values are presented as probable effect concentrations (PECs), which represent the levels above which toxicity was frequently observed (based on evidence of biological effects), and the threshold effect concentrations (TEC), which

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represent the level below which toxicity was rarely observed (based on evidence of biological effects) (URS et al. 2002). A fourth comparison was made using regional historical sediment quality data.

NYSDEC Sediment Criteria

A comparison of the analytical results from the October 2002 sediment sampling event to the NYSDEC criteria indicated the following:

- Levels of at least three of the five PAHs exceeded criteria values in all but two samples (a sample in the upper Niagara River and the downstream sample in the lower Niagara River).
- For pesticides, levels of hexachlorobenzene exceeded criteria values in two samples; one from the upper Niagara River and one from the upstream sample collected from the lower Niagara River. Mirex exceeded the criteria in the sample from the upper Niagara River and in one sample from the reservoir.
- Total PCBs exceeded criteria values in the upstream sample in the lower Niagara River and in each of the samples collected from the reservoir.
- For metals, levels of arsenic exceeded criteria values in one sample (and its duplicate) in the reservoir, lead exceeded criteria values in the upstream sample from the lower Niagara River and in each of the reservoir samples, and mercury exceeded criteria values in one sample from the upper Niagara River, as well as the upstream location in the lower Niagara River, and in each of the reservoir samples.

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PEC Assessment Values

A comparison of the analytical results from the October 2002 sediment sampling event to the PEC assessment values indicated the only exceedance of the assessment values was for three PAH compounds in the upstream sample collected in the lower Niagara River.

TEC Assessment Values

A comparison of the analytical results from the October 2002 sediment sampling event to the TEC assessment values indicated the following.

- Levels of three of the five PAH compounds and total PAHs exceeded assessment values in all but two samples (a sample from the upper Niagara River and the upstream sample from the lower Niagara River).
- Levels of total PCBs exceeded assessment values in both lower Niagara River samples and in four of the samples collected from the reservoir (including a duplicate sample).
- For metals, levels of arsenic exceeded assessment values in one sample in the reservoir, lead exceeded assessment values in the upstream sample from the lower Niagara River and in four of the reservoir samples (including a duplicate sample), and mercury exceeded assessment values in one sample from the upper Niagara River, the upstream sample from the lower Niagara River and in one of the reservoir samples.

Fate of Chemicals in Reservoir Sediments

Arsenic, lead, mercury, PAHs, mirex, and PCBs were present in Lewiston Reservoir sediments above NYSDEC sediment screening criteria. Environmental fate processes such as dilution,

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volatilization, biodegradation, adsorption, and chemical reactions with sediment-bound materials often reduce chemical concentrations in sediments; however, benthic microfauna or invertebrates may transform chemicals in sediments into more toxic compounds under certain environmental conditions. Because natural partitioning processes in Lewiston Reservoir sediments are assumed to have taken place, the presence of the aforementioned chemicals in bed sediments indicates that these chemicals will remain there. Based on pH and sediment organic carbon levels in the reservoir, lead and mercury in sediment are not expected to partition to the overlying water column. Arsenic compounds vary in terms of their solubilities, however, the presence of clays in the benthic substrate of the reservoir suggest that leaching of arsenic to surface water or groundwater from sediments is unlikely. PAHs and PCBs detected in sediments are also likely to remain there, owing to their extremely low solubilities in water and their strong tendency to sorb to organic carbon in bed sediments. Sediment-bound PAHs and PCBs, if re-suspended to the overlying water column, will in all likelihood adhere to suspended particulate matter rather than be redissolved in water. Mirex, an organochlorine pesticide detected in one reservoir sediment sample, adsorbs strongly to sediment particles and has a low solubility in water. As such, residual mirex in sediments should not redissolve to surface water or groundwater.

Historical Data Comparison

Data on constituent levels found in studies conducted at various locations on the Niagara River were gathered from NYSDEC 1994, which reported historical data from U.S. and Canadian agencies, as well as from technical journals. These locations included the upper Niagara River at Lake Erie (near Buffalo Harbor), the upper Niagara River in the Tonawanda Channel (the eastern side of Grand Island), the upper Niagara River near Bird Island (which splits the Black Rock canal and upper Niagara River), and the upper Niagara River near Twomile Creek. A comparison of detected constituent levels in the reservoir to the historical river data is provided below.

- Total PAH concentrations in the reservoir samples range from 5,500 μg/kg to 9,500 μg/kg. Mean sample concentrations from the historical data ranged from 710 μg/kg to 39,000 μg/kg and maximum sample concentrations ranged from 6,901 μg/kg to

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210,000 μg/kg. The reservoir sample levels are at the lower ends of each of these ranges.

- Total PCB concentrations in the reservoir samples range from 44 μg/kg to 190 μg/kg. Mean sample concentrations from the historical data ranged from 23 μg/kg to 2,140 μg/kg and maximum sample concentrations ranged from 136 μg/kg to 26,000 μg/kg. The reservoir sample levels are at the lower ends of each of these ranges.

- PCBs may also be compared to historical data from the reservoir. In October 2002, total PCB concentrations in sediment samples collected from the reservoir ranged from 44 μg/kg to190 μg/kg. In October 1983, PCBs were detected in all three sediment samples collected from the Lewiston Reservoir at levels ranging from 189 μg/kg to 241 μg/kg. The level of PCBs found within the reservoir in 2002 was, therefore, somewhat lower than the historical data from the reservoir.

- Lead concentrations in the reservoir samples range from 31.6 mg/kg to 72.4 mg/kg. Mean sample concentrations from the historical data ranged from 13 mg/kg to 250 mg/kg and maximum sample concentrations ranged from 32 mg/kg to 1,760 mg/kg. The reservoir sample levels are at the lower ends of each of these ranges.

- Mercury concentrations in the reservoir samples range from 0.163 mg/kg to 0.206 mg/kg. Mean sample concentrations from the historical data ranged from 0.022 mg/kg to 0.65 mg/kg and maximum sample concentrations ranged 0.11 mg/kg to 1.825 mg/kg. The reservoir sample levels are at the lower ends of each of these ranges.

- Mirex was detected in only one sample in the reservoir at an estimated concentration of 53 μg/kg. Detected mirex concentrations from the historical data ranged from 4 μg/kg to 86 μg/kg. The mean sample concentration from the historical data is 25

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μg/kg. One of the samples collected in the upper Niagara River had an estimated mirex level of 6,400 μg/kg. The reservoir sample level is within the range of historical levels and is significantly lower than the level detected in the upper Niagara River.

Physical Data

Fine-grained sediments of adequate thickness to easily obtain sediment samples were present at each of the five sampling locations in the reservoir. The results of the bathymetry survey, which indicated sediment deposits of greater than 2 feet, corresponded well with the findings of the sampling activities.

The swift current in the forebay does not allow an appreciable amount of fine-grained sediment to be deposited. The typical sediment encountered during sampling activities was predominantly gravel and cobble. Because of the coarse nature of the sediments and the swift current and the remoteness of the sampling personnel from the sample locations, it was not possible to make a determination of the presence and extent of sediment in the forebay.

The sediments in the upper and lower Niagara River are typically comprised of sand with small amounts of silt, clay, and gravel. At one sample location in the upper Niagara River, however, fine-grained sediments were encountered in the top several inches of the sample.

Summary

Typically, fine-grained sediments were encountered in the Lewiston Reservoir at the locations of predicted sediment accumulations. These sediments had significantly higher organic carbon content than the coarser-grained sediments encountered in the Niagara River. The fine-grained organic sediment encountered in the Lewiston Reservoir was targeted for this study, because sediments with these physical

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and chemical characteristics are more likely to contain chemical constituents (providing a "worst case scenario").

The sediment that was obtained from the forebay was very coarse-grained (sand, gravel, and cobbles) and was very limited in volume. Consequently, forebay sediments were not assessed as to their chemical or physical quality.

In general, the constituents detected in the Lewiston Reservoir sediments (PAHs, PCBs, Mirex, arsenic, lead, and mercury) were also detected in the Niagara River sediments. The reservoir samples had consistent detections of PAHs, PCBs, and various metals. The detected constituent levels in the Lewiston Reservoir samples were similar to, and in some instances considerably less than, the levels detected in the Niagara River sediments. In fact, the sample collected in the lower Niagara River, upstream of the tailrace, was impacted by the highest number of constituents at generally higher concentrations than in the Lewiston Reservoir samples. There were several exceedances (i.e., arsenic, lead, mercury, PAHs, mirex and PCBs) of NYSDEC sediment criteria and PEC and TEC assessment values in the samples collected in the Lewiston Reservoir. But as with the detections discussed above, any exceedance of a constituent in the Lewiston Reservoir was also exceeded in the upper Niagara River and/or the lower Niagara River, upstream of the tailrace.

Based on pH and sediment organic carbon levels in the reservoir, lead and mercury in sediment are not expected to partition to the overlying water column. Arsenic compounds vary in terms of their solubilities; however, the presence of clays in the benthic substrate of the reservoir suggest that leaching of arsenic to surface water or groundwater from sediments is unlikely. PAHs and PCBs detected in sediments are also likely to remain there, owing to their extremely low solubilities in water and their strong tendency to sorb to organic carbon in bed sediments. Sediment-bound PAHs and PCBs, if re-suspended to the overlying water column, will in all likelihood adhere to suspended particulate matter rather than be redissolved in water. Mirex, an organochlorine pesticide detected in one reservoir sediment sample, adsorbs strongly to sediment particles and has a low solubility in water. As such, residual mirex in sediments should not redissolve to surface water or groundwater.

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1.0 INTRODUCTION

The New York Power Authority (NYPA) is in the process of relicensing the Niagara Power Project, located in Lewiston, Niagara County, New York (Project). As part of the relicensing process, NYPA is developing information related to various aspects of the Project, including assessment of the quality of sediment at various locations within the Lewiston Reservoir and forebay.

This report has been prepared to describe the field activities and to present the findings of the 2002 sediment quality assessment program conducted as part of the relicensing effort.

1.1 Project Background

The 1,880-MW (firm capacity) Niagara Power Project (NPP) is one of the largest non-federal hydroelectric facilities in North America. The Project was licensed to the Power Authority of the State of New York (now the New York Power Authority) in 1957. Construction of the Project began in 1958 and the electricity was first produced in 1961.

The Project has several components (Figure 1.1-1). Twin intakes are located approximately 2.6 miles above Niagara Falls. Water entering these intakes is routed around the Falls via two large low-head conduits to a 1.8 billion-gallon forebay, lying on an east-west axis about 4 miles downstream of the Falls. The forebay is located on the east bank of the Niagara River. At the west end of the forebay, between the forebay itself and the river, is the Robert Moses Niagara Power Plant (RMNPP), NYPA's main generating plant at Niagara. This plant has 13 turbines that generate electricity from water stored in the forebay. Head is approximately 300 feet. At the east end of the forebay is the Lewiston Pump Generating Plant (LPGP). Under non-peak usage conditions (i.e., at night and on weekends), water is pumped from the forebay via the plant's 12 pumps into the 22-billion-gallon Lewiston Reservoir, which lies east of the plant. During peak usage conditions (i.e., daytime Monday through Friday), the pumps are reversed for use as generators, and water is allowed to flow back through the plant, producing electricity. The forebay, therefore, serves as headwater for the Robert Moses plant and tailwater for the LPGP. South

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of the forebay is a switchyard, which serves as the electrical interface between the Project and its service area.

