Hamilton Conservation Authority
838 Mineral Springs Road
P.O. Box 7099
Ancaster, Ontario
L9G 3L3

Reservoir Sediment Study
Crooks' Hollow Dam
Class EA

April 2006

16681D0

Acres International
Niagara Falls, Ontario

A member of The Hatch Group

Table of Contents

List of Tables
List of Figures

List of Tables

List of Figures

1 Introduction

The Hamilton Conservation Authority (HCA) has initiated a Class Environmental Assessment (Class EA) to review design alternatives for the rehabilitation of the Crooks' Hollow Dam. The dam, which is located on Spencer Creek in the City of Hamilton, was originally constructed in 1913 to supply potable water to the community of Dundas. Years later, after a municipal supply of water was established for the village, the dam's reservoir was no longer used to supply drinking water. In 1959, the Dundas Valley Golf and Curling Club began using the reservoir as a source for irrigation; however, this use ceased in 2001. The reservoir is now used for recreational purposes (e.g., fishing and hiking around the shorelines). The dam is 6.1 m high and 36.6 m long, impounding a small reservoir. Since 1993, due to stability concerns, the dam has been operated at lower water levels.

The Class EA will examine several alternatives to address the currently deteriorated state of the Crooks Hollow Dam. This includes

- Alternative 1 – Do nothing
- Alternative 2 – Repair and maintain the existing dam
- Alternative 3 – Modify the dam and convert to an overflow weir
- Alternative 4 – Decommission and remove the dam.

It is unlikely that Alternatives 1, 2 and 3 would have any significant effect on sediment located upstream from the dam. However, dam removal has the potential to result in increased sediment transport as the reservoir reverts back to a more natural riverine state. A sediment transport study carried out by Hatch Acres in 2005 found that the dam removal option could potentially result in the rapid release of accumulated sediments from the reservoir, if unmitigated. This potential release could negatively impact water quality, aquatic habit and aquatic organisms.

Therefore, in order to assess the potential impacts of dam removal it is necessary to have an understanding of the chemical and physical nature, and overall amount of sediment accumulated upstream from the dam.

In order to achieve this understanding, a study was undertaken in May 2005 to determine bathymetry and sediment depths throughout the reservoir. In addition,

sediment samples were collected and examined in order to determine stratigraphy (layering) of sediment deposits, particle size characteristics and the presence of any contaminants.

The objectives of the May 2005 sediment study were to determine

- reservoir bathymetry such that the approximate boundaries of the low flow channel of the reservoir following the proposed dam removal could be delineated
- the depth and overall quantity of fine sediment deposits in the reservoir at the normal winter elevation
- the physical properties of representative sediment samples from the reservoir to assess the potential for erosion and sediment movement under the proposed dam removal scenario
- the chemical composition of sediment from the reservoir to assess potential effects of sediment movement on aquatic biota.
- if some form of sediment management would be required if the dam removal option were pursued (i.e., to mitigate impacts associated with sediment transport), and if so, what options would be available and at what cost.

The initial fieldwork component of the sediment and bathymetry study was conducted on May 31, 2005, prior to the annual filling of the reservoir to the normal summer level.

A follow-up sampling program was conducted on November 22, 2005, after the annual drawdown of the reservoir to the normal winter level. The follow-up program was initiated in response to the results of the May 2005 sampling event, which showed contamination of several chemical constituents throughout the sediment cores at several sampling locations. The purpose of the November sampling event was to verify the results of the May study with respect to presence of contamination, and further, to determine if chemical composition differed between the upper and lower sediment layers within each core.

The methodology for the study is presented in Section 2, while the results, sediment management alternatives and recommendations are provided in Sections 3, 4 and 5, respectively.

2 Methodology

The following sections document the methodology used for the bathymetry, sediment depth and sediment core sampling activities.

2.1 Bathymetry

A bathymetry study was conducted in order to assess the water depths and creek bottom elevation in the reservoir at a number of locations. The bathymetry study involved establishing a total of six cross-sectional transects upstream of the dam. The first transect was located along the upstream face of the dam, with the remaining transects located approximately every 100 to 200 m along the length of the pond. The last transect was located upstream of the Morden's Mill dam (Figure 2.1).

Measurements of water depth were recorded at 1-m intervals along each transect. The locations of the transects, channel depth measurement and sediment depth probe locations are shown in Figure 2.1. The left and right bank location of each transect were located using a Global Positioning System (GPS) and recorded as GIS shapefiles in geographic coordinates and then converted to UTM NAD 83.

2.2 Sediment Depth and Quantity

Sediment depth probing was conducted in order to estimate the depth of surficial sediments in the reservoir that may be susceptible to erosion should the dam be removed. The probing methodology consisted of conducting a probe survey of sediment depth at 1-m intervals along the six transects.

At each probe survey site, a 50-mm diameter aluminum tube with an enclosed bottom was used to measure sediment depth. The measurement device was manually pushed into the sediment until refusal and the sediment depth was recorded. The same technician operated the sampler each time to ensure consistent effort in probing. The water level in the reservoir was used as the datum for the sediment depth measurement. These measurements were recorded at each probing point along the six transects (at 1-m intervals) for a total of 127 probing points (Figure 2.1).

The measured sediment depth along each transect was then used to estimate the quantity of fine sediment in the reservoir.

2.3 Sediment Core Sampling

Sediment core samples were collected in five locations in May 2005 and eight locations in November 2005 (Figure 2.1). Each sample was collected at the approximate midpoint of the transect to extract a vertical sediment core from the bottom of the reservoir using a sediment core collection tube. The depth that the corer was pushed into the sediment was recorded at each sampling site. Excess water was then drained from the top of the coring device and cores were extruded from the coring tube. Each core was then longitudinally split to expose the inner core material, photographed (see Appendix A) and measured for total length. The sediment layers within the core were identified and described.

During the May 2005 sampling event, approximately half of each sample (i.e., one longitudinal section) was placed in an amber 250-mL glass bottle provided by Maxxam Analytics Inc., packed in a cooler and transported to the laboratory for chemical analysis. The remaining sample was submitted to the Acres Geotechnical Laboratory for grain size analysis (sieve and hydrometer testing). The grain size distribution of inorganic particles was determined and a particle size curve was plotted for each sample as presented in Appendix B.

The November 2005 sampling event was conducted to determine if there was any variability in chemical composition between the upper and lower layers of the sediment core. Accordingly, each core was split into an upper layer fraction and a lower layer fraction. Each of the subsamples was placed in an amber 250-mL glass bottle provided by Maxxam Analytics Inc., packed in a cooler and transported to the laboratory for chemical analysis.


Transect 1
T1-B
S1
T1-A
S5
Crooks' Hollow Dam
Transect 2
T2
S8
S2
Crooks' Hollow Road
S7
T3
Transect 3
S3
S6
Transect 4
T4
S4
Transect 5
Spencer Creek
Transect 6
Remains of
"Morden Mill Dam"
Kirby Avenue
Legend
Core Sample Number and Location - Phase 1
Depth / Bathymetry
Core Sample Number and Location - Phase 2
Notes:
1. Air photo depicts reservoir at normal winter level
2. Air photo and regional base data provided by the Hamilton Conservation Authority
N
0 10 20 40 60 80
Meters
1:1,500
Hamilton Conservation Authority
Crooks' Hollow Dam
Crooks' Hollow Reservoir Sampling Locations
Figure 2.1
ACRES International

3 Study Results

The following section documents the results of the bathymetry and sediment studies conducted in Crooks' Hollow Reservoir.

3.1 Bathymetry

Bathymetry results are provided in Table 3.1, which indicates the water depth at the time of the survey (i.e., at the normal winter drawdown level of 215.06 m) and the channel bottom elevation (in meters above sea level). The maximum water depth encountered during the survey was 0.91 m (channel bottom elevation of 214.15 m), immediately upstream from the dam. Water depths became increasingly shallower moving upstream from the dam. Transect 2 had a maximum depth of 0.69 m, Transect 3 had a maximum depth of 0.51 m, Transect 4 had a maximum depth of 0.27 m, Transect 5 had a maximum depth of 0.84 m and Transect 6 (upstream from Morden's Mill Dam) had a maximum depth of 0.33 m. Channel bottom elevation upstream from Morden's Mill Dam was not determined as water level elevation during the time of the survey was unknown.

The water channel bottom elevation was plotted on a plan aerial photo of the reservoir using the GPS coordinates collected for each transect and input into GIS software. A water surface of 215.06 m elevation was assumed. A 3D analysis was completed of the channel bottom, as shown in Figure 3.1, and contours were plotted on the plan at a contour interval of 0.20 m.