Impoundment of reservoir waters is accomplished by a 6.5-mile riprapped earthen dike, anchored to either end of the LPGP. When the reservoir is full, water depth is about 42 feet (1,900-acre surface area). At maximum reservoir drawdown, average water depth is just over 3 feet. Monday through Friday, the reservoir is drawn down 6-7 feet daily, with partial refilling overnight. Water level is, therefore, generally at its minimum on Friday night. The reservoir is typically refilled during the weekend so that the reservoir water level is at its maximum on Monday morning.

1.2 Investigation Objectives

The present investigation has two objectives: (1) to document the extent of sedimentation (including depth and location) in the Lewiston Reservoir and forebay, and (2) to assess the physical/chemical quality of sediment in these two water bodies. The sediment quality was assessed during this investigation by comparing analytical results to the appropriate environmental sediment quality guidelines and available historical data.

The investigation also included the collection of sediment samples from the upper and lower Niagara River for laboratory analysis of the same chemical and physical parameters as the samples collected in the reservoir and forebay. The data from these samples provided additional information that was used to (1) assess the potential impacts to sediment quality from upstream sources and (2) compare sediment quality results obtained from the Lewiston Reservoir and forebay to the upstream and downstream samples.

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1.3 Investigation Area

The area of this investigation was the Lewiston Reservoir and forebay. Samples were also collected in the upper Niagara River (near the Project water intakes) and lower Niagara River (near the Project tailrace (Figure 1.1-1)).

1.4 Summary of Existing Site Data

No recent data are available relative to the chemical quality of sediment in the Lewiston Reservoir and forebay. The field activities conducted as part of this study provided information on the levels of the constituents of concern (derived from the Niagara River Toxics Management Plan [NRTMP]) in Lewiston Reservoir and forebay sediments, as well as in the sediments collected at upstream and downstream locations in the upper and lower Niagara River.

A bathymetric survey was conducted in May 2001 (TVGA and C&C 2002) to provide current, accurate bottom contour data and mapping of the Lewiston Reservoir and forebay. Multibeam sonar was used to collect depth soundings throughout the reservoir and forebay. These soundings were used to create an electronic model of bathymetry, as it existed in May 2001. Another electronic model was created using data from a topographic ground survey performed at the time of construction by Lewis-Dickerson Associates. It should be noted that more data are available in the 2001 data set than in the 1961 data set. To more accurately compare the two electronic models, the 2001 model was recompiled using only those points that correspond to a point where data was collected in 1961. Elevation differences between the 2001 (recompiled) and 1961 electronic models were used to indicate areas of potential deposition in the reservoir (Figure 1.3-1) and forebay (Figure 1.3-2). Estimated deposits of some sediment in some areas of the Reservoir and forebay were greater than 4 feet based on the survey data. Sampling locations were biased to sediment deposits that were believed to be sufficiently thick and where grain size and organic content would allow the sediment to be properly collected and characterized.

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1.5 Investigation Team

The URS Team (consisting of URS Corporation, Gomez and Sullivan Engineers, P.C., and E/PRO Engineering & Environmental Consulting, LLC) contracted Environmental Standards, Inc., on behalf on the NYPA, to perform this sediment quality investigation. Environmental Standards, Inc. (Environmental Standards) led the investigation team, which consisted of Lee H. Harper, Ph.D., a licensed watercraft operator (U.S. Coast Guard Master), of Riveredge Associates, LLC [Riveredge]); a local crane operator (Clark Rigging & Rental Corporation [Clark]); and five laboratories (Severn Trent Laboratories, Inc. [STL], of North Canton, Ohio; STL of Burlington, Vermont; STL of Austin, Texas; Battelle Ocean Sciences of Sequim, Washington; and Lancaster Laboratories of Lancaster, Pennsylvania).

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This material is contained in:
Volume 2
Section: Extent of Sedimentation and Quality of Sediment in the Lewiston Reservoir and Forebay

FIGURE 1.1-1

NYPA NIAGARA POWER PROJECT COMPONENTS

[NIP – General Location Maps]

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FIGURE 1.3-1

LEWISTON RESERVOIR SEDIMENT THICKNESS MAP

[NIP – General Location Maps]

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FIGURE 1.3-2

FOREBAY SEDIMENT THICKNESS MAP

[NIP – General Location Maps]

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2.0 FIELD METHODS

The field sampling program was conducted in accordance with the following documents, all prepared by Environmental Standards:

(1) Field Sampling Plan (FSP), (2) Quality Assurance Project Plan (QAPP), and (3) Site-Specific Health and Safety Plan (HASP).

2.1 Sample Collection Sites

The 2001 bathymetric survey (TVGA and C&C 2002) coupled with the construction elevations allowed for the determination of areas of sediment accumulation in the Lewiston Reservoir and forebay as presented in Figure 1.3-1 and Figure 1.3-2. Sediment sample locations in these two water bodies were selected by targeting areas of highest sediment accumulations (potentially greater than 2 feet) while maintaining an appropriate spatial distribution.

2.1.1 Lewiston Reservoir

Within the reservoir, the areas of highest sediment accumulation typically occurred at distances of more than 5,000 feet from the pumps/turbines at the LPGP. There is no significant amount of sediment deposited near the plant likely due to frequent turbulent water flow into and out of the reservoir through the plant. The five reservoir sample locations proposed in the FSP were based on the specific vertical and horizontal sediment deposition patterns in this water body as interpreted from the bathymetric survey (TVGA and C&C 2002) and historical construction elevations. The sediment sample locations are presented in Figure 2.1-1.

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2.1.2 Forebay

Areas of the highest sediment accumulation in the forebay were generally limited to locations along the southern sidewall, and to some extent, the northern sidewall of the forebay. The two sediment sample locations proposed for the forebay were selected at points along the southern side of the forebay because: (1) the areas of highest accumulation and aerial extent of sediment existed along the southern side and (2) the southern side was more accessible in terms of being able to safely and efficiently mobilize the equipment needed for sample collection. Forebay sediment sample locations are presented in Figure 2.1-2.

2.1.3 Upper and Lower Niagara River

The sampling locations in the upper and lower Niagara River were less specific than the reservoir and forebay because a bathymetric survey had not been conducted in these water bodies. The goal of sampling activities in the Niagara River was to collect two sediment samples in the upper Niagara River (one just upstream of the intakes along the northern side of the river and the other near Buckhorn Island) and two samples in the lower Niagara River (one just upstream of the tailrace and the other just downstream of the tailrace). The specific sampling locations had to be determined during sampling activities due to the uncertainty of locations of significant accumulations of the targeted high organic content, fine-grained sediment. The actual sample locations (presented in Figure 2.1-3) were generally consistent with the proposed locations (i.e., two samples were collected upstream of the intakes in the upper Niagara River, and one sample was collected upstream and one sample downstream of the tailrace in the lower Niagara River), but the distances from the intakes and tailrace differed from what had been proposed in the FSP due to the actual locations of sediment deposits that would allow for the collection of fine grained sediment.

Prior to initiating sampling activities, a field reconnaissance was conducted of sampling locations in the forebay, the lower Niagara River, and the upper Niagara River.

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2.2 Sampling Activities

Sediment sampling activities were conducted from October 1 through October 3, 2002. Sample collection activities were completed in one area before advancing to the next. Nine of 11 proposed sampling locations were accessed using a 2001 Lund Alaskan 18-foot boat, with a 70-HP motor. The remaining two sampling locations (in the forebay) were accessed with the largest crane that could feasibly be mobilized to the forebay area.

The upper Niagara River sampling locations were reached by launching the boat at Griffon Park in Niagara Falls, New York, and proceeding downstream to the intakes. The lower Niagara River sampling locations were reached by launching the boat at the Lewiston Landing Waterfront Park in Lewiston, New York, and proceeding upstream to the tailrace. The Lewiston Reservoir sampling locations were accessed by launching a boat from the reservoir boat launch and proceeding across the reservoir to the sample locations. Within the reservoir, the boat was navigated to within 10 feet of the proposed sample locations using a GPS unit that had been programmed with the latitude and longitude of the proposed sampling locations. The boat was anchored during sampling at each sampling location.

The forebay was accessed using a crane with a 220-foot reach. Various techniques were used in an attempt to collect samples in the forebay (see Section 2.2.4).

At each sampling location, several sample aliquots were collected at sample sublocations (locations within approximately 15 feet of the original sample location) so that there would be sufficient sample volume for laboratory analysis of all the requested analytical parameters and so that the sample would be representative of the sediment quality in the general area of the sample location. Once the sediment samples had been collected, the project geologist visually classified each sediment sample for physical characteristics such as grain size, color, and relative density and for evidence of chemical impact. The sediment was field-screened for volatile organic vapors using a photoionization detector (PID). The fraction of the samples designated for volatile organic compound (VOC) analysis was collected immediately and placed in appropriate glass containers. The remainder of the sediment was homogenized in Pyrex® bowls using disposable wooden scoops and subsequently transferred to appropriate containers

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for transport to the laboratory. The samples were packaged carefully and placed into iced coolers. A Chain-of-Custody (COC) record accompanying the samples to the point of analysis was completed. The samples were then shipped via United Parcel Service (UPS) overnight carrier. A more detailed discussion of sampling activities is provided below.

2.2.1 Upper Niagara River

On October 1, 2002, Environmental Standards collected two sediment samples (UNR-SED01 and UNR-SED02) in the upper Niagara River, near the Project intakes (Figure 2.1-3). Sonar was used to measure river depth at various locations in the river to predict likely areas of sediment accumulation. Although more than 15 attempts were made to obtain a sediment sample using a Ponar dredge in the areas of suspected sediment accumulation, the coarse-grained substrate (cobbles and boulders) and thick vegetation precluded the collection of an appropriate volume and the targeted sample type (i.e., fine grain, high organic content sediment) using the Ponar dredge. A sediment corer was finally successfully used to collect the two sediment samples of the targeted sediment type in the upper Niagara River.

2.2.2 Lower Niagara River

On October 1, 2002, Environmental Standards collected two sediment samples in the lower Niagara River. One sediment sample was collected upstream of the tailrace (LNR-SED03) and one sediment sample was collected downstream of the tailrace (LNR-SED04) (Figure 2.1-3).

Sonar and visual observations were used to evaluate likely areas of sediment accumulation in the lower Niagara River. Water current was much stronger and the water level was much deeper in the lower Niagara than in the upper river, which made it difficult to find areas of suspected sediment accumulation. Upstream of the tailrace, the sediment deposits identified from the boat were only 1 to 2 inches thick and were located amongst cobbles and boulders. These circumstances precluded using the Ponar dredge and the sediment corer from obtaining an adequate volume of sediment for laboratory analysis; consequently, a nearshore sediment sample was collected using a stainless-steel trowel. The sample collected (LNR-

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SED03) was believed to be sediment deposited by the river and not to be the result of shoreline sloughing based on two factors: (1) the riverbank in the area showed no signs of sloughing (the shoreline approximately 20 feet from the sampling location was, in fact, a bedrock wall); and (2) the water level rose approximately 1 foot during sampling at this location, with complete submergence of the sampling site (indicating that sediment deposition may occur during higher water level periods).

The depth of water in the river channel at the sampling location downstream of the tailrace was much deeper (40-80 feet), and the current was swifter than the water upstream of the tailrace. It was, therefore, necessary to move the sampling location farther downstream than originally proposed in the FSP. Accumulated sediment was found just downstream of the Niagara escarpment near Artpark. The downstream sample (LNR-SED04) was collected several feet from shore at this location using the Ponar dredge.

2.2.3 Lewiston Reservoir

On October 2, 2002, Environmental Standards collected five sediment samples (RES-SED05 through RES-SED09) and a field duplicate (RES-SED12) in the Lewiston Reservoir. Using, latitude and longitude information for each sampling location and a Global Positioning System unit on the boat, the boat operator was able to anchor the boat within approximately 10 feet of each proposed location (Figure 2.1-1). A Ponar dredge was used to collect the sediment samples in the Lewiston Reservoir.

2.2.4 Forebay

On October 3, 2002, Environmental Standards attempted to collect two sediment samples (BAY-SED10 and BAY-SED11) at the proposed locations in the forebay (Figure 2.1-2) using a large crane with a reach of over 220 feet. The proposed sample locations were located in the field using landmarks observed on the aerial photograph.

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Approximately 50 feet of nylon rope was attached to the crane cable to eliminate the possibility of sample contamination by the cable (one end of the rope was attached to the crane hook and the other end to the sampling equipment). Multiple attempts were made using various configurations of sampling equipment (including a single Ponar, dual Ponars, and a sediment corer) and methods (including placing weights around the corers and using a separator bar). The dual-Ponar samplers, held apart by a separator bar, were the most effective. However, even this sampling method wasn't successful in obtaining fine-grained, high organic content sediments suitable for collection. Multiple attempts were made to collect samples within approximately 100 feet east and west of the depicted sample locations at distances of approximately 50 to 125 feet from the forebay sidewall. These attempts were also unsuccessful in obtaining a sample for laboratory analysis, due to the coarse nature of the sediment deposits, the swift current, and the significant depth of the water (approximately 40 feet). Limited amounts of coarse-grained sediments (cobbles and gravel) were obtained during some sampling attempts, but this type of material was not sampled because it does not readily adsorb chemical constituents being investigated and was unsuitable for laboratory analysis.

2.3 Documentation

2.3.1 Field Logbooks

A bound field logbook with sequentially numbered pages was maintained at the site by the Environmental Standards Field Team Leader to record information pertinent to field sampling activities, including equipment preparation efforts. Logbook entries were made in permanent, waterproof ink. The Field Team Leader reviewed field logbook entries daily and initialed each page.

A separate entry was made for each sample collected. Information typically recorded in the field logbook included:

- Name and location of site
- Name and affiliation of Field Team Leader

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- Names of team members
- Daily time of arrival at and departure from the Project
- Daily weather conditions
- Field observations
- Dates and times of sample collection or event
- Numbers and types of samples taken and sample identification numbers
- A description of sampling methodology
- A record of daily phone calls and/or contact with individuals at the sampling areas
- Health and safety observations

Photographs were taken of each sampling location to document the area, sampling equipment, sample type, etc. Frame numbers were logged in the field logbook to associate photographs with the correct sampling location. A log of selected photographs is provided in Appendix A.

2.3.2 Sample Labeling

Environmental Standards field personnel attached a sample label to each sample container before filling the container. Each sample label contained the following information (much of the information was pre-printed and the remainder was handwritten in permanent, waterproof ink):

- Project name and number
- Unique field sample identifier
- Date and time of collection
- Sampling procedure (i.e., composite, grab, etc.)
- Preservatives used

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- Analysis requested
- Sampler's initials

A unique sample identifier, as presented below, was assigned to each sample collected. Each sample identifier contained three fields: organization, area, and sample type with ID number. For this project, the first field in all cases was "NYPA"; for brevity purposes this field has not been included in the sample identifiers presented in this report. The second field was one of the following:

- Upper Niagara River UNR
- Lower Niagara River LNR
- Forebay BAY
- Lewiston Reservoir RES

The third field was one of the following:

- Sediment SED (followed by ID number)
- Equipment Rinsate Blank ERB

The sample ID numbers employed ran from 01 through 11 (10 and 11, originally assigned to the forebay samples, were not used). The number 12 was used for the field duplicate sample.

2.4 Decontamination

In an effort to limit the potential for contamination and to reduce the costs involved in decontamination of reusable equipment, disposable sediment sampling equipment was employed to the extent possible. Non-disposable equipment was decontaminated between sampling locations using the procedures described in SOP 005 of the FSP, as summarized below.

- Alconox and water wash

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- Distilled water rinse
- Nitric acid rinse (1%) (used only on nonmetallic equipment)
- Methanol rinse
- Distilled/deionized water rinse
- Air-drying (and wrapping in plastic or foil if not to be used immediately).

2.5 Quality Assurance/Quality Control

Field QC samples were used to assess laboratory performance and to gauge the likelihood of contamination associated with field or laboratory activities. QC samples were collected and analyzed in conjunction with samples designated for laboratory analysis using U.S. Environmental Protection Agency (USEPA) protocols.

For this program, the following field QC samples were collected:

- One equipment rinsate blank (analyzed for the same parameters as the investigative samples, except for total volatile solids and grain size).
- One field duplicate sample (analyzed for the same parameters as specified for the associated investigative sample, except for grain size). The field duplicate, identified as RES-SED12, was collected as a duplicate of sample RES-SED08.
- One matrix spike/matrix spike duplicate (MS/MSD) pair (analyzed for the same parameters as specified for the associated investigative sample, except for total volatile solids and grain size). The MS/MSD pair was collected at LNR-SED03.

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2.6 Packaging/Shipping

Samples were packed and shipped at the end of each day's sampling activities in accordance with the procedures presented in the FSP. The samples were shipped via UPS for next morning delivery to the appropriate laboratories.

2.7 Sample Custody

A COC record accompanied the samples that were collected and sent to the laboratories for analysis. The information recorded on the COC was consistent with that presented in the FSP. Sample custody in the field and laboratory was in compliance with the requirements of the FSP and QAPP.

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This material is contained in:
Volume 2
Section: Extent of Sedimentation and Quality of Sediment in the Lewiston Reservoir and Forebay

FIGURE 2.1-1

LEWISTON RESERVOIR SAMPLE LOCATIONS

[NIP – General Location Maps]

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FIGURE 2.1-2

FOREBAY SAMPLE LOCATIONS

[NIP – General Location Maps]

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FIGURE 2.1-3

NIAGARA RIVER SAMPLE LOCATIONS

[NIP – General Location Maps]

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3.0 FINDINGS

3.1 Chemical Data

Sediment samples collected by Environmental Standards were analyzed at approved (10 NYCRR Part 55, Subpart 55-2) laboratories for the constituents identified in the project FSP, including 18 priority toxic pollutants identified in the Niagara River Toxics Management Plan (NRTMP) and five additional parameters of interest to the New York State Department of Environmental Conservation (NYSDEC). The NRTMP priority toxics were selected based on their history of exceeding water, fish, or sediment criteria values in the Niagara River or Lake Ontario. A summary of the analytical constituents is provided below.

NRTMP Priority Toxic Pollutants

- tetrachloroethylene (PCE) (one location).
- polynuclear aromatic hydrocarbons (PAHs) - reported individually as benzo(a)anthracene (six locations), benzo(a)pyrene (seven locations), benzo(b) fluoranthene (seven locations), benzo(k)fluoranthene (six locations), chrysene (seven locations).
- octachlorostyrene (none)
- total polychlorinated biphenyls (PCBs) (comprising Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260) (seven locations).
- pesticides (technical chlordane [none], total mirex [includes mirex and photomirex] [two], dieldrin [none], hexachlorobenzene [two], DDD [none], DDE [none], DDT [none], and toxaphene [none]).
- metals – mercury (seven locations), arsenic (nine locations), and lead (nine locations).

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- dioxin (2,3,7,8-TCDD) (one location).

Additional Constituents

- total PAHs (reported as a total concentration of acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene) (seven locations).
- cadmium (unusable data).
- total organic carbon (TOC) (nine location).
- total volatile solids (nine locations).
- grain size

STL (North Canton, Ohio), which was the prime contracted laboratory, routed the samples for the requested analyses to its laboratory network facilities. STL outsourced the mercury analysis to Battelle Marine Sciences Laboratory (Battelle) in Sequim, Washington. Environmental Standards directly subcontracted Lancaster Laboratories, Inc. of Lancaster, Pennsylvania, to provide total volatile solids analysis. A summary of the laboratories that performed the analyses, as well as the analytical parameters and the analytical methods, is provided in Table 3.1-1. The results of the laboratory analyses for the Lewiston Reservoir samples are presented in Figure 3.1-1 and the results of the upper and lower Niagara River samples are provided in Figure 3.1-2.

The laboratories provided Environmental Standards with Contract Laboratory Program (CLP) full data deliverables sufficient for performing manual data validation and an electronic data deliverable. Comprehensive Analytical Results tables are provided in Appendix B. Environmental Standards chemists validated these results; a copy of the data validation report, entitled "Quality Assurance Review of Sediment Samples Collected for the Niagara Power Project Extent of Sedimentation and Quality of Sediment in the Lewiston Reservoir and Forebay," is included as Appendix C.

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Below is a summary of analytical findings, addressed by analytical category. Only detected analytes are discussed in this section. A summary of detected analytes is provided on Table 3.1-2.

3.1.1 Volatile Organic Compounds

PCE, the only VOC analyzed for, was detected in one of the nine samples (upstream of the tailrace, LNR-SED03) at a concentration of 0.62 micrograms per kilogram (μg/kg).

3.1.2 Polynuclear Aromatic Hydrocarbons

- Benzo(a)anthracene was detected upstream of the tailrace (LNR-SED03) and in all reservoir samples at concentrations ranging from 260 μg/kg in the reservoir (RES-SED09) to 2,100 μg/kg upstream of the tailrace (LNR-SED03). The highest concentration detected was, therefore, in an upstream sample.
- Benzo(a)pyrene was detected in the center of the river, near the intakes (UNR-SED02), upstream of the tailrace (LNR-SED03), and in all reservoir samples at concentrations ranging from 26 μg/kg near the intakes (UNR-SED02) to 2,900 μg/kg upstream of the tailrace (LNR-SED03). Again, the highest concentration was in an upstream sample.
- Benzo(b)fluoranthene was detected in the center of the river, near the intakes (UNR-SED02), upstream of the tailrace (LNR-SED03), and in all reservoir samples at concentrations ranging from 27 μg/kg near the intakes (UNR-SED02) to 2,600 μg/kg upstream of the tailrace (LNR-SED03). The highest concentration was, therefore, detected in an upstream sample.
- Benzo(k)fluoranthene was detected in the sample upstream of the tailrace (LNR-SED03) and in all reservoir samples. Concentrations ranged from 380 μg/kg in reservoir sample RES-SED07 to 2,400 μg/kg upstream of the

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tailrace (LNR-SED03). Again, the highest concentration was detected in an upstream sample.