3.2 Sediment Depth and Quantity

The results of sediment probing activities are presented in Table 3.2, and the estimated sediment accumulation in the reservoir is depicted in Figure 3.2. Sediment probing points for each transect were labeled numerically beginning at the northwest side of the reservoir (left bank looking downstream) and then progressing to the southeast of the reservoir. Sediment depths ranged from a high of 1.87 m at 13.0 m from the left bank (approximately 4 m southeast of the centerline) at Transect 2 (approximately 42 m upstream from the dam structure) to a low of no sediment encountered on the northwest side at the upstream end of the reservoir (Transect 5). Where no sediment was encountered, the base was comprised of bedrock or cobbles over rock. Sediment depths typically decreased

Table 3.1
Bathymetry Results

Distance on	Water Depth (m)						Channel Bottom Elevation (m)				
Transect (m)*	T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5
0.00	0.00	0.00	0.00	0.00	0.00	0.00	215.06	215.06	215.06	215.06	215.06
1.00	0.23	0.18	0.08	0.05	0.05	0.05	214.83	214.88	214.98	215.01	215.01
2.00	0.50	0.43	0.13	0.08	0.13	0.18	214.56	214.63	214.93	214.98	214.93
3.00	0.69	0.58	0.15	0.10	0.15	0.23	214.37	214.48	214.91	214.96	214.91
4.00	0.76	0.61	0.30	0.15	0.18	0.25	214.30	214.45	214.76	214.91	214.88
5.00	0.81	0.69	0.28	0.23	0.18	0.28	214.25	214.37	214.78	214.83	214.88
6.00	0.84	0.69	0.30	0.25	0.23	0.28	214.22	214.37	214.76	214.81	214.83
7.00	0.86	0.64	0.36	0.27	0.23	0.28	214.20	214.43	214.70	214.79	214.83
8.00	0.91	0.66	0.43	0.27	0.30	0.28	214.15	214.40	214.63	214.79	214.76
9.00	0.86	0.56	0.48	0.25	0.33	0.33	214.20	214.50	214.58	214.81	214.73
10.00	0.81	0.48	0.51	0.24	0.38	0.30	214.25	214.58	214.55	214.82	214.68
11.00	0.84	0.56	0.46	0.18	0.41	0.30	214.22	214.50	214.60	214.88	214.65
12.00	0.81	0.46	0.38	0.10	0.38	0.30	214.25	214.60	214.68	214.96	214.68
13.00	0.76	0.33	0.33	0.00	0.46	0.20	214.30	214.73	214.73	215.06	214.60
14.00	0.66	0.28	0.28		0.53	0.05	214.40	214.78	214.78		214.53
14.30						0.00	214.44	214.82	214.80		214.50
15.00	0.58	0.20	0.23		0.58		214.48	214.86	214.83		214.48
16.00	0.51	0.15	0.15		0.53		214.55	214.91	214.91		214.53
17.00	0.41	0.10	0.10		0.66		214.65	214.96	214.96		214.40
17.50		0.00					214.67	215.06	214.98		214.36
18.00	0.36		0.05		0.74		214.70		215.01		214.32
18.80			0.00				214.73		215.06		214.26
19.00	0.30				0.84		214.76				214.22
20.00	0.23				0.81		214.83				214.25
21.00	0.20				0.71		214.86				214.35
22.00	0.10				0.64		214.96				214.42
22.50	0.00						215.06				214.43
23.00					0.61						214.45
24.00					0.61						214.45
25.00					0.46						214.60
26.00					0.38						214.68
27.00					0.37						214.69
28.00					0.33						214.73
29.00					0.28						214.78
30.00					0.30						214.76
31.00					0.30						214.76
32.00					0.28						214.78
33.00					0.00						215.06

*Beginning on left bank (looking downstream).

T1 = Transect #1 etc

Note: Channel bottom elevation at Transect #6 (T6) was not able to be determined because the surface water elevation during the time of the survey was unknown.

Hamilton Conservation Authority
Crooks' Hollow Dam

Crooks' Hollow Reservoir Bottom Topography

Figure 3.1

Table 3.2
Sediment Depth Results

Distance on Transect (m)*	Sediment Depth (m)						Sediment Elevation (m)				
	T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5
0.00	0.00	0.00	1.63	0.49	0.20	0.00	215.06	215.06	213.43	214.57	214.86
1.00	0.00	0.00	1.62	0.74	0.12	0.00	214.83	214.88	213.36	214.27	214.89
2.00	0.00	0.44	1.55	0.64	0.04	0.00	214.56	214.19	213.38	214.34	214.89
3.00	0.00	0.66	1.52	0.82	0.10	0.00	214.37	213.82	213.39	214.14	214.81
4.00	0.10	1.02	1.30	0.63	0.05	0.00	214.20	213.43	213.46	214.28	214.83
5.00	0.13	1.29	1.31	0.10	0.10	0.00	214.12	213.08	213.47	214.73	214.78
6.00	0.18	1.45	1.51	0.53	0.15	0.00	214.04	212.92	213.25	214.28	214.68
7.00	0.22	1.77	1.22	0.48	0.00	0.00	213.98	212.66	213.48	214.31	214.83
8.00	1.00	1.62	1.31	0.60	0.00	0.00	213.15	212.78	213.32	214.19	214.76
9.00	1.09	1.67	0.94	0.30	0.00	0.00	213.11	212.83	213.64	214.51	214.73
10.00	0.10	1.83	0.91	0.29	0.00	0.00	214.15	212.75	213.64	214.53	214.68
11.00	1.12	1.55	1.00	0.16	0.00	0.00	213.10	212.95	213.60	214.72	214.65
12.00	1.10	1.80	1.08	0.18	0.00	0.08	213.15	212.80	213.60	214.78	214.68
13.00	0.98	1.87	1.02	0.12	0.00	0.25	213.32	212.86	213.71	214.94	214.60
14.00	0.39	1.80	1.12		0.00	0.40	214.01	212.98	213.66		214.53
14.30						0.50	213.50	213.10	213.61		214.50
15.00	1.69	1.65	1.27		0.00		212.79	213.21	213.56		214.48
16.00		1.35	1.13		0.00		212.98	213.56	213.78		214.53
17.00	1.54	0.79	1.24		0.00		213.11	214.17	213.72		214.40
17.50		0.43					213.22	214.63	213.85		214.36
18.00	1.35		0.94		0.00		213.35		214.07		214.32
18.80			0.96				213.50		214.10		214.22
19.00	1.08				0.10		213.68				214.12
20.00	0.74				0.38		214.09				213.87
21.00	0.15				0.53		214.71				213.82
22.00	0.05				0.79		214.91				213.63
22.50	0.05				0.77		215.01				213.60
23.00					0.88						213.57
24.00					0.95						213.50
25.00					0.90						213.70
26.00					0.58						214.10
27.00					0.70						213.99
28.00					0.59						214.14
29.00					0.40						214.38
30.00					0.44						214.32
31.00					0.33						214.43
32.00					0.15						214.63
33.00					0.00						215.06

*Beginning on left bank (looking downstream).
T1 = Transect #1 etc
Note: Channel bottom elevation at Transect #6 (T6) was not able to be determined as the surface water elevation during the time of the survey was unknown.

moving upstream from the dam, with maximum depth encountered in Transect 4 being only 0.82 m, compared to values well over 1 m on the three downstream transects. Transect 5 had a range of substrate depths with the left side (looking downstream) of the channel being composed primarily of rock, while the deeper right side of the channel had a maximum sediment depth of 0.95 m. Transect 6 (upstream from Morden's Mill Dam) consisted primarily of exposed bedrock over approximately 77% of the channel width (from the left bank). The right bank and right side of the channel (3.3 m from shore) is a more depositional environment, with a maximum sediment depth of 0.50 m encountered at the water's edge.

A longitudinal profile of sediment depths at the approximate mid-point of the channel is presented in Figure 3.3. Depths in the middle of the channel were generally greater than along the channel margins, although depths toward the northwest side of the channel (the depositional inside bend of the low flow channel of the reservoir) tended to be greater near the middle of the reservoir. Sediment depths were highest on the southeast side of the reservoir, in the area of the dam (Transects 1 and 2). Average sediment depth within the pond, where sediment was encountered was approximately 0.8 m, although a high variability was noted throughout most areas.

Cross-sectional profiles of sediment depth along each transect are presented in Figure 3.4.

Based on the observed cross-sectional sediment accumulation along the series of five transects* within the reservoir, it is estimated that approximately 5000 m^3 of relatively unconsolidated fine sediment exists in the creek channel that would develop between the Crooks' Hollow Dam and the former Morden's Mill Dam following dam removal (the dry sediment volume may be less). This amount represents the maximum quantity of sediment that could potentially be susceptible to erosion and downstream transport should the dam removal option be pursued. However, this is likely a conservative estimate since the post-dam removal channel cross section would likely be narrower than that used as a basis for calculation and since the natural channel dynamics would not be expected to result in the complete removal of all sediments across the cross section.

* Transect 6 has not been included in the sediment accumulation calculation as sediment upstream of the former Morden's Mill Dam) would not be impacted due to removal of Crooks Hollow Dam