- Chrysene was detected in the center of the river, near the intakes (UNR-SED02), upstream of the tailrace (LNR-SED03), and in all reservoir samples at concentrations ranging from 55 μg/kg near the intakes (UNR-SED02) to 2,200 μg/kg upstream of the tailrace (LNR-SED03). The highest concentration detected was in an upstream sample.
- Analysis for total PAHs (including 15 analytes) revealed PAHs in the center of the river near the intakes (UNR-SED02), upstream of the tailrace (LNR-SED03), and in all reservoir samples at concentrations ranging from 405 μg/kg in the channel center near the intakes (UNR-SED02) to 22,000 μg/kg upstream of the tailrace (LNR-SED03). As in the case of individual PAHs measured, the highest total PAH concentration was detected in an upstream sample.

Note that sample UNR-SED01, near the shoreline at the intakes, was diluted 200-fold due to interfering non-target compounds which increased the reporting detection limit to 71,000 ug/kg. This dilution probably explains the lack of PAH detections in the sample, which, based on field observations and PID readings was expected to have detectable levels of PAHs.

3.1.3 Total PCBs

Analysis for total PCBs (consisting of Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260) identified PCBs in both lower river locations (upstream of the tailrace at LNR-SED03 and downstream of the tailrace at LNR-SED04) and in all reservoir samples. Concentrations ranged from 44 μg/kg in one of the reservoir samples (RES-SED08) to 470 μg/kg upstream of the tailrace (LNR-SED03). The highest total PCB concentration was detected in an upstream sample.

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3.1.4 Pesticides

- Hexachlorobenzene was detected in two samples: upstream of the tailrace (LNR-SED03) at 190 μg/kg, and at the intakes near the shoreline (UNR-SED01) at 21,000 μg/kg. Hexachlorobenzene was not detected in any other samples.
- Total mirex (including photomirex) was detected in two samples: the lower concentration (53 μg/kg) detected in one reservoir sample (RES-SED05) and the higher concentration (6,400 μg/kg) detected in the sample collected upstream of the intakes near the shoreline (UNR-SED01).

3.1.5 Metals

- Arsenic was detected in all samples at concentrations ranging from 1.6 milligrams per kilogram (mg/kg) at the intakes near the shoreline (UNR-SED01) to 14.5 mg/kg in one of the reservoir samples (RES-SED08).
- Lead was detected in all samples at concentrations ranging from 4.2 mg/kg in the sample collected downstream of the tailrace (LNR-SED04) to 72.4 mg/kg in one of the reservoir samples (RES-SED08).
- Mercury was detected near the northern shoreline of the river (UNR-SED01), upstream of the tailrace (LNR-SED03), and in all the reservoir samples, at concentrations ranging from 0.163 mg/kg in one of the reservoir samples (RES-SED012) to 0.577 mg/kg in the sample collected upstream of the tailrace (LNR-SED03).
- Note that due to the presence of cadmium and mercury in the associated equipment blank, laboratory-reported positive results for cadmium in all sediment samples and for mercury in sample UNR-SED02 and LNR-SED04 are considered unusable and have been flagged “R” on the data tables.

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3.1.6 Dioxin

The compound 2,3,7,8-TCDD was detected in one sample collected upstream of the tailrace (LNR-SED03) at a concentration of 0.0079 picograms per gram (pg/g).

3.1.7 Total Organic Carbon

Analysis for TOC indicated organic carbon in all samples at concentrations ranging from 249 mg/kg downstream of the tailrace (LNR-SED04) to 16,800 mg/kg in one of the reservoir samples (RES-SED07).

3.1.8 Total Volatile Solids

Total volatile solids levels ranged from 1.89% by weight in the sample collected at the intakes near the shoreline (UNR-SED01) to 2.67% by weight in two of the reservoir samples (RES-SED05 and RES-SED06).

3.2 Chemical Data Completeness and Usability

Completeness is a measure of the degree to which the amount of sample data collected meets the needs of the sampling program and is quantified as the relative number of analytical data points that meet the acceptance criteria (including accuracy, precision, and any other criteria required by the specific analytical method used). Completeness is defined as a comparison of actual numbers of usable data points compared to the number of expected usable points, and is expressed as a percentage. The equipment blank is not included in the calculation.

A summary of the data completeness for the individual analytical fractions is presented on Table 3.2-1.

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The percent completeness for the entire data set is 95.7% and the majority of the data is usable with some qualification. While the project goal identified in the QAPP was 100%, regulatory agencies typically accept a minimum of 90% to 95% completeness (which was achieved for this data set). A more detailed completeness and usability report is provided in Appendix D.

3.3 Physical Data

STL performed grain size/hydrometer testing on all samples. A summary of the grain size analysis is presented on Table 3.3-1. The physical classification of each sample (using the Burmeister Classification System) and other associated sample information is presented on Table 3.3-2. Generally, the sediments in the upper and lower Niagara River were coarse materials (coarse to fine sand with varying amounts of fine gravel, silt, and clay). The sediments in the reservoir consisted primarily of silt and clay, with varying amounts of medium to fine sand. The limited volume of sediment obtained in the forebay allowed for only visual (not laboratory) classification. The forebay sediments consisted predominantly of cobbles and coarse to fine gravel. Further details on Lewiston Reservoir, forebay, and river sediments follow.

3.3.1 Lewiston Reservoir

As depicted in the sample location figure for the Lewiston Reservoir (Figure 2.1-1), the sediment samples were collected in spatially distributed areas of the potentially thickest sediment accumulations, as indicated by the bathymetric survey (TVGA and C&C 2002). Sample collection activities confirmed the presence of fine-grained sediment accumulations at the sampling locations. Sediment sample collection efforts in the reservoir were the least complicated of all the sampling areas due to the presence of adequate volumes of fine-grained sediment and the absence of impeding vegetation and current.

The type of sediment encountered at the five sampling locations within the reservoir was dark gray silt and clay, with small amounts of medium to fine sand; no petroleum or chemical odors were detected. This sediment type is typical of the sediments found in low-flow surface water bodies. The

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majority of the reservoir is considered a low-flow surface water body, except for the area near the intake/outlet area of the Lewiston Pump Generating Plant.

3.3.2 Forebay

In the forebay as elsewhere, areas of suspected accumulated sediments, as indicated by the bathymetric survey (TVGA and C&C 2002), were targeted for sampling (Figure 2.1-2). As stated previously, however, despite careful planning and the application of adequate manpower and equipment to the task, it was not possible to collect a significant amount of sediment from the areas most likely to contain accumulated sediments. The limited amount of sediment that was obtained included little fine-grained material and was mainly cobbles and gravel, as is typical of surface water bodies that have as swift a current as the forebay.

3.3.3 Niagara River

As previously discussed, significant time and effort were devoted to locating areas of accumulated fine-grained, high organic content sediment in the upper and lower Niagara River. The selected sample locations (Figure 2.1-3) represent the areas closest to the proposed locations where any appreciable sediment (consisting of both fine- and coarse-grained materials) could be obtained. In the upper Niagara River, UNR-SED01 was collected near the northern shore and consisted of sand, silt, and clay with a small amount of fine gravel. This material was black in color, had a PID reading of 4.8 parts per million (ppm), had an oil sheen, and had a strong petroleum-like odor. At UNR-SED02 in the middle of the river channel, the top several inches of material was predominantly brown silt and clay, and the bottom several inches was brown sand, silt, and clay with a small amount of fine gravel; no petroleum or chemical odors were detected in this sample.

The sediment types in the lower Niagara River were much coarser than those in the upper Niagara River, and sediment deposits were considerable less available due to a swifter water current. The

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sediment at these locations was comprised predominantly of sand with small amounts of silt, clay, and fine gravel.

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TABLE 3.1-1

LABORATORIES PERFORMING SEDIMENT SAMPLE ANALYSIS

Parameter	Laboratory	Method
Pesticides	STL N. Canton	SW-846 Method 8081A
PCBs	STL N. Canton	SW-846 Method 8082
Arsenic	STL N. Canton	SW-846 Method 6020
Cadmium	STL N. Canton	SW-846 Method 6020
Lead	STL N. Canton	SW-846 Method 6020
Tetrachloroethylene	STL N. Canton	SW-846 Method 8260B
TOC	STL N. Canton	Lloyd Kahn
Grain Size	STL Burlington	ASTM Method D-422
PAHs	STL Austin	SW-846 Method 8270C
Mercury	Battelle	US EPA Method 1631B
Total Volatile Solids	Lancaster Laboratories	SM Method 2540G Modified

PCBs = polychlorinated biphenyls;
TOC = Total Organic Carbon;
PAHs = polynuclear aromatic hydrocarbons

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TABLE 3.1-2

DETECTED ANALYTES

		Units	UNR-SED01 Upper River	UNR-SED02 Upper River	LNR-SED03 Lower River	LNR-SED04 Lower River	RES-SED05 Reservoir	RES-SED06 Reservoir	RES-SED07 Reservoir	RES-SED08 Reservoir	RES-SED09 Reservoir	RES-SED12 (DUP OF SED-08) Reservoir	ERB-01 Equip. Blank
VOCs	Tetrachloroethylene	µg/kg			0.62 J								
PAHs	Benzo(a)anthracene	µg/kg			2100		480	360 J	280 J	450 J	260 J	340 J	
	Benzo(a)pyrene	µg/kg		26 J	2900		710	570 J	490 J	840 J	560 J	640 J	
	Benzo(b)fluoranthene	µg/kg		27 J	2600		860	670 J	670 J	1100 J	750 J	840 J	
	Benzo(k)fluoranthene	µg/kg			2400		630	540 J	380 J	690 J	480 J	520 J	
	Chrysene	µg/kg		55 J	2200		800	640 J	620 J	1100 J	640 J	810 J	
	Total PAHs	µg/kg		405 J	22000 J		7400 J	6100 J	5500 J	9500 J	6000 J	7200 J	
Pesticides	Hexachlorobenzene	µg/kg	21000		190								
	Mirex	µg/kg	6400 J				53 J						
PCBs	Aroclor 1242	µg/kg				96	150	130 J	79 J		57 J	99 J	
	Aroclor 1248	µg/kg			390					44 J			
	Aroclor 1260	µg/kg			80 J	22 J	43 J	37 J	28 J				
	Total PCBs	µg/kg			470 J	120 J	190 J	170 J	110 J	44 J	57 J	99 J	

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TABLE 3.1-2 (CONT.)

DETECTED ANALYTES

		Units	UNR-SED01 Upper River	UNR-SED02 Upper River	LNR-SED03 Lower River	LNR-SED04 Lower River	RES-SED05 Reservoir	RES-SED06 Reservoir	RES-SED07 Reservoir	RES-SED08 Reservoir	RES-SED09 Reservoir	RES-SED12 (DUP OF SED-08) Reservoir	ERB-01 Equip. Blank
Metals	Arsenic	mg/kg	1.6 J	4.7 J	4.9 J	2.2 J	5.0 J	5.4 J	5.9 J	14.5 J	8.7 J	9.1 J	
	Cadmium	µg/l											48.1
	Lead	mg/kg	22.2 J	6.8 J	39.7 J	4.2 J	36.8 J	32.6 J	31.6 J	72.4 J	46.6 J	45.6 J	
	Lead	µg/l											0.34
	Mercury	mg/kg	0.265		0.577		0.206	0.169 J	0.171 J	0.175 J	0.173 J	0.163 J	
	Mercury	ng/l											0.398
Miscellaneous	2,3,7,8-TCDD	pg/g			7.9								
	Total Organic Carbon	mg/kg	4020 J	272 J	11800 J	249 J	15100 J	13400 J	16800 J	15300 J	16600 J	16200 J	
	Total Organic Carbon	mg/l											3.4
	Total Volatile Solids	%W/W	1.89 J	2.08 J	2.23 J	2.52 J	2.67	2.67	2.32	2.21	2.46	2.25	

VOC – Volatile Organic Compound
PAHs – Polynuclear Aromatic Hydrocarbons
PCBs – Polychlorinated Biphenyls
µg/kg – micrograms per kilogram
µg/l – micrograms per liter
mg/kg – milligrams per kilogram
mg/l – milligrams per liter
ng/l – nanograms per liter
pg/g – picograms per gram
%W/W – Percent Weight by Weight
J – Estimated Value

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TABLE 3.2-1

CHEMICAL DATA COMPLETENESS

Analytical Fraction	% Completeness *
volatile organic compounds	100%
polynuclear aromatic hydrocarbons	100%
pesticides	100%
PCBs	100%
TCDD	90.0%
Metals **	66.7%
Mercury **	80.0%
total volatile solids	100%
total organic carbon	100%

Notes:

PCBs = polychlorinated biphenyls
TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin

* - Overall project percent completeness is 95.7%.
** - Cadmium detected in associated equipment blank, therefore, all detected cadmium results are considered unusable. Detected mercury results in two samples are considered unusable due to detections in the associated rinse blank.

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TABLE 3.3-1

SUMMARY OF GRAIN SIZE ANALYSIS

Soil Classification	Particle Size (microns)	UNR-SED01 Percent by Weight of Total Sample	UNR-SED02 Percent of Total Sample	LNR-SED03 Percent of Total Sample	LNR-SED04 Percent of Total Sample	RES-SED05 Percent of Total Sample	RES-SED06 Percent of Total Sample	RES-SED07 Percent of Total Sample	RES-SED08 Percent of Total Sample	RES-SED09 Percent of Total Sample
Gravel	75,000 - 4,750	10.1	10.7	15.3	7.2	0.0	0.0	0.0	0.0	0.0
Sand	4,750 - 75	65.3	53.0	72.5	81.0	7.4	4.1	1.2	0.3	0.1
Coarse Sand	4,750 – 2,000	11.1	18.9	10.8	23.7	0.0	0.0	0.0	0.0	0.0
Medium Sand	2,000 - 425	11.6	12.6	21.9	39.8	0.4	0.5	0.2	0.1	0.0
Fine Sand	425 - 75	42.7	21.6	39.9	17.6	7.0	3.6	1.0	0.2	0.1
Silt	75 - 5	19.3	7.8	10.2	9.9	59.0	63.1	61.4	55.9	44.5
Clay	<5	5.3	28.5	2.0	1.8	33.6	32.9	37.4	43.9	55.4

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TABLE 3.3-2

SAMPLE INFORMATION

Sample ID	Sampling Date	Sampling Method	Easting[1]	Northing[1]	Sample Description	PID Reading[2]	Water Depth[3]	Water Temp.[4]	Water pH[4]
UNR-SED01	10/1/2002	Sediment Corer	388676.24	1120072.15	Black c-f SAND, some clayey Silt, little (-) f Gravel	4.8	12	20.8	8.10
UNR-SED02	10/1/2002	Sediment Corer	388528.62	1118746.64	Brown c-f SAND, and silty Clay, little (-) f Gravel	0	13	NR	NR
LNR-SED03	10/1/2002	Sampling Spoon	376533.52	1142975.76	Brown c-f SAND, little clayey Silt, little f Gravel	0	at shoreline	21.9	8.32
LNR-SED04	10/1/2002	Ponar/Boat	376317.22	1153465.63	Brown c-f SAND, little (-) clayey Silt, trace f Gravel	NR	2	NR	NR
RES-SED05	10/2/2002	Ponar/Boat	388751.06	1145751.67	Dark gray Clayey SILT, trace m-f Sand	NR	26	20.9	8.12
RES-SED06	10/2/2002	Ponar/Boat	387918.78	1147968.16	Dark gray Clayey SILT, trace (-) m-f Sand	0	24	20.8	8.14
RES-SED07	10/2/2002	Ponar/Boat	389731.36	1150240.72	Dark gray Clayey SILT, trace (-) m-f Sand	0	19	21.0	6.80
RES-SED08	10/2/2002	Ponar/Boat	392367.77	1146918.49	Dark gray Clayey SILT	0	22	21.0	8.12
RES-SED09	10/2/2002	Ponar/Boat	392057.87	1144088.07	Dark gray SILT & CLAY	0	21	21.0	8.13
BAY-SED10	10/3/2002	Ponar/Crane	380659.46	1145092.55	Cobbles and Gravel	-	-	-	-
BAY-SED11	10/3/2002	Ponar/Crane	381740.67	1145115.42	Cobbles and Gravel	-	-	-	-

[1] New York State Plane, West Zone, coordinate system, Units US Survey Feet, Project Horizontal Datum is NAD027. [2] Total volatile organic vapor readings obtained using a Mini Rae photoionization detector (10.6 eV lamp), reported in parts per million (ppm). [3] Water depths are approximate; obtained using boat's sonar (Hummingbird 300 TX), reported in feet. [4] Water quality data obtained using a Horiba U10 multi-parameter water quality meter; temperature in °C; pH in standard pH units.
NR = Not Recorded. Multiple attempts were made to collect sediment samples in the forebay, but due to the nature of the substrate or to lack of sediment, no sediment could be collected

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This material is contained in:
Volume 2
Section: Extent of Sedimentation and Quality of Sediment in the Lewiston Reservoir and Forebay

FIGURE 3.1-1

DETECTED ANALYTES IN THE LEWISTON RESERVOIR

[NIP – General Location Maps]

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FIGURE 3.1-2

DETECTED ANALYTES IN THE UPPER AND LOWER NIAGARA RIVER

[NIP – General Location Maps]

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4.0 ASSESSMENT OF FINDINGS

To evaluate site-specific sediment sample analytical results, detected values for the parameters measured were compared to NYSDEC sediment criteria (i.e., protective of human health from toxic effects of bioaccumulation) that were organic-carbon-normalized (using the TOC data from the samples collected during this investigation) according to NYSDEC Technical Guidance for Screening Contaminated Sediments (1999). According to this guidance document,

> The basis for the Equilibrium Partitioning (EP) methodology for deriving sediment criteria is that the toxicity of a contaminant in a sediment is attributable to the fraction of the contaminant that dissolves in the interstitial pore water, and is considered to be freely biologically available. The EP methodology predicts the concentration of contaminant that will dissolve in the interstitial pore water from three factors: (1) the concentration of the contaminant in the sediment; (2) the concentration of organic carbon in the sediment; and (3) the affinity of the contaminant for organic carbon in the sediment. The EP-based criteria should only be derived for sediments with organic carbon fractions between approximately 0.2%-12%. (NYSDEC 1999).

The TOC values for the nine collected sediment samples were all below 12%, but two samples (UNR-SED02 and LNR-SED04) had TOC values below 0.2%. Environmental Standards contacted NYSDEC and discussed the available options of deriving sediment criteria when the % TOC is below 0.2%. The NYSDEC cited a NYSDEC Memorandum dated February 7, 2003 (included as Appendix E), that presents three options with regard to this issue. Following the review of the Memorandum and discussions with the NYSDEC and NYPA, the option of using the actual measured TOC (and report that it did not meet the recommended range) was determined to be the most appropriate. Sediment criteria for inorganics did not require organic-carbon normalization.

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An example calculation of organic carbon normalized criteria (as presented in Table 4.0-1) for sample RES-SED-12 is as follows:

$SC(mirex) = SC_{oc\ (mirex)} \times f_{oc}$

SC_{oc} (mirex) = 0.07 μg/gOC

f_{oc} = 1.62% = 16,200 mgOC/Kg = 16.2 gOC/Kg

SC(mirex) = 0.07μg/Kg x 16.2gOC/Kg = 1.134 μg/Kg

Where:

SC_{oc} (mirex) – NYSDEC organic carbon normalized sediment criterion

f_{oc} – Percent organic carbon per kilogram sediment

SC(mirex) – Sample-specific sediment criterion for mirex

In addition to the NYSDEC sediment criteria, the NYSDEC also uses sediment quality assessment values described in various papers. "In one paper (MacDonald et al. 2000) currently used by NYSDEC to assess sediment quality, sediment quality assessment values were developed by matching the evidence of biological effects to observed constituent levels in sediment. Two assessment values, probable effect concentrations (PEC) and threshold effect concentrations (TEC) (both are sometimes referred to in this report as literature-based criteria) were derived for 29 constituents. The PEC represents the levels above which toxicity was frequently observed and the TEC represents the level below which toxicity was rarely observed" (URS et al. 2002). Table 4.0-1 lists the NYSDEC sediment criteria and the PEC, and TEC assessment values used in this assessment.

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A fourth comparison conducted as part of this assessment was a comparison to upstream historical sediment quality data gathered from various reports and publications.

A comparison of the analytical results from the October 2002 sediment sampling event to the three above-listed criteria and (to the extent possible) to the upstream historical data is presented below.

4.1 Comparison of Results to NYSDEC Sediment Criteria and PEC and TEC Assessment Values

Validated data from each sample were compared in this section to the NYSDEC normalized Sediment Criteria and PEC and TEC assessment values. A summary of exceedances of the NYSDEC sediment criteria is provided on Table 4.1-1, a summary of the exceedances of PEC assessment values is provided on Table 4.1-2, and a summary of the exceedances of TEC assessment values is provided on Table 4.1-3.

4.1.1 Volatile Organic Compounds

The single PCE value detected (upstream of the tailrace, at LNR-SED03) did not exceed the NYSDEC sediment criteria. There is no PEC or TEC assessment value for PCE.

4.1.2 PAHs

- Concentrations of benzo(a)anthracene exceeded the PEC assessment value at only the location upstream of the tailrace (LNR-SED03) and exceeded the NYSDEC sediment criteria and the TEC assessment value in the sample collected upstream of the tailrace (LNR-SED03) and in all reservoir samples.
- Benzo(a)pyrene levels exceeded the PEC assessment value at only the location upstream of the tailrace (LNR-SED03); exceeded the NYSDEC sediment criteria in upper-river sample (mid-channel near the intakes) UNR-SED02, lower-river sample (upstream of tailrace) LNR-SED03, and all

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reservoir samples; and exceeded the TEC assessment value in the sample collected upstream of the tailrace (LNR-SED03) and in all reservoir samples.

- Benzo(b)fluoranthene concentrations exceeded the NYSDEC sediment criteria in the sample collected mid-channel near the intakes (UNR-SED02), in the sample collected upstream of the tailrace (LNR-SED03), and in all reservoir samples. There is no PEC or TEC assessment value for benzo(b)fluoranthene.
- Levels of benzo(k)fluoranthene exceeded the NYSDEC sediment criteria in the sample collected upstream of the tailrace (LNR-SED03) and in all reservoir samples. There is no PEC or TEC assessment value for benzo(k)fluoranthene.
- Chrysene concentrations exceeded the PEC assessment value at only the location upstream of the tailrace (LNR-SED03); exceeded the NYSDEC sediment criteria in the sample collected mid-channel near the intakes (UNR-SED02), in the sample collected upstream of the tailrace (LNR-SED03), and in all reservoir samples; and exceeded the TEC assessment value in the sample collected upstream of the tailrace (LNR-SED03) and in all reservoir samples.
- Total PAHs did not exceed the PEC assessment value, but exceeded the TEC assessment value in the sample collected upstream of the tailrace (LNR-SED03) and in all reservoir samples. There is no NYSDEC sediment criterion for total PAHs.