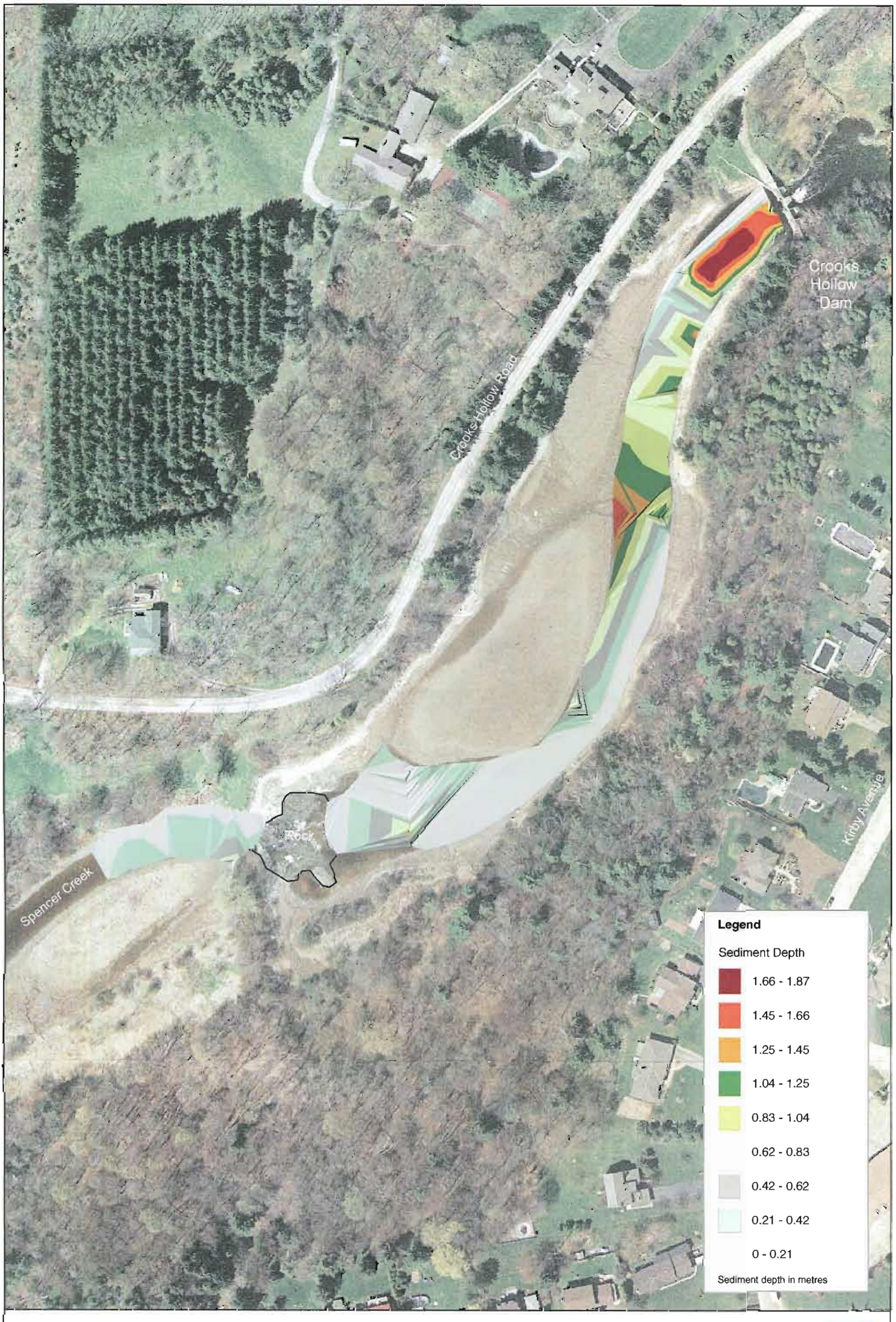
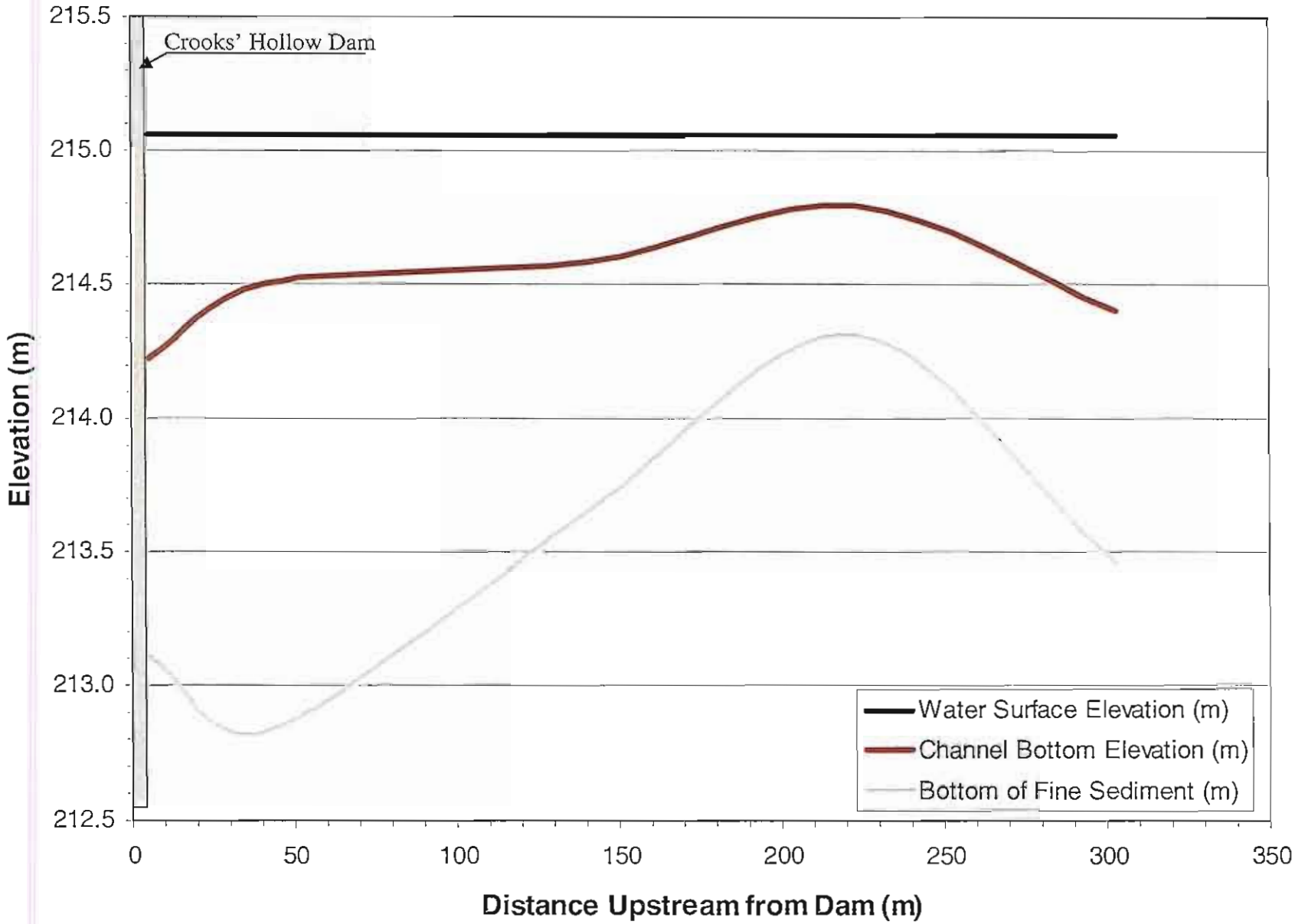


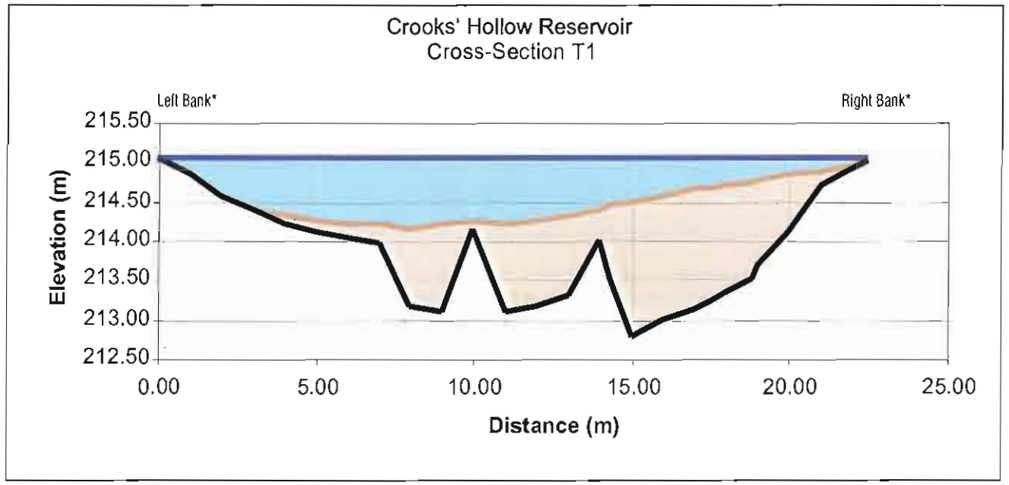
Figure 3.2
Hamilton Conservation Authority
Crooks' Hollow Dam
Crooks' Hollow Reservoir Sediment Depth