4.1.3 PCBs

Total PCBs did not exceed the PEC criteria but did exceed the NYSDEC screening criteria in the sample collected upstream of the tailrace (LNR-SED03), in the sample collected downstream of the tailrace (LNR-SED04), and in all reservoir samples; total PCBs exceeded the TEC assessment value in

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the sample collected upstream of the tailrace (LNR-SED03) and at all locations in the reservoir except RES-SED09.

4.1.4 Pesticides

- Hexachlorobenzene levels exceeded the NYSDEC sediment criteria in the upstream sample collected upstream of the intakes near the shoreline (UNR-SED01) and in the sample collected upstream of the tailrace (LNR-SED03). There is no PEC or TEC assessment value for hexachlorobenzene.
- Concentrations of mirex exceeded the NYSDEC sediment criteria in the sample collected upstream of the intakes near the shoreline (UNR-SED01) and in one reservoir sample (RES-SED05). There is no PEC or TEC criterion assessment value for mirex.

4.1.5 Metals

- Arsenic levels did not exceed the PEC assessment value, but did exceed the NYSDEC sediment criteria at two reservoir locations (RES-SED08 [and its duplicate RES-SED012] and RES-SED09) and the TEC assessment value at one sample location in the reservoir (RES-SED08).
- Lead levels did not exceed the PEC assessment value but did exceed the NYSDEC sediment criteria in the sample collected upstream of the tailrace (LNR-SED03) and in all reservoir samples; and the TEC assessment value at the sample collected upstream of the tailrace (LNR-SED03) and at three sample locations in the reservoir (RES-SED05, RES-SED08 [and its duplicate RES-SED12], and RES-SED09).
- Concentrations of mercury did not exceed the PEC assessment value but did exceed the NYSDEC sediment criteria in the sample collected upstream of the intakes near the shoreline (UNR-SED01), in the sample collected upstream of the tailrace (LNR-SED03), and in all reservoir samples and the

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TEC assessment value in the sample collected upstream of the intakes near the shoreline (UNR-SED01), in the sample collected upstream of the tailrace (LNR-SED03), and in one reservoir sample (RES-SED05).

- No comparisons could be made for cadmium because the detected values of cadmium in the sediment samples were qualified as unusable data during data validation due to the presence of cadmium in the associated equipment blank.

4.1.6 Dioxin

There is no PEC or TEC assessment value for 2,3,7,8-TCDD. Detected levels of 2,3,7,8-TCDD did not exceed the NYSDEC sediment criteria.

4.1.7 Assessment of Non-detect Reporting Limit

A summary of instances of reported non-detect levels whose reporting limit exceeded screening criteria is presented below. In those instances where laboratory reporting limits exceeded sediment criteria and/or assessment values, the analysis did not yield unusable data. Although the data may not be fully used for comparison purposes within the context of the study, the data does provide information on the levels above which the constituents are not present in the sediment samples. Overall, the study provided sufficient data for comparison purposes to develop a general understanding of the presence, level, and distribution of the constituents being investigated.

- Tetrachloroethylene was reported as non-detect in samples UNR-SED01, UNR-SED02, LNR-SED04, and RES-SED08. The non-detect reporting limits for these samples exceeded the NYSDEC criteria for tetrachloroethylene. There is no PEC or TEC assessment value for tetrachloroethylene.
- All five PAH compounds in UNR-SED01, two PAH compounds in UNR-SED02, and all five PAH compounds in LNR-SED04 were reported as non-

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detect. The non-detect reporting limits for these compounds in these samples exceeded the NYSDEC criteria. Three PAH compounds that were reported as non-detect in UNR-SED01 exceeded the PEC criteria. Three PAH compounds in UNR-SED01, one PAH compound in UNR-SED02, and three PAH compounds in LNR-SED04 that were reported as non-detect exceeded the TEC criteria.

- Six pesticide compounds in UNR-SED01, seven pesticide compounds in LNR-SED03 and RES-SED-05, all eight pesticide compounds in UNR-SED02, LNR-SED04, RES-SED06, RES-SED07, RES-SED08, RES-SED09, and RES-SED12 were reported as non-detect. The reporting limits for these compounds in these samples exceeded the NYSDEC criteria. Four pesticide compounds in UNR-SED01, three pesticide compounds in RES-SED05, RES-SED06, RES-SED08, and RES-SED12, and one pesticide in the remaining samples that were reported as non-detect exceeded the PEC criteria. Five pesticide compounds that were reported as non-detect in each of the samples exceeded the TEC criteria.
- Octachlorostryene was reported as non-detect in each of the samples. The reporting limit for each sample exceeded the NYSDEC criteria. There is no PEC or TEC assessment value for octachlorostryene.
- Total PCBs were reported as non-detect in samples UNR-SED01 and UNR-SED02. The reporting limits for these samples exceeded the NYSDEC criteria for total PCBs. Total PCBs was reported as non-detect in sample UNR-SED01. The reporting limit for this sample exceeded the TEC assessment value for total PCBs.

In those instances where laboratory reporting limits exceeded sediment criteria and/or assessment values, the analysis did not yield unusable data. Although the data may not be fully used for comparison purposes within the context of the study, the data does provide information on the levels above which the constituents are not present in the sediment samples. Overall, the study provided sufficient data for

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comparison purposes to develop a general understanding of the presence, level, and distribution of the constituents being investigated.

4.2 Historical Local Data

Data on constituent levels found in nearby surface water bodies were gathered from NYSDEC 1994, which reported historical data from U.S. and Canadian agencies, as well as from technical journals. These locations included the upper Niagara River at Lake Erie (near Buffalo Harbor), the upper Niagara River in the Tonawanda Channel (the eastern side of Grand Island), the upper Niagara River near Bird Island (which splits the Black Rock canal and upper Niagara River), and the upper Niagara River near Twomile Creek. A comparison of detected constituent levels in the reservoir to the historical river data is provided below and in Table 4.2-1

4.2.1 Total PAHs

Total PAH concentrations in the reservoir samples range from 5,500 μg/kg to 9,500 μg/kg. Mean sample concentrations from the historical data ranged from 710 μg/kg to 39,000 μg/kg and maximum sample concentrations ranged from 6,901 μg/kg to 210,000 μg/kg. The reservoir sample levels are at the lower ends of each of these ranges.

4.2.2 Total PCBs

Total PCB concentrations in the reservoir samples range from 44 μg/kg to 190 μg/kg. Mean sample concentrations from the historical data ranged from 23 μg/kg to 2,140 μg/kg and maximum sample concentrations ranged from 136 μg/kg to 26,000 μg/kg. The reservoir sample levels are at the lower ends of each of these ranges.

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PCBs may also be compared to historical data from the reservoir. In October 2002, total PCB concentrations in sediment samples collected from the reservoir ranged from 44 µg/kg to190 µg/kg. In October 1983, PCBs were detected in all three sediment samples collected from the Lewiston Reservoir at levels ranging from 189 µg/kg to 241 µg/kg. The level of PCBs found within the reservoir in 2002 was, therefore, somewhat lower than the historical data from the reservoir.

4.2.3 Lead

Lead concentrations in the reservoir samples range from 31.6 mg/kg to 72.4 mg/kg. Mean sample concentrations from the historical data ranged from 13 mg/kg to 250 mg/kg and maximum sample concentrations ranged 32 mg/kg to 1,760 mg/kg. The reservoir sample levels are at the lower ends of each of these ranges.

4.2.4 Mercury

Mercury concentrations in the reservoir samples range from 0.163 mg/kg to 0.206 mg/kg. Mean sample concentrations from the historical data ranged from 0.022 mg/kg to 0.65 mg/kg and maximum sample concentrations ranged 0.11 mg/kg to 1.825 mg/kg. The reservoir sample levels are at the lower ends of each of these ranges.

4.2.5 Mirex

Mirex was detected in only one sample in the reservoir at an estimated concentration of 53 µg/kg. Detected mirex concentrations from the historical data ranged from 4 µg/kg to 86 µg/kg. The mean sample concentration from the historical data is 25 µg/kg. One of the samples collected in the upper Niagara River had an estimated mirex level of 6,400 µg/kg. The reservoir sample level is within the range of historical levels and is significantly lower than the level detected in the upper Niagara River.

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4.3 Fate of Chemicals in Reservoir Sediments

Chemicals detected in sediments in the Lewiston Reservoir above NYSDEC sediment criteria, or TEC or PEC assessment values include constituents from four chemical classes: metals, PAHs, organochlorine pesticides, and PCBs. The list of chemicals that exceed the NYSDEC sediment criteria includes all of the chemicals that exceed either the TEC or PEC assessment values. Table 4.3-1 summarizes the exceedances of NYSDEC sediment criteria values in Lewiston Reservoir sediments.

The partitioning and fate of these chemicals in sediments is dependent on a multitude of chemical-specific and site-specific factors. In general, the environmental fate of a compound in sediment is largely a function of transport, transformation, and degradation processes. Chemical, physical, and biological agents can transform or degrade chemicals in sediment into new compounds. Natural processes such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with sediment-bound materials often reduce chemical concentrations in sediments. In some instances, benthic microorganisms or invertebrates may transform chemicals in sediments into more toxic compounds (e.g., see Section 4.3.3). The tendency of these processes to occur, as well as the rates at which they proceed, are controlled by a multitude of factors, including but not limited to:

- Presence of complexing materials (e.g., organic carbon);
- Reduction/oxidation potential, pH, dissolved oxygen, and other physical variables;
- Substrate particle size;
- Biological flora and fauna present;
- Potential for synergistic or antagonistic reactions with other chemicals; and
- Stability and reactivity of chemicals in sediment.

The following sections provide perspective on the environmental fate processes for those chemicals that exceed NYSDEC and other sediment criteria values and the potential fate of these chemicals in the Lewiston Reservoir. It should be noted that because natural partitioning processes in

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Lewiston Reservoir sediments have taken place, the presence of such chemicals in sediments is a strong indication that they will remain there.

4.3.1 Arsenic

Arsenic can exist in the environment in both inorganic and organic compounds in its trivalent (As^{+3}) and pentavalent (As^{+5}) oxidation states. Transport and partitioning of arsenic depends on the valence state, which is controlled largely by the presence of complexing materials (e.g., sulfide), dissolved oxygen levels, salinity, temperature, and pH (ATSDR 1991). Solubility of inorganic arsenic compounds in water ranges from "insoluble" (e.g., elemental arsenic) to "soluble" (e.g., sodium arsenate). Organic arsenic compounds are generally "slightly soluble" to "highly soluble." In the presence of clays, many arsenic compounds may be adsorbed onto sediment particles from the water. Arsenic may also be released back to the water column (usually as inorganic arsenate) by chemical or biological transformations (ATSDR 1991); however, the bioaccumulation potential of arsenic compounds is low. The high incidence of clays in Lewiston Reservoir sediments suggests that arsenic may partition to sediment particles, and not leach significantly to surface water.

4.3.2 Lead

The majority of lead in sediments is anticipated to occur as ions sorbed to the surface of sediment mineral particles. Lead in sediments and surface water has a tendency to complex with sulfate and other anions to form compounds with low solubilities. Solubilities in water of lead oxide and lead carbonate, two commonly observed lead compounds in natural aquatic systems, are extremely low, hence the potential for bioaccumulating lead in aquatic systems is low. Hardness, pH, and organic carbon content regulate the amount of lead in solution. At a pH exceeding 5.4, lead tends to precipitate out with carbonate ions to form lead carbonate. Lead may also form insoluble organic complexes with organic matter in sediments. Based on the surface water pH values obtained from the Lewiston Reservoir (pH range = 6.8-8.1) and the level of organic carbon in sediments (see Tables 3.1-2 and 3.3-2), transport of soluble lead from sediment to surface water or groundwater is not anticipated to be an important fate process in the Lewiston Reservoir.

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4.3.3 Mercury

The distribution of mercury in the environment is strongly dependent on the sorption of mercury compounds to soils and sediments. Non-volatile mercury compounds are anticipated to partition to the sediments upon entering a surface water body. Sorption of mercury to sediments is controlled principally by the organic carbon content. Sediments may act as important sinks for mercury because leaching of inorganic mercury from sediments is not an important fate process. In other words, inorganic mercury is not readily desorbed from sediments; thus both freshwater and marine sediments are important repositories for inorganic forms of mercury. Increased levels of organic carbon in sediments may bind a significant percentage of mercury; however, higher organic carbon content is favorable for the microbiological conversion of inorganic mercury to methylmercury, a highly soluble and bioaccumulative organic compound (ATSDR 1992). Methylation of mercury is usually executed under anaerobic conditions and low pH by sulfur-reducing bacteria. High levels of chloride reduce the methylation of mercury in sediments. The potential for bioaccumulation and other fates for mercury will be evaluated further in a separate report being prepared. (a separate study is being performed to evaluate if water level fluctuations in the Lewiston Reservoir increase mercury that is bioavailable (Tetra Tech 2003)).

4.3.4 PAHs

Sediments are major repositories for PAHs, primarily because of the low solubility of these compounds and their affinity for organic carbon in particulate matter. The higher molecular weight PAHs, which include benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and chrysene, have an extremely strong tendency to adsorb to sediment organic carbon (log Koc range = 5.3-6.7) and are virtually insoluble in water. The Koc is the ratio of sediment organic carbon to sediment pore water, and is an index of the tendency for a chemical to sorb to organic carbon. Organic carbon partition coefficients and solubility rates are presented for these PAHs in Table 4.3-2.

Some PAH compounds are susceptible to significant metabolism by microorganisms in some natural waters with reduced levels of carbon or other energy source, but in most waters and in sediments they have been shown to be stable towards biodegradation. Hydrolysis of these compounds is considered

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to be an unimportant process, and bioconcentration may occur in benthic organisms unable to metabolize them.

Binding of PAHs to sediments also increases with decreasing particle size, indicating that PAHs will sorb more strongly to clays and silts compared to sand. Table 3.3-1 shows that Lewiston Reservoir sediments are comprised almost exclusively of silt and clay (93-100%). Small substrate grain size and moderate levels of organic carbon in sediments indicate that residual PAHs in Lewiston Reservoir sediments are not likely to be released in a soluble form to the overlying water column.

4.3.5 Mirex

This organochlorine compound was detected in one of the five sediment samples (RES-SED05) collected in the Lewiston Reservoir. Mirex is a stable, highly persistent chemical formerly used as an insecticide and fire-resistant additive to polymers. Mirex adsorbs strongly to organic matter in soils and sediments (Koc = 2.4×10^7) and, therefore, is expected to partition from the water column to sediments and suspended solids (Spectrum Laboratories 2003). For the most part, mirex is resistant to chemical and biological degradation; sediment-dwelling organisms may accumulate mirex in waterbodies contaminated with mirex. Solubility of mirex in water at 25°C was determined experimentally to be 0.085 mg/L (Yalkowsky and Dannenfelser, 1992). The tendency of this compound to partition to organic matter and its low solubility in water indicates that residual mirex will remain bound to reservoir sediment particles and not redissolve into the surface water.

4.3.6 Total PCBs

Based on their hydrophobicity (i.e., insolubility) and strong affinity to sediments and organic matter, PCBs are not anticipated to leach significantly from sediments to the overlying water column. The Koc (organic carbon partiton coefficient) and Kow (octanol-water partition coefficient) values of 5.3×10^5 and 1.1×10^6 indicate the strong tendency of PCBs to bind to organic carbon and lipids, respectively. The Kow is the ratio of the concentration of a chemical in octanol (an organic solvent used

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as a surrogate for organic matter) to water at equilibrium and at a specified temperature, and is a measure of a chemical's tendency to partition to organic matter (e.g., lipids). More highly chlorinated Aroclor compounds will sorb more strongly to sediments and particulate matter than less chlorinated compounds (ATSDR 1993a). Because PCBs tend to settle from the water column to sediments, bioaccumulation potential in bottom-oriented fauna, particularly fish, is anticipated to be significant under conditions of elevated sediment PCB concentrations. PCBs are persistent in aquatic systems but may be biodegraded slowly, depending on temperature, concentration, organic matter, and type of microorganisms present.

PCBs are not very soluble in water; solubilities of individual Aroclor congeners range from 2.7 x 10^{-3} mg/L for Aroclor 1260 to 5.9 x 10^{-1} mg/L for Aroclor 1221 (ATSDR 2000). Volatilization to the air and "re-dissolving" to the water column from sediments could occur, but is unlikely to happen in systems with sufficient TOC in bed sediments. Leaching of PCBs to the water column is also hindered in systems with high rates of sedimentation. For the reasons described above, aquatic sediments, particularly in stratified lake systems, are considered to be major sinks for PCBs. Resuspension of PCBs from uppermost sediment horizons to the water column may occur, but PCBs are much more likely to be adsorbed to suspended particulates than to be redissolved in water.

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TABLE 4.0-1

SUMMARY OF PEC AND TEC ASSESSMENT VALUES AND NYSDEC SEDIMENT CRITERIA

	Units	PEC	TEC	NYSDEC Sediment Criteria**	UNR-SED01 Upper River	UNR-SED02 Upper River	LNR-SED03 Lower River	LNR-SED04 Lower River	RES-SED05 Reservoir	RES-SED06 Reservoir	RES-SED07 Reservoir	RES-SED08 Reservoir	RES-SED09 Reservoir	RES-SED12 (DUP OF SED-08) Reservoir
					NYSDEC Normalized Sediment Criteria *									
VOC														
Tetrachloroethylene	µg/kg	NG	NG	800	3.216	0.2176	9.44	0.1992	12.08	10.72	13.44	12.24	13.28	12.96
Semivolatiles														
Octachlorostyrene	µg/kg	NG	NG	500	2.01	0.136	5.9	0.1245	7.55	6.7	8.4	7.65	8.3	8.1
PAHs														
Benzo(a)anthracene	µg/kg	1050	108	1300	5.226	0.3536	15.34	0.3237	19.63	17.42	21.84	19.89	21.58	21.06
Benzo(a)pyrene	µg/kg	1450	150	1300	5.226	0.3536	15.34	0.3237	19.63	17.42	21.84	19.89	21.58	21.06
Benzo(b)fluoranthene	µg/kg	NG	NG	1300	5.226	0.3536	15.34	0.3237	19.63	17.42	21.84	19.89	21.58	21.06
Benzo(k)fluoranthene	µg/kg	NG	NG	1300	5.226	0.3536	15.34	0.3237	19.63	17.42	21.84	19.89	21.58	21.06
Chrysene	µg/kg	1290	166	1300	5.226	0.3536	15.34	0.3237	19.63	17.42	21.84	19.89	21.58	21.06
Total PAHs	µg/kg	22800	1610	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
Pesticides														
4,4'-DDD	µg/kg	28.0	4.88	10	0.0402	0.00272	0.118	0.00249	0.151	0.134	0.168	0.153	0.166	0.162
4,4'-DDE	µg/kg	31.3	3.16	10	0.0402	0.00272	0.118	0.00249	0.151	0.134	0.168	0.153	0.166	0.162

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TABLE 4.0-1 (CONT.)

SUMMARY OF PEC AND TEC ASSESSMENT VALUES AND NYSDEC SEDIMENT CRITERIA

	Units	PEC	TEC	NYSDEC Sediment Criteria**	UNR-SED01 Upper River	UNR-SED02 Upper River	LNR-SED03 Lower River	LNR-SED04 Lower River	RES-SED05 Reservoir	RES-SED06 Reservoir	RES-SED07 Reservoir	RES-SED08 Reservoir	RES-SED09 Reservoir	RES-SED12 (DUP OF SED-08) Reservoir
					NYSDEC Normalized Sediment Criteria *									
4,4'-DDT	µg/kg	572	5.28	10	0.0402	0.00272	0.118	0.00249	0.151	0.134	0.168	0.153	0.166	0.162
Chlordane (technical)	µg/kg	17.6	3.24	1.0	0.00402	0.000272	0.0118	0.000249	0.0151	0.0134	0.0168	0.0153	0.0166	0.0162
Dieldrin	µg/kg	61.8	1.90	100	0.402	0.0272	1.18	0.0249	1.51	1.34	1.68	1.53	1.66	1.62
Hexachlorobenzene	µg/kg	NG	NG	150	0.603	0.0408	1.77	0.03735	2.265	2.01	2.52	2.295	2.49	2.43
Mirex	µg/kg	NG	NG	70	0.2814	0.01904	0.826	0.01743	1.057	0.938	1.176	1.071	1.162	1.134
Toxaphene	µg/kg	NG	NG	10	0.0402	0.00272	0.118	0.00249	0.151	0.134	0.168	0.153	0.166	0.162
PCBs														
Total PCBs	µg/kg	676	59.8	0.8	0.003216	0.0002176	0.00944	0.0001992	0.01208	0.01072	0.01344	0.01224	0.01328	0.01296
Dioxins														
2,3,7,8-TCDD	µg/kg	NG	NG	10	0.0402	0.00272	0.118	0.00249	0.151	0.134	0.168	0.153	0.166	0.162
Metals														
Arsenic	mg/kg	33.0	9.79	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Cadmium	mg/kg	4.98	0.990	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Lead	mg/kg	128	35.8	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0
Mercury	mg/kg	1.06	0.180	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

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Notes:

TEC – Threshold Effect Concentration
NYSDEC – New York State Department of Environmental Conservation
VOCs – Volatile Organic Compounds
µg/kg– micrograms per kilogram
NG – No Guidance
PEC – Probable Effect Concentration
PCBs – Polychlorinated Biphenyls
PAHs – Polynuclear Aromatic Hydrocarbons
mg/kg – milligrams per kilogram

* - NYSDEC Normalized Criteria (which apply only to organic parameters) account for equilibrium partitioning using sample-specific organic carbon levels.
** - NYSDEC criteria was converted from ug/g to ug/kg for the purpose of keeping the units consistent in the table