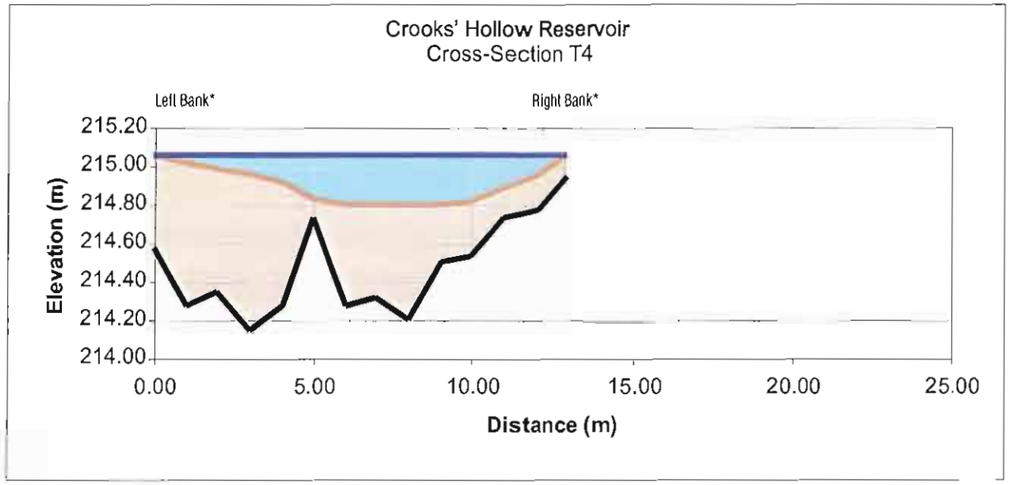
ACRES International

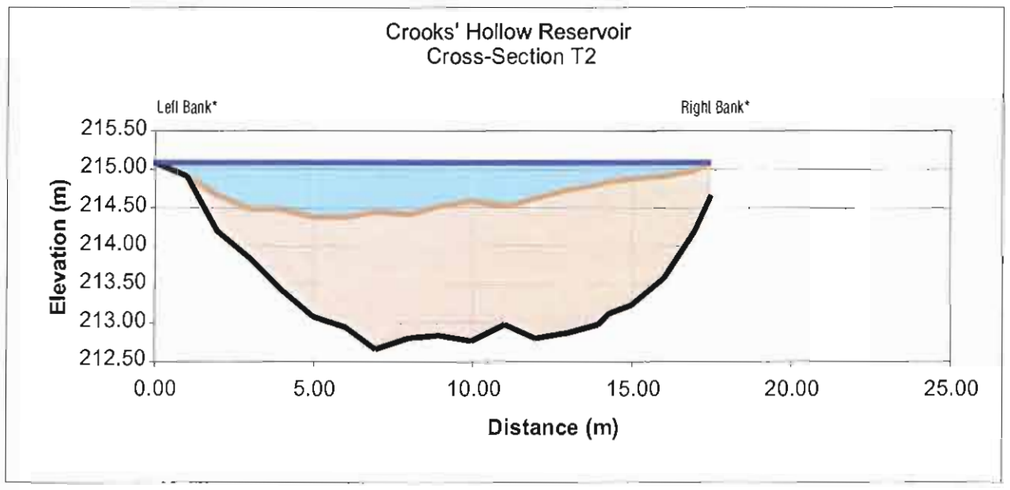


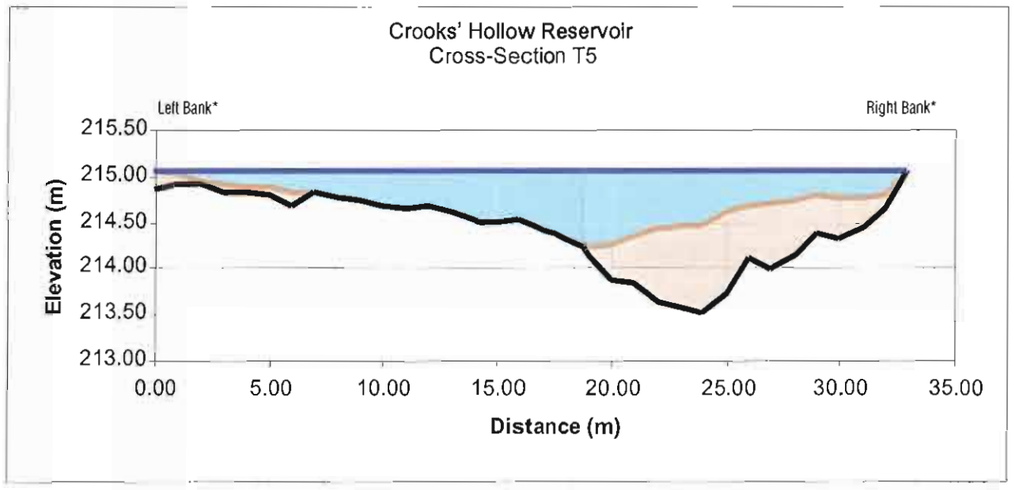
Hamilton Conservation Authority
Crooks' Hollow Dam
Crooks' Hollow Reservoir – Longitudinal Profile
Figure 3.3

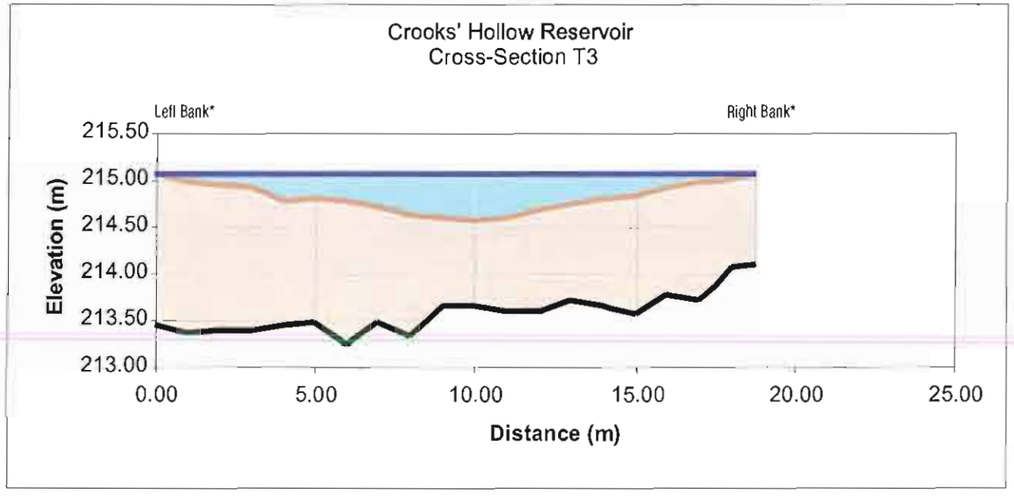
AGRES International











Legend

- Water
- Sediment
- Water Surface (Winter Water Level)
- Bottom of Reservoir
- Bottom of Sediment (Depth of Probing)

* Looking Downstream

Note:
Transect 6 has not been shown as elevations were not available for this transect

Figure 3.4
Hamilton Conservation Authority
Crooks' Hollow Reservoir Sediment Study
Reservoir Cross-Sectional Profiles

However, grading of channel banks to a stable angle to meet the new channel bottom would also require some sediment removal.

3.3 Sediment Core Sampling

3.3.1 Physical Analysis

Based on the field analysis of sediment core substrate composition, the substrate of the reservoir is typically characterized by a thick layer of accumulated fine sediments of varying texture, overlying native rocky material that likely comprised the riverbed prior to construction of the dam. The results of the sediment sampling study are presented in Table 3.3 while photographs of each core are provided in Appendix A. The surficial surface layer is typically comprised of a thin (0.03 to 0.19 m) band of loose dark brown sandy silt with mixed fine organics. A narrow, approximately 0.05-m wide band of fine to medium grained sand is common in the upper layer of most cores throughout the reservoir. The lower layer typically consists of reddish brown to dark brown soft clayey silt to silty clay, with some mixed organics. However, immediately upstream of the dam, the clayey silt constitutes the upper sediment layers, while sandy silts to sands are found in the lower layers.

The results of the grain size analysis of the core samples collected in May 2005 are presented in Appendix B and summarized in Table 3.4. Grain size analysis was performed on the complete retained core sample and therefore, makes no differentiation between the distinct sediment layers observed within the core. The clay/silt fraction formed the dominant component of all five samples, with fine sand being the second most dominant particle size. Medium and coarse sand were present in very small amounts in all samples, while fine gravel was present in negligible amounts in all samples except sample T1-A. Sample T1-A, taken immediately upstream from the dam, had the highest clay and silt content (88%), while sample T3-A had the lowest clay and silt content (58%). The results indicate that the samples generally became finer from the upstream end to the downstream end, although the clay and silt content of sample T4-A, taken from a deeper, more depositional area of the channel, ranked as the second highest.

Table 3.3
Sediment Core Results

Sampling Site	Core No.	Penetration Depth (m)*	Total Core Depth (m)*	Sediment Layer (m)	Description
May-05					
T1-A	1	0.76	0.3	0.0-0.10	Loose, black to medium grey organics, fibrous, wood and roots
				0.1-0.3	Compact, dark grey to brown silt
	2	0.88	0.25	0-0.10	Loose, grey silt and organics, trace fine sand
				0.10-0.25	Compact, dark grey silt and organics
T1-B	1	0.55	0.42	0-0.15	Loose, grey silty sand, with medium sand pockets
				0.15-0.28	Loose to compact, medium grey silt and organics, trace fine sand, 1cm banding of organcis
				0.28-0.42	Loose to compact, dark grey to black organics and silt, trace fine sand, occassional wood fibres
T2-A	1	1.17	0.39	0.0-0.13	Loose, grey to brown uniform silt and organics
				0.13-0.39	Compact grey/brown silt and organics, trace fine sand, occassional black organic layering
T3-A	1	1.07	0.22	0.0-0.15	Loose, grey/brown organics/silt and fine sand
				0.15-0.22	Loose, grey organics/silt and fine sand, fragments of limestone, wood
T4-A	1	0.46	0.22	0.0-0.10	Loose, grey/black organics and silty fine sand
				0.10-0.22	Loose, grey organics and silty fine sand, occasional fine gravel
Nov-05					
S1	1	1.18	0.43	0.0-0.03	Loose, dark brown, mixed fine organics and silt, some fine grained sand
				0.03-0.10	Reddish brown silty clay with occasional organics
				0.10-0.24	Dark brown to reddish brown clayey silt to silty clay
				0.24-0.43	Soft, dark grey, sandy silt to fine grained sand with 2 thin layers of coarse organic material
S5	1	1.03	0.45	0.0-0.05	Loose, dark grey, mixed sandy silt with mixed organics
				0.05-0.20	dark brown silt with mixed organics (leaf litter) and some fine sand
				0.20-0.26	Grey fine to medium sand with some silt, occassional shell fragments and rounded gravel
				0.26-0.45	Dark brown to reddish brown clayey silt mixed with fine organics, one band of silty clay
S8	1	1.03	0.5	0.0-0.07	Loose, greyish brown sandy silt
				0.07-0.16	Dark brown, soft sandy silt with some organics and shell fragments
				0.16-0.50	Reddish brown silty clay to clayey silt with occasional organics
S2	1	1.04	0.5	0.0-0.08	Dark brown, loose, silty sand
				0.08-0.34	dark brown, soft clayey silt with some mixed organics
				0.34-0.50	Reddish brown to dark brown, soft, clayey silt to silty clay, occassional organics
S7	1	1.3	0.41	0.0-0.21	Dark brown, clayey silt, with mixed fine organics and some shell fragments
				0.21-0.26	Medium grey, fine to medium grained sand, some silt, some woody fragments
				0.26-0.36	Reddish brown to dark brown, soft, clayey silt to silty clay, some black organic laminations
				0.36-0.41	Wood chips and fragments with silt
S3	1	1.05	0.41	0.0-0.19	Dark brown, mixed fine sand and silt, some organics throughout
				0.19-0.21	Light grey, fine to medium grained sand
				0.21-0.36	Dark brown to reddish brown, clayey silt, some mixed organics
				0.36-0.41	Mixed wood debris and silt
S6	1	0.81	0.48	0.0-0.10	Dark blackish brown mixed silt and fine organics
				0.10-0.14	Medium grey, fine to medium grained sand, some organics and shell fragments
				0.14-0.40	Mottled dark reddish brown to dark brown clayey silt to silty clay, some mixed organics
				0.40-0.48	Dark brown clayey silt with wood fragments
S4	1	0.47	0.15	0.0-0.08	Blackish grey, fine to medium grained sand with some mixed organic litter
				0.08-0.17	Dark reddish brown clayey silt with trace organics, some fine grained sand

*Penetration depth represents the vertical distance the corer was pushed into the sediment.
Total core depth represents the length of consolidated sediment obtained from the corer.

Table 3.4
Particle Size Analysis Summary

Sample No.	Clay and Silt (%)	Sand		
		Fine (%)	Medium (%)	Coarse (%)
T1-A	88	11	<1	<1
T1-B	72	24	3	1
T2-A	68	27	3	1
T3-A	58	38	3	1
T4-A	74	24	1	1

Note: See Grain Size Distribution charts in Appendix B.

3.3.2 Chemical Analysis

The results of the chemical analysis of the sediment samples are presented in Table 3.5. Results were compared to the Provincial Sediment Quality Guidelines (PSQG) (MOE, 1993), which indicate the Lowest Effect Level (LEL) and the Severe Effect Level (SEL) for a number of chemical parameters. Threshold levels are not available for the majority of parameters included in the PSQG. Contaminant levels below the LEL, but above the No Effect Level indicate that the sediment is non-impacted to marginally impacted and only has the potential to affect some sensitive water uses. The LEL indicates a level of sediment contamination that can be tolerated by the majority of benthic organisms. Concentrations exceeding the LEL indicate that the sediment is marginally to significantly impacted and the contaminant levels may affect some benthic organisms. Levels exceeding the SEL indicate that sediment is grossly impacted and will significantly affect benthic organisms.

Results were also compared to the Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act (MOE, 2004). These standards are based on the PSQG LEL values (adverse effects based). These standards provide a level of human health and ecosystem protection consistent with background and protective of sensitive ecosystems. Standards for copper and silver are provided, although there is no corresponding PSQG for those parameters.

A total of nine parameters were found to equal or exceed LEL values in at least one core sample. The parameters include

- Arsenic
- Cadmium
- Lead
- Copper
- Mercury
- Nickel
- Zinc
- Phosphorus
- Total Kjeldahl Nitrogen.

Table 3.5
Results of Sediment Chemical Analysis

Parameter	Units	Location																			PSQG*		
				S1		S5			S8		S2		S7			S3		S6			S4				
		T1-A	T1-B	S1-A	S1-B	S5-A	S5-B	T2-A	S8-A	S8-B	S2-A	S2-B	S7-A	S7-B	T3-A	S3-A	S3-B	S6-A	S6-B	T4-A	S4-A	S4-B	LEL	SEL	Standard+
Antimony (Sb)	ug/g	ND	ND	ND	ND	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NV	NV	NV
Arsenic (As)	ug/g	6	5	7	2	3	7	4	3	5	3	9	3	16	3	2	7	3	10	2	2	3	6	33	6
Barium (Ba)	ug/g	100	100	93	29	52	110	83	57	90	60	100	52	120	45	33	88	48	86	120	39	86	NV	NV	NV
Beryllium (Be)	ug/g	0.6	0.5	0.5	ND	ND	0.7	ND	ND	0.5	ND	0.5	ND	0.6	ND	ND	ND	ND	ND	ND	ND	ND	NV	NV	NV
Boron (B)	ug/g	0.6	0.67	0.63	0.68	0.73	0.98	0.72	0.76	0.7	0.48	0.8	0.23	1.16	0.67	0.86	1.9	0.33	0.93	0.7	0.18	0.85	NV	NV	NV
Cadmium (Cd)	ug/g	1.2	1.2	1	0.3	0.6	1.2	1.2	0.6	0.9	0.7	0.8	0.6	0.7	0.7	ND	0.6	0.4	0.7	1	0.3	0.4	0.6	10	0.6
Total Chromium (Cr)	ug/g	16	16	16	6.2	9.4	20	14	9.8	17	12	17	9.7	20	7.4	5.6	15	8.3	16	8.9	6.1	12	26	110	26
Chromium VI (Cr)	ug/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NV	NV	NV
Cobalt (Co)	ug/g	7.8	7.9	7.9	3	4.1	8.8	6.6	4.4	7.4	4.8	7.8	4.1	8.2	3.4	2.8	5.5	3.9	6.5	4.7	3.1	5.7	NV	NV	50
Copper (Cu)	ug/g	38	39	32	11	16	48	40	16	43	23	40	15	31	13	7.8	24	15	28	10	7.2	19	16	110	16
Lead (Pb)	ug/g	62	68	63	19	30	85	65	26	68	35	69	26	61	25	16	43	26	58	37	16	33	31	250	31
Mercury (Hg)	ug/g	0.34	0.17	0.15	ND	0.07	0.16	0.26	0.05	0.12	0.08	0.19	0.05	0.5	0.13	ND	0.25	0.08	0.25	ND	ND	0.07	0.2	2	0.2
Molybdenum (Mo)	ug/g	ND	ND	ND	ND	ND	0.5	ND	ND	ND	0.7	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NV	NV	NV
Nickel (Ni)	ug/g	16	15	16	5.2	7.6	17	12	8.3	15	8.7	16	7.2	16	5.7	4.8	10	7.3	11	8.8	4.8	11	16	75	16
Selenium (Se)	ug/g	2	2	1	ND	ND	2	1	ND	2	1	2	ND	2	ND	ND	1	ND	1	1	ND	1	NV	NV	NV
Silver (Ag)	ug/g	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NV	NV	0.5
Thallium (Ti)	ug/g	2	2	ND	ND	ND	ND	1	ND	ND	ND	ND	ND	ND	1	ND	ND	ND	ND	1	ND	ND	NV	NV	NV
Vanadium ((V)	ug/g	NT	NT	22	8.2	11	24	NT	13	20	13	21	12	22	NT	8	15	12	16	NT	10	16	NV	NV	NV
Zinc (Zn)	ug/g	500	750	670	280	400	820	640	420	660	490	590	400	460	340	250	380	380	460	1100	300	450	120	820	120
pH	pH	7.80	7.70	NT	NT	NT	NT	7.89	NT	NT	NT	NT	NT	NT	7.83	NT	NT	NT	NT	6.68	NT	NT	NV	NV	5 to 11
Phosporus Total (P)	ug/g	1200	1200	1200	670	890	1300	1100	740	1000	810	1000	740	1300	660	490	780	650	880	960	540	790	600	2000	NV
Kjeldahl Nitrogen (TKN)	ug/g	3270	2860	3140	1560	2470	3600	3010	2350	3410	2920	2920	2110	2900	1620	1880	3370	1400	2590	2280	352	2180	550	4800	NV
Organic Carbon (TOC)	ug/g	54600	58000	NT	NT	NT	NT	55600	NT	NT	NT	NT	NT	NT	37600	NT	NT	NT	NT	18500	NT	NT			NV
Moisture	%	47	51	NT	NT	NT	NT	50	NT	NT	NT	NT	NT	NT	39	NT	NT	NT	NT	24	NT	NT			NV
Arochlor 1262	ug/g	ND	NT	NT	NT	NT	NT	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT			NV
Arochlor 1016	ug/g	ND	NT	NT	NT	NT	NT	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT			NV
Arochlor 1221	ug/g	ND	NT	NT	NT	NT	NT	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT			NV
Arochlor 1232	ug/g	ND	NT	NT	NT	NT	NT	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT			NV
Arochlor 1242	ug/g	ND	NT	NT	NT	NT	NT	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT			NV
Arochlor 1248	ug/g	ND	NT	NT	NT	NT	NT	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT			NV
Arochlor 1254	ug/g	0.02	NT	NT	NT	NT	NT	0.02	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT			NV
Arochlor 1260	ug/g	ND	NT	NT	NT	NT	NT	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT			NV
Arochlor 1268	ug/g	ND	NT	NT	NT	NT	NT	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT			NV
Total PCB	ug/g	0.02	NT	NT	NT	NT	NT	0.02	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	0.07	530	0.07

Legend

* PSQG - Provincial Sediment Quality Guidelines (Ontario Ministry of the Environment, 1993)
LEL - Lowest effect level
SEL - Severe effect level
****Table 2:** Full Depth Generic Condition Standards in a Potable Groundwater Condition in Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act (MOE, 2004).
ND - Concentration of parameter was undetectable at the Method Detection Limit
NT - Not tested for tested parameter
NV - No value currently exists for this parameter
0.6 denotes that result equals or exceeds LEL
10 denotes that result equals or exceeds SEL

In general, chemical concentrations were highest in front of the dam, decreasing toward the upstream end of the reservoir. Also, concentrations within the underlying sediment were typically higher than in the upper layers.

However, immediately upstream of the dam, chemical concentrations were higher in the thick upper layer and lower in the underlying layer.

Zinc was found to equal or exceed the SEL value at two sampling locations (T4-A and S5-B). However, sampling in November 2005 did not confirm the high zinc concentration at site T4-A. The May 2005 zinc concentration throughout the sediment core (T4-A) was 1100 µg/g, whereas the November 2005 core (taken within 1 m of the original sampling location), values were 300 µg/g and 450 µg/g from the upper (S4-A) and lower (S4-B) layers of the core, respectively. These lower values are below the SEL, but above the LEL for zinc.

A number of the metal parameters (i.e., arsenic, cadmium, lead, copper, mercury, nickel) were at or only slightly above the LEL value. Several of these parameters, with the exception of arsenic and nickel, may be attributable to local background levels, although these levels are not considered reflective of a natural, healthy ecosystem. The source of the elevated arsenic levels may be attributable to historical pesticide use in the upstream watershed. The source of the elevated nickel concentrations is unknown.

Phosphorus and TKN values, the LEL for which was exceeded at almost all sampling locations, are likely attributable to upstream agricultural land use practices (i.e., fertilizer).

3.4 Significance of Results

The results of the sediment studies conducted in the Crooks Hollow Reservoir in 2005 showed that

- approximately 5000 m^3 of relatively unconsolidated fine sediment exists in the creek channel that would develop between the dam and the former Morden's Mill Dam following dam removal (dry sediment volume may be less)

- a total of nine chemical parameters, including a variety of metals, phosphorus and TKN were found to exceed the LEL values of the PSQG at one or more sample locations

- two samples were found to equal or exceed the SEL value for zinc.