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TABLE 4.1-1

EXCEEDANCES OF NYSDEC SEDIMENT CRITERIA

		UNR-SED01 Upper River		UNR-SED02 Upper River		LNR-SED03 Lower River		LNR-SED04 Lower River		RES-SED05 Reservoir		RES-SED06 Reservoir		RES-SED07 Reservoir		RES-SED08 Reservoir		RES-SED09 Reservoir		RES-SED12 (DUP OF SED-08) Reservoir	
	Units	Criteria	Results	Criteria	Results	Criteria	Results	Criteria	Results	Criteria	Results	Criteria	Results	Criteria	Results	Criteria	Results	Criteria	Results	Criteria	Results
Benzo(a)anthracene	µg/kg					15.34	2100			19.63	480	17.42	360 J	21.84	280 J	19.89	450 J	21.58	260 J	21.06	340 J
Benzo(a)pyrene	µg/kg			0.3536	26 J	15.34	2900			19.63	710	17.42	570 J	21.84	490 J	19.89	840 J	21.58	560 J	21.06	640 J
Benzo(b)fluoranthene	µg/kg			0.3536	27 J	15.34	2600			19.63	860	17.42	670 J	21.84	670 J	19.89	1100 J	21.58	750 J	21.06	840 J
Benzo(k)fluoranthene	µg/kg					15.34	2400			19.63	630	17.42	540 J	21.84	380 J	19.89	690 J	21.58	480 J	21.06	520 J
Chrysene	µg/kg			0.3536	55 J	15.34	2200			19.63	800	17.42	640 J	21.84	620 J	19.89	1100 J	21.58	640 J	21.06	810 J
Hexachlorobenzene	µg/kg	0.603	21000			1.77	190														
Mirex	µg/kg	0.2814	6400 J							1.057	53 J										
Total PCBs	µg/kg					0.00944	470 J	0.0001992	120 J	0.01208	190 J	0.01072	170 J	0.01344	110 J	0.01224	44 J	0.01328	57 J	0.01296	99 J
Arsenic	mg/kg															6.0	14.5 J	6.0	8.7 J	6.0	9.1 J
Lead	mg/kg					31.0	39.7 J			31.0	36.8 J	31.0	32.6 J	31.0	31.6 J	31.0	72.4 J	31.0	46.6 J	31.0	45.6 J
Mercury	mg/kg	0.15	0.265			0.15	0.577			0.15	0.206	0.15	0.169 J	0.15	0.171 J	0.15	0.175 J	0.15	0.173 J	0.15	0.163 J

Notes:

NYSDEC – New York State Department of Environmental Conservation
PAHs – Polynuclear Aromatic Hydrocarbons
PCBs – Polychlorinated Biphenyls
mg/kg – milligrams per kilogram
µg/kg – micrograms per kilogram
J – Estimated value
The criteria listed above are NYSDEC Normalized Values (which apply only to organic parameters); these values account for equilibrium partitioning using sample-specific organic carbon levels

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TABLE 4.1-2

EXCEEDANCES OF TEC ASSESSMENT VALUES

				UNR-SED01 Upper River	LNR-SED03 Lower River	LNR-SED04 Lower River	RES-SED05 Reservoir	RES-SED06 Reservoir	RES-SED07 Reservoir	RES-SED08 Reservoir	RES-SED09 Reservoir	RES-SED12 (DUP OF SED-08) Reservoir
PAHs		**Units**	**Threshold Effect Concentration (TEC):**									
	Benzo(a)anthracene	µg/kg	108		2100		480	360 J	280 J	450 J	260 J	340 J
	Benzo(a)pyrene	µg/kg	150		2900		710	570 J	490 J	840 J	560 J	640 J
	Chrysene	µg/kg	166		2200		800	640 J	620 J	1100 J	640 J	810 J
	Total PAHs	µg/kg	1610		22000 J		7400 J	6100 J	5500 J	9500 J	6000 J	7200 J
PCBs												
	Total PCBs	µg/kg	59.8		470 J	120 J	190 J	170 J	110 J			99 J
Metal												
	Arsenic	mg/kg	9.79							14.5 J		
	Lead	mg/kg	35.8		39.7 J		36.8 J			72.4 J	46.6 J	45.6 J
	Mercury	mg/kg	0.180	0.265	0.577		0.206					

TEC – Threshold Effect Concentration
PAHs – Polynuclear Aromatic Hydrocarbons
PCBs – Polychlorinated Biphenyls
µg/kg – micrograms per kilogram
mg/kg – milligrams per kilogram
J – Estimated value

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TABLE 4.1-3

EXCEEDANCES OF PEC ASSESSMENT VALUES

PAHs	Units	PEC	LNR-SED03 Lower River
Benzo(a)anthracene	µg/kg	1050	2100
Benzo(a)pyrene	µg/kg	1450	2900
Chrysene	µg/kg	1290	2200

Notes:

PEC – Probable Effect Concentration
PAHs – polynuclear aromatic hydrocarbons

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TABLE 4.2-1

COMPARISON OF CONSTITUENT LEVELS IN LEWISTON RESERVOIR TO REGIONALLY HISTORIC RIVER DATA

	Range of Concentrations in Reservoir Samples	Range of Regionally Historic Mean Concentrations	Range of Regionally Historic Maximum Concentrations[a]
PAHs (µg/kg)	5,500 – 9,500	710 – 39,000	6,901 – 210,000
PCBs (µg/kg)	44 – 190	23 – 2,140	136 – 26,000
Lead (mg/kg)	31.6 – 72.4	13 – 250	32 – 1,720
Mercury (mg/kg)	0.163 – 0.206	0.022 – 0.65	0.11 – 1.825
Mirex (µg/kg)	53	4 – 86[b]	6,400[c]

Notes:

[a] NYSDEC 1994

[b] Kauss 1983. Range of discrete sample concentrations, not mean concentrations.

[c] Concentration detected at location UNR-SED01, October 2002.

PAHs = polynuclear aromatic hydrocarbons

PCBs = polychlorinated biphenyls

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TABLE 4.3-1

FREQUENCY OF EXCEEDANCE OF NYSDEC SEDIMENT CRITERIA, LEWISTON RESERVOIR SEDIMENTS

Chemical Class/Chemical	Frequency of Exceedance (%)
Metals	
Arsenic	40
Lead	100
Mercury	100
PAHs	
Benzo(a)anthracene	100
Benzo(a)pyrene	100
Benzo(b)fluoranthene	100
Benzo(k)fluoranthene	100
Chrysene	100
Organochlorine Pesticides	
Mirex	20
PCBs	
Total PCBs	100

PAHs = polynuclear aromatic hydrocarbons
PCBs = polychlorinated biphenyls

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TABLE 4.3-2

LOG K_{OC} AND SOLUBILITY CONSTANTS, VARIOUS HIGH-MOLECULAR-WEIGHT PAHS

PAH Compound	Log K_{oc}	Solubility (mg/l)
Benzo(a)anthracene	5.30	9.0×10^{-3}
Benzo(a)pyrene	6.74	3.8×10^{-3}
Benzo(b)fluoranthene	5.74	1.2×10^{-3}
Benzo(k)fluoranthene	5.74	"virtually insoluble"
Chrysene	5.30	1.5×10^{-3}

Source: ATSDR 1993b.

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5.0 SUMMARY

5.1 Assessment of Physical Data

Typically, fine-grained sediments were encountered in the Lewiston Reservoir at the locations of predicted sediment accumulations. These sediments had significantly higher organic carbon content than the coarser-grained sediments encountered in the Niagara River. The fine-grained organic sediment encountered in the Lewiston Reservoir was targeted for this study, because sediments with these physical and chemical characteristics are more likely to contain chemical constituents (providing a "worst case scenario").

Sediment samples were collected with relative ease in the Lewiston Reservoir because sufficient fine-grained sediment was retrieved with each sampling attempt.

As previously discussed in this report, the sediment that was obtained from the forebay was very coarse-grained (sand, gravel, and cobbles) and was very limited in volume. Consequently, forebay sediments were not assessed as to their chemical or physical quality.

5.2 Assessment of Chemical Data

In general, the constituents detected in the Lewiston Reservoir sediments (PAHs, PCBs, Mirex, arsenic, lead, and mercury) were also detected in the Niagara River sediments. The sample collected in the lower Niagara River, upstream of the tailrace, was impacted by the highest number of constituents at generally the highest concentrations. The reservoir samples had consistent detections of PAHs, PCBs, and various metals. The detected constituent levels in the Lewiston Reservoir samples were similar to, and in some instances considerably less than, the levels detected in the Niagara River sediments. In fact, the sample collected in the lower Niagara River, upstream of the tailrace, was impacted by the highest number of constituents at generally higher concentrations than in the Lewiston Reservoir samples. With

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the exception of one PCB Aroclor (Aroclor 1242), there were no other constituents detected in the Lewiston Reservoir that were not detected in the upper Niagara River and/or the lower Niagara River, upstream of the tailrace.

The sediment quality comparison that was made using historical data revealed that the constituents detected in the Lewiston Reservoir where commonly detected during prior studies of sediments in the upper Niagara River at Lake Erie (near Buffalo Harbor), the upper Niagara River in the Tonawanda Channel (the eastern side of Grand Island), and the upper Niagara River near Bird Island (which splits the Black Rock canal and upper Niagara River. The constituent levels in the Lewiston Reservoir were similar and oftentimes significantly lower than the levels in the upper Niagara River at Lake Erie, the upper Niagara River in the Tonawanda Channel, and the upper Niagara River near Bird Island.

There were several exceedances of NYSDEC sediment criteria and PEC and TEC assessment values in the samples collected in the Lewiston Reservoir. But as with the detections discussed above, any exceedance of a constituent in the Lewiston Reservoir was also exceeded in the upper Niagara River and/or the lower Niagara River, upstream of the tailrace.

Arsenic, lead, mercury, PAHs, mirex, and PCBs were present in Lewiston Reservoir sediments above NYSDEC sediment screening criteria. Environmental fate processes such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with sediment-bound materials often reduce chemical concentrations in sediments; however, benthic microfauna or invertebrates may transform chemicals in sediments into more toxic compounds under certain environmental conditions. Because natural partitioning processes in Lewiston Reservoir sediments are assumed to have taken place, the presence of the aforementioned chemicals in bed sediments indicates that these chemicals will remain there. In addition, designated sampling areas are depositional in nature, and likely serve as sinks for chemicals introduced into the reservoir.

Based on pH and sediment organic carbon levels in the reservoir, lead and mercury in sediment are not expected to partition to the overlying water column. Arsenic compounds vary in terms of their

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solubilities; however, the presence of clays in the benthic substrate of the reservoir suggest that leaching of arsenic to surface water or groundwater from sediments is unlikely. PAHs and PCBs detected in sediments are also likely to remain there, owing to their extremely low solubilities in water and their strong tendency to sorb to organic carbon in bed sediments. Sediment-bound PAHs and PCBs, if re-suspended to the overlying water column, will in all likelihood adhere to suspended particulate matter rather than be redissolved in water. Mirex, an organochlorine pesticide detected in one reservoir sediment sample, adsorbs strongly to sediment particles and has a low solubility in water. As such, residual mirex in sediments should not redissolve to surface water or groundwater.

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