The sediment transport study conducted by Acres, using information derived from the sediment studies, found that, in the absence of mitigation, dam removal could potentially result in the rapid downstream transport of the unconsolidated, fine sediment from the channel that would develop following dam removal. The transport of up to 5000 m^3 of fine sediment would likely result in a significant but temporarily adverse impact on water quality (due to increased suspended sediment loading) with associated impacts on aquatic fauna (fish, benthic invertebrates). The deposition of this fine sediment, whether it be throughout the Spencer Creek channel or at the mouth of the creek in Cootes Paradise/Hamilton Harbour would potentially result in significant adverse impacts to fish habitat. Regardless of whether the transport of this sediment occurred rapidly (i.e., 2 to 3 weeks immediately following dam removal) or over a longer time period (i.e., 2 to 3 years if a staged dam removal process were to be implemented, it is considered that the sheer volume of sediment that would be deposited would be an unacceptable environmental impact, particularly in the Spencer Creek/Cootes Paradise watershed, which is already under extreme pressure due to past and present development.

In addition to potential impacts due to sediment volume, the chemical make-up of the sediment that would be prone to downstream movement, may create sediment contamination problems in areas where deposition occurs. Although only two samples exceeded the PSQG SEL value for a single parameter (zinc), several samples exceeded the LEL value for a number of parameters. Downstream movement and deposition of this slightly impacted sediment may degrade the downstream areas, and could potentially impact benthic invertebrate use of the sediment.

Given the potential impacts associated with the unmitigated downstream transport of the fine sediments behind the dam, it is evident that, if the dam removal option were to be pursued, some form of sediment management would be necessary to prevent environmental degradation.

4 Sediment Management Alternatives

A number of sediment management alternatives were examined to prevent/ mitigate the potential adverse environmental effects associated with the downstream movement of sediment, should the dam removal option be pursued*. These sediment management alternatives included

- preparation of a risk assessment
- construction of a low-head weir to retain sediment in the reservoir
- removal of sediment from the reservoir (full or partial removal).

Each of these alternatives is discussed in the following sections.

4.1 Risk Assessment

Risk assessment is a tool that is typically used to assess the human or ecological health risks associated with management options for contaminated soils or sediments. Risk assessment is often used to identify the best balance between active management (i.e., soil/sediment removal, in situ treatment) and passive management (i.e., leave in place) based on the acceptable level of risk of significant human health or ecological impacts.

A risk assessment was initially considered as a potential alternative to address concerns associated with sediment quality. The complications associated with this type of study (i.e., addressing the dynamic movement of impacted sediments in the river system), may require an extremely complex and costly study or it may not be possible to carry out such a complex study.

In addition, risk assessment is typically used to assess sediment/soil quality concerns and may not be able to address sediment quantity issues, which in this case, may pose more of a potential environmental concern than sediment quality issues. Based on this, it was determined that some form of active sediment management would be required.

* If the dam removal option is not selected as the preferred alternative, no significant sediment disturbance would be anticipated. Environmental impacts (due to sediment) associated with the other alternatives could likely be mitigated through standard in-water construction Best Management Practices.

4.2 Installation of a Low-Head Weir to Retain Sediment

The installation of a low-head weir at the site of the existing dam would serve to retain a reservoir-like environment, although at a reduced water level compared to the existing environment. This would result in decreased flow velocities within the reservoir area, thereby resulting in significantly lower sediment transport potential, compared to the complete dam removal option. This option is similar to overall Alternative 3 (modify the dam and convert to an overflow weir), depending on the weir crest elevation that was selected.

Several alternatives for weir crest elevation would be available to mitigate downstream sediment transport. The most effective option would be to construct the weir crest at the elevation of the base of the short rapids downstream from the former Morden's Mill dam in order to reduce the river surface gradient and associated flow velocities throughout the reservoir area. However, a lower crest elevation may be possible if it could be shown through modeling, that any sediments mobilized from the upper end of the reservoir would settle out of the flow prior to water flowing over the weir. This approach would also mitigate downstream sediment transport.

However, implementation of this option, while mitigating sediment transport concerns, required the presence of a water control structure within the creek. The potentially negative aspects of this include

- long-term maintenance requirements of the weir structure
- continued HCA liability for the structure
- lack of complete restoration of this section of Spencer Creek to a free-flowing environment.

Therefore, in order for this alternative to be selected as the preferred alternative it would be necessary for HCA to consider the economic, technical and environmental advantages and disadvantages of this alternative compared to other management options (i.e., sediment removal). If sediment removal was determined to be too costly and the disadvantages of the construction of a low-head weir were not prohibitive to HCA's goals for this project, this alternative would be effective to mitigate potential sediment transport concerns.

4.3 Sediment Removal

The final option for sediment management is to physically remove sediment from the portion of the reservoir that would revert to a free-flowing state following dam removal.

The purpose of sediment removal from the reservoir would be to improve the health of the aquatic habitat in the restored river channel following removal of the dam and to prevent sediments from being eroded and transported downstream. Overall, the removal of sediments is anticipated to contribute to the protection and enhancement of Spencer Creek, both in the former reservoir area and in downstream reaches that would potentially receive sediment eroded from the reservoir.

Sediment removal options range from partial removal of the sediment from the reservoir (i.e., the largest volumes deposited in the short reach upstream of the existing dam) to the complete removal of sediment along the entire section of the reservoir, extending approximately 300 m upstream of the dam to the base of the rapids downstream from Morden's Mill Dam. The partial sediment removal option would focus on removing approximately 3000 m^3 of sediment present within 140 m upstream of the dam versus the complete removal of the approximately 5000 m^3 of sediment present over the entire 300 m length of the reservoir*. The partial sediment removal option was originally conceived since it was considered to address the major quantity of sediment while attempting to minimize removal costs. However, the partial sediment removal option was not considered viable given the distributed nature of the somewhat contaminated sediments upstream of the dam and the expected creek flow and sediment transport characteristics following the dam removal, which would result in the downstream movement of the remainder of fine sediments (2000 m^3). Thus, removing a portion of the reservoir sediment only to have the remaining quantity of sediment prone to erosion and downstream transport was deemed an unacceptable and unwarranted impact to the environment.

* Removal of 5000 m^3 of sediment accounts for all fine sediments within and on the banks of the Crook channel that would develop following dam removal. This does not include the removal of any sediment from the portions of the reservoir that would constitute the floodplain of the newly developed channel, as it is anticipated that such sediments can be stabilized through revegetation or by other means so they are not susceptible to erosion.

The following discussion therefore focuses on the complete sediment removal option. For this option, sediment removal would be conducted by dredging, which is classified into two broad categories that include mechanical dredging and hydraulic dredging.

4.3.1 Sediment Removal Techniques

Typically an open bucket or clam-shell type bucket is used for mechanical dredging. The material is loaded into a container on a barge or the material is cast directly on shore for local placement if the reach of the excavating equipment is sufficient. The dredged material is allowed to dewater and then is transported for appropriate offsite disposal or graded onsite if local placement is suitable. (Disposal options are discussed further below.)

In the case of hydraulic dredging, a pumping bucket increases the efficiency of the dredging equipment by allowing a greater percentage of solids to be pumped in the form of a slurry. Typically, pumps on the bucket are fed continuously by means of auger-cutter heads. This method is appropriate for homogenous, fine-grained materials that form a slurry. The slurry would likely be pumped to a temporary settling pond or another type of dewatering process to remove suspended material from the water/sediment slurry. The water would be decanted and the solids could then be removed for appropriate on or offsite disposal.

Based on the results of the sediment particle size analysis, which indicated that the reservoir sediment consists largely of silt and clay mixed with organic materials, hydraulic dredging, using a suction dredge is recommended for removal of the materials in order to minimize potential sediment resuspension and transport of fine materials downstream.

Should the removal of sediment be carried out in dewatered conditions, it is likely that conventional excavation equipment could be used to remove the sediment faster and at less cost. This equipment may include excavators, bulldozers and haulage trucks. Since ultimately, the reservoir will have to be dewatered for the dam removal to occur, a staged reservoir drawdown, dewatering and sediment removal approach would be advantageous. Such an approach would allow the existing dam to be used for sediment and water control as the reservoir is drawn down, allow sediments to dry out and

stabilize prior to removal and permit revegetation of exposed shoreline areas along the periphery of the new channel to further stabilize soils and mitigate sediment transport.

4.3.2 Sediment Disposal Alternatives

Several alternatives exist to dispose of the sediment that is removed from the reservoir. This includes

- off-site removal to an appropriate landfill
- off-site removal to other HCA properties
- off-site removal to private property (e.g., agricultural fields)
- on-site use (i.e., spreading on floodplain).

Each of these options is discussed briefly in the following sections.

Removal to Landfill

This alternative would involve placing the dredged sediment into a dump truck (either at the time of dredging or later on through temporary stockpiling of the dredgeate) and transporting it to an approved, off-site landfill disposal facility. The sediment for disposal would have to be classified in accordance with Regulation 347 (as amended by Regulation 558), to determine if it would be hazardous or non-hazardous waste. Accordingly the material would have to be transported to an appropriately classified waste facility. This alternative would likely involve the highest transportation costs, although it has the benefit of eliminating the risk associated with other uses of the soil.

Removal to Other Properties

This alternative would involve transporting the sediment off-site to other properties including property owned by the HCA and private properties.

If the sediment was classified as a non-hazardous according to Regulation 347 (as amended by Regulation 558), it may be suitable for non-landfill uses at other HCA sites or for spreading over agricultural fields. To determine this viability, it would be necessary to assess the sediment quality according to the specific land use in the MOE's "Soil Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act".

In particular, it would need to be confirmed that the zinc concentration in the sediment material would be acceptable for use as a soil, associated with a specific land use as the zinc concentration in two samples slightly exceeded the MOE Standard of 800 µfor parkland use.

This alternative would likely involve relatively high transportation costs, depending on the ultimate destination for the sediment.

On-Site Use

The final sediment disposal alternative would be to place the material removed from the low flow channel, on the bottom of the former reservoir, which would become the floodplain of Spencer Creek following dam removal. The feasibility of this alternative would be contingent on the sediment being classified as a non-hazardous waste and meeting the MOE standard for parkland use.

If the sediment is found to be chemically suitable for this use, the most feasible alternative would be to place it into containment cells along the periphery of the floodplain. The containment cells would likely be constructed of stone-filled gabion retaining walls or similar containment structures around the perimeter of the cells. These cells would be renaturalized after the disposal is complete to prevent erosion and improve aesthetics of the area. This alternative would also be contingent on showing the above-grade containment cells would not have a significant impact of flooding.

Overall, this alternative would be the lowest cost solution because it eliminates the requirement for off-site transport.

A comparison of the in-water versus dewatered reservoir sediment removal strategies and estimated costs are presented in Table 4.1. For these cost estimates, it was assumed the sediment quality would be suitable for local placement in or near the existing floodplain in containment cells along the creek and that, construction mobilization, silt migration control measures and setup costs would be the same for both strategies. For the dewatering strategy, costs include an allowance for diverting the creek flow around the working area. Costs associated with permits, approvals and additional assessments are not included. Should it be necessary to transport the sediment

material to an offsite location, additional transportation and disposal costs would be applicable. Transportation costs would likely range from $5 to $10/m^3, depending on the distance to the disposal site (i.e., possibly add $25,000 to $50,000 to the estimated costs shown below).

Table 4.1
Sediment Removal Alternatives

Sediment Removal Alternative	Sediment Volume (m^3)	Removal Condition	Equipment Type	Estimated Costs* ($)
Full Removal	5000	In the wet	Suction Dredge	175,000
		In the dry	Excavator	115,000

* Budget level cost estimate only. Contingency factor of -25 to +50% would apply. Permits, approvals and the cost of the material transport off site are not included.

5 Summary and Recommendations

5.1 Summary

Sediment Quality and Quantity

Sediment and bathymetry studies in the Crooks' Hollow Reservoir were conducted on May 31 and November 22, 2005 to provide baseline sediment and bathymetry data for the Crooks' Hollow Dam Class Environmental Assessment.

Water depth during the May 2005 study was a maximum of 0.91 m (channel bottom elevation of 214.15 m) immediately upstream from the dam. This would equate to an approximate water depth of 2.13 m at the normal summer water level of 216.28 m.

Sediment depth in the reservoir reached a maximum of 1.87 m (in Transect 2). Sediment depth typically decreased moving upstream from the dam to a maximum center channel depth of 0.27 m in Transect 4. The majority of the channel upstream from Morden's Mill Dam is composed of exposed bedrock with a veneer of rocky material (cobble and gravel). However, the right bank (looking downstream) is a deposition environment, with a maximum observed sediment depth of 0.50 m.

The substrate of the reservoir is typically characterized by a thick layer of sediment consisting of a mixture of decomposed organic material and fine-grained inorganic material that was deposited on the underlying bedrock or granular materials. Grain size analysis indicated that the clay/silt fraction formed the dominant component of all five samples, with fine sand being the second most dominant particle size. Sample T1-A, taken immediately upstream from the dam, had the highest clay and silt content (88%), while sample T3-A had the lowest clay and silt content (58%).

It was estimated that approximately 5000 m^3 of unconsolidated fine sediments exist in the channel that would form following dam removal. A sediment transport study confirmed that this complete amount (5000 m^3) would be susceptible to downstream transport following dam removal.

The results of the chemical analysis indicated that reservoir sediments exceeded the LEL for eight parameters including arsenic, cadmium, lead, copper, mercury,

nickel, zinc, total phosphorus, and total Kjeldahl nitrogen. At these observed levels, benthic invertebrate populations may be impacted. One parameter (zinc) was found to exceed the SEL at two locations, indicating heavily impacted sediment likely to affect the health of sediment dwelling organisms. Chemical concentrations were typically higher in the lower sediment layers, with concentrations decreasing moving downstream. However, the upper sediment layer immediately upstream from the dam exhibited higher chemical concentrations than did the lower layer.

Sediment Management

Based on the relatively large quantity of sediment existing in the reservoir that would be susceptible to downstream transport following dam removal, and the somewhat chemically degraded nature of these sediments, it is evident that some form of sediment management will be necessary to prevent significant environmental impact if the dam removal option is pursued.

Several sediment management options were investigated including

- preparation of a risk assessment
- construction of a low head overflow weir to retain reservoir sediments
- full or partial removal of sediments from the area of the channel that would result following dam removal.

It was determined that a risk assessment may not be feasible because of the potential complexity and high cost, and would not address the sediment quality issue. Construction of a low head weir would be a feasible alternative to mitigate downstream sediment transport. However the advantages of this option (e.g., potentially lower cost that sediment removal) would need to be compared to the potential disadvantages (e.g., continued long-term maintenance costs and liability, environmental restoration issues) to determine if this is an acceptable solution.

Complete sediment removal would be an effective solution to mitigate sediment related problems and allow for complete dam removal. However, this is the highest cost option and the benefits must be weighted against the higher cost.

5.2 Recommendations

If the dam removal option is pursued, preparation of a sediment management plan is recommended to confirm the specific sediment removal method, disposal options, monitoring, timing and costs. Completion of the sediment management plan would be conducted in conjunction with the demolition plan for the dam and restoration strategy for the river.

Appendix A

Sediment Core Photographs

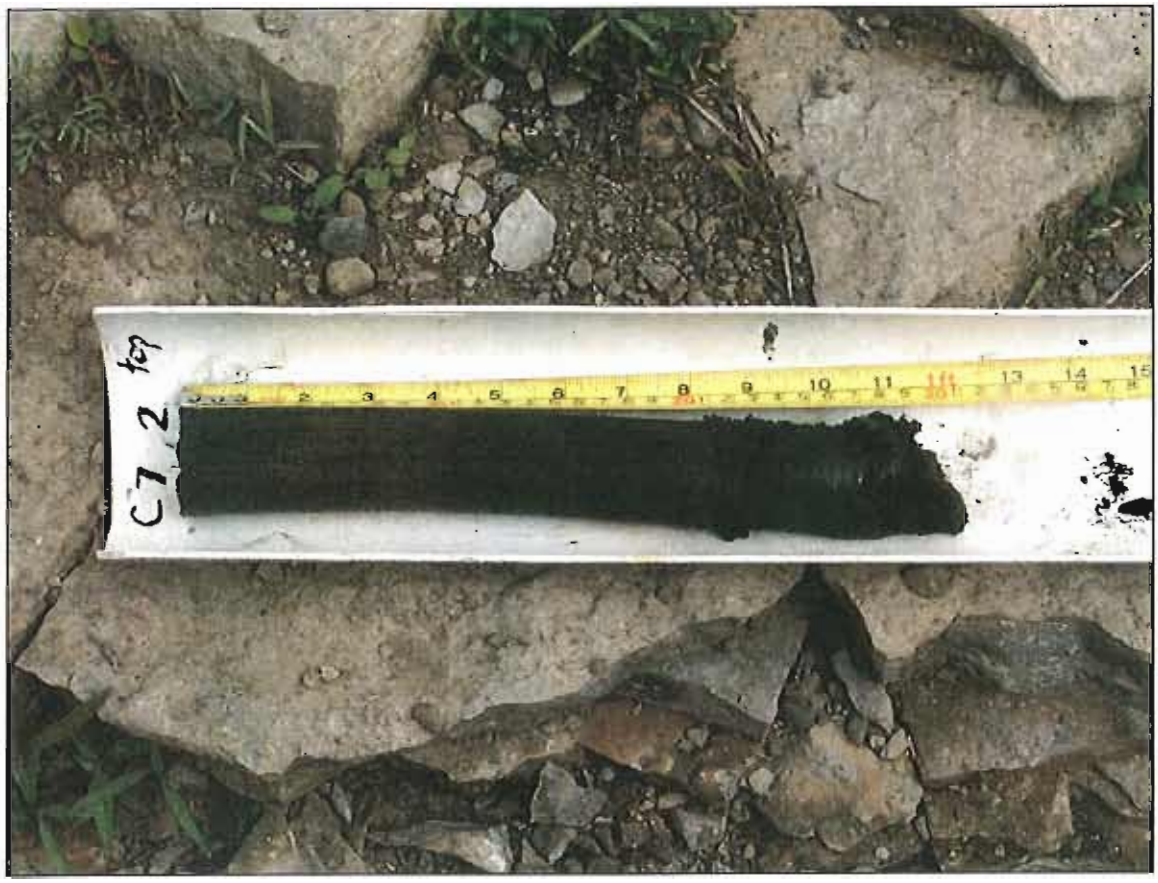


Photo 1 Sample T1-A

Photo 2 Sample T1-B

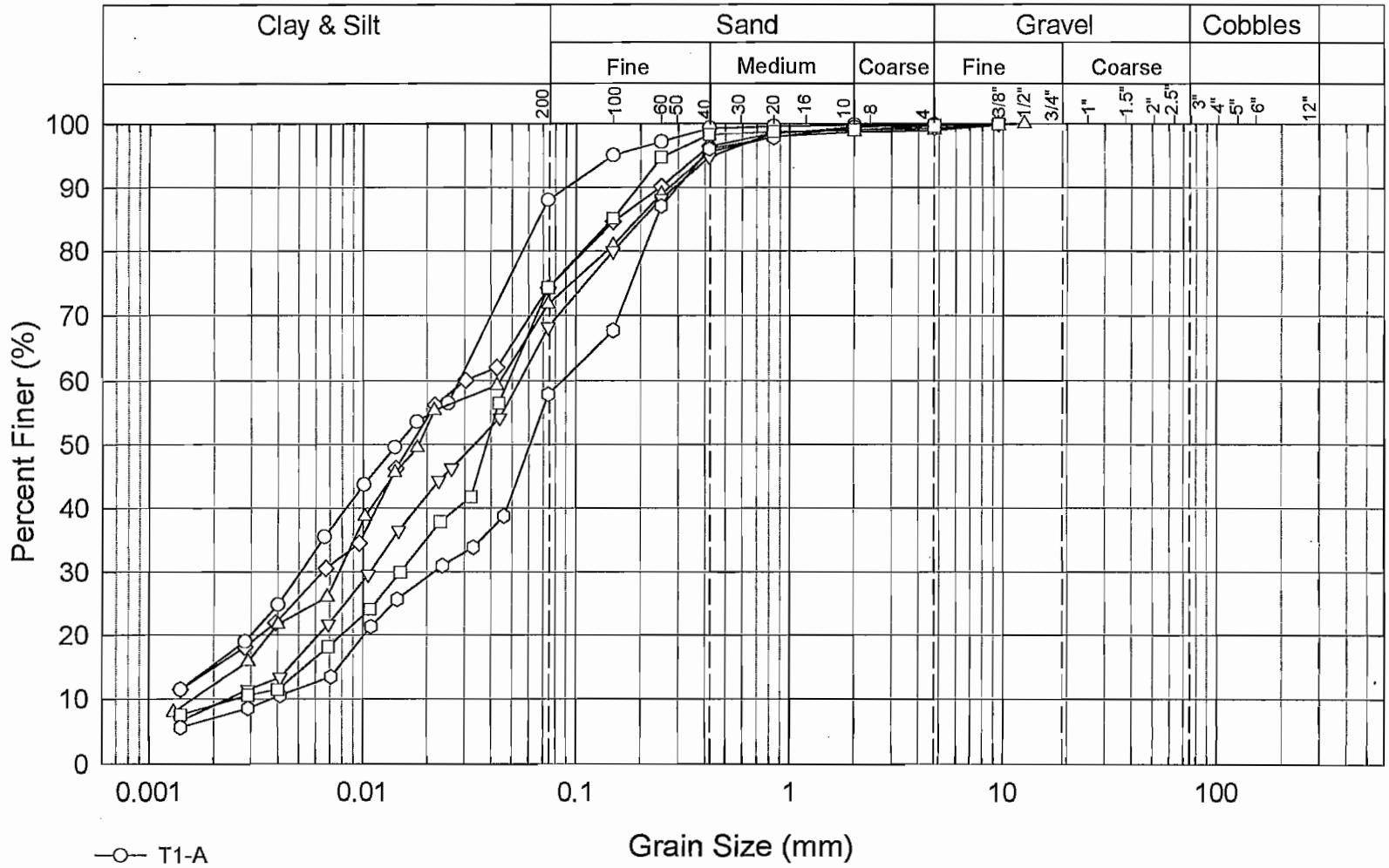
Photo 3 Sample T2-A

Photo 4 Sample T3-A

Photo 5 Sample T4-A

Appendix B

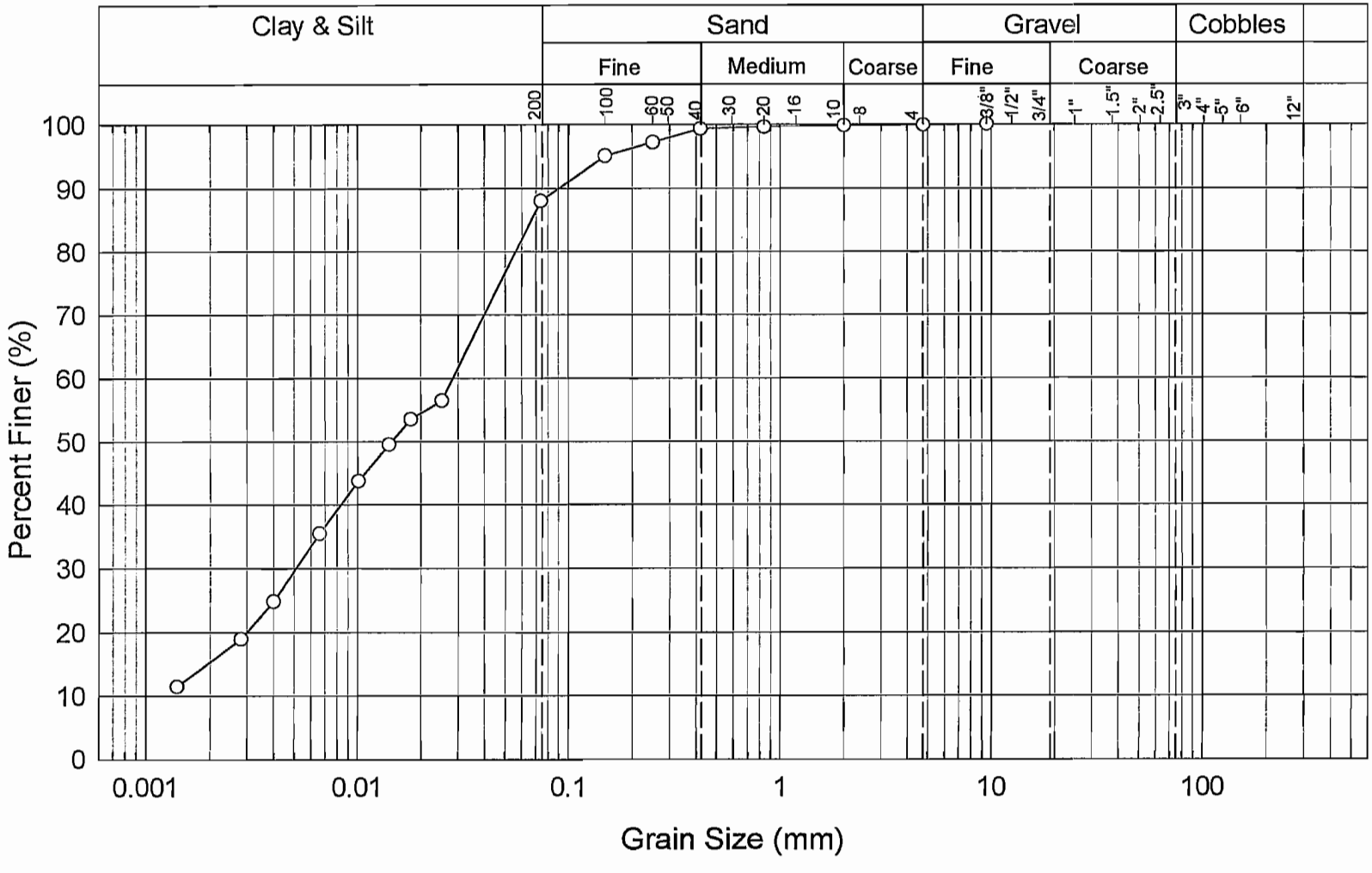
Sediment Core Grain Size Analysis Results



Crooks Hollow Dam Class EA

Grain Size Distribution - All Tests

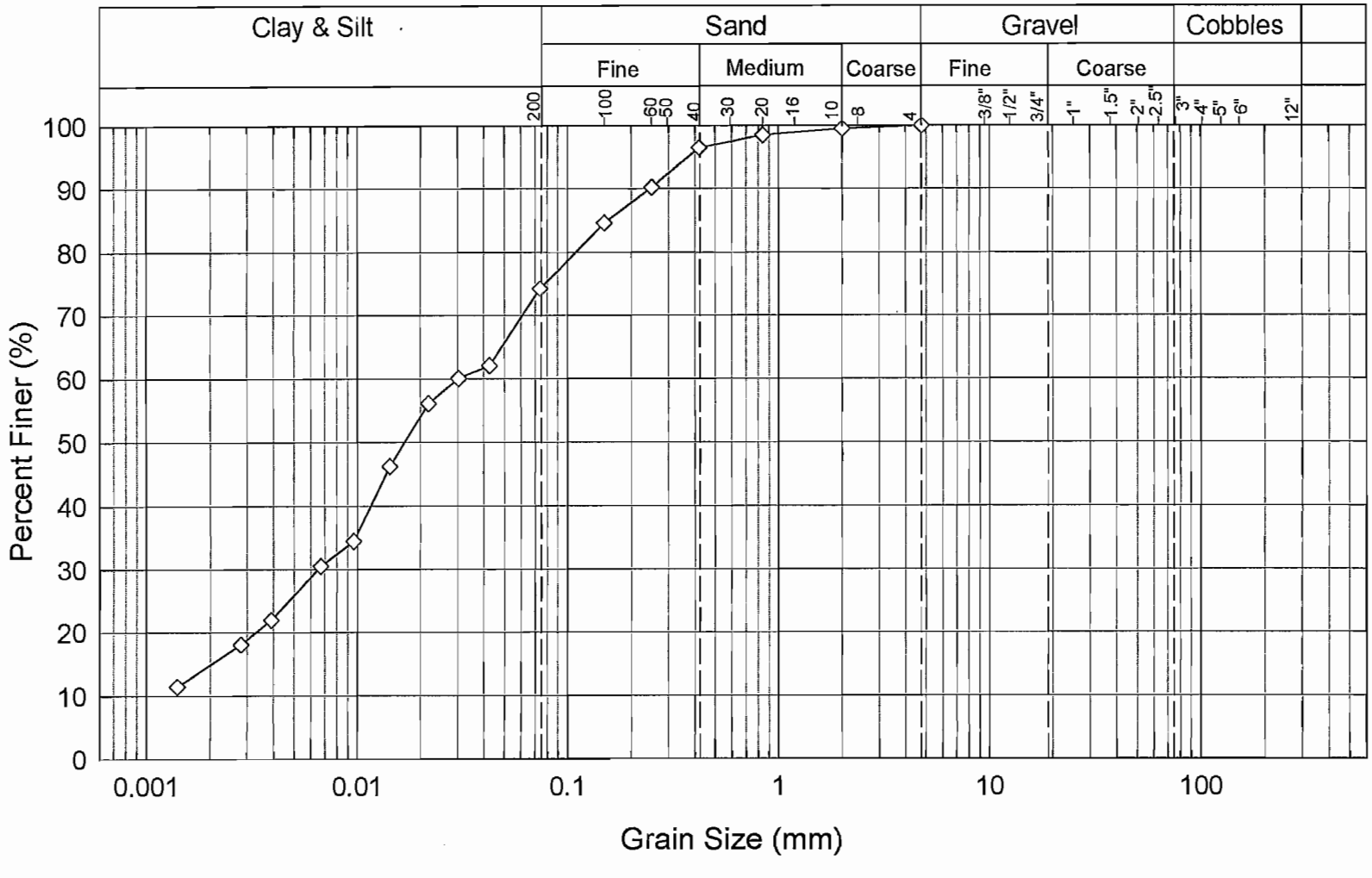
AGRES International



Crooks Hollow Dam Class EA

Grain Size Distribution - T1-A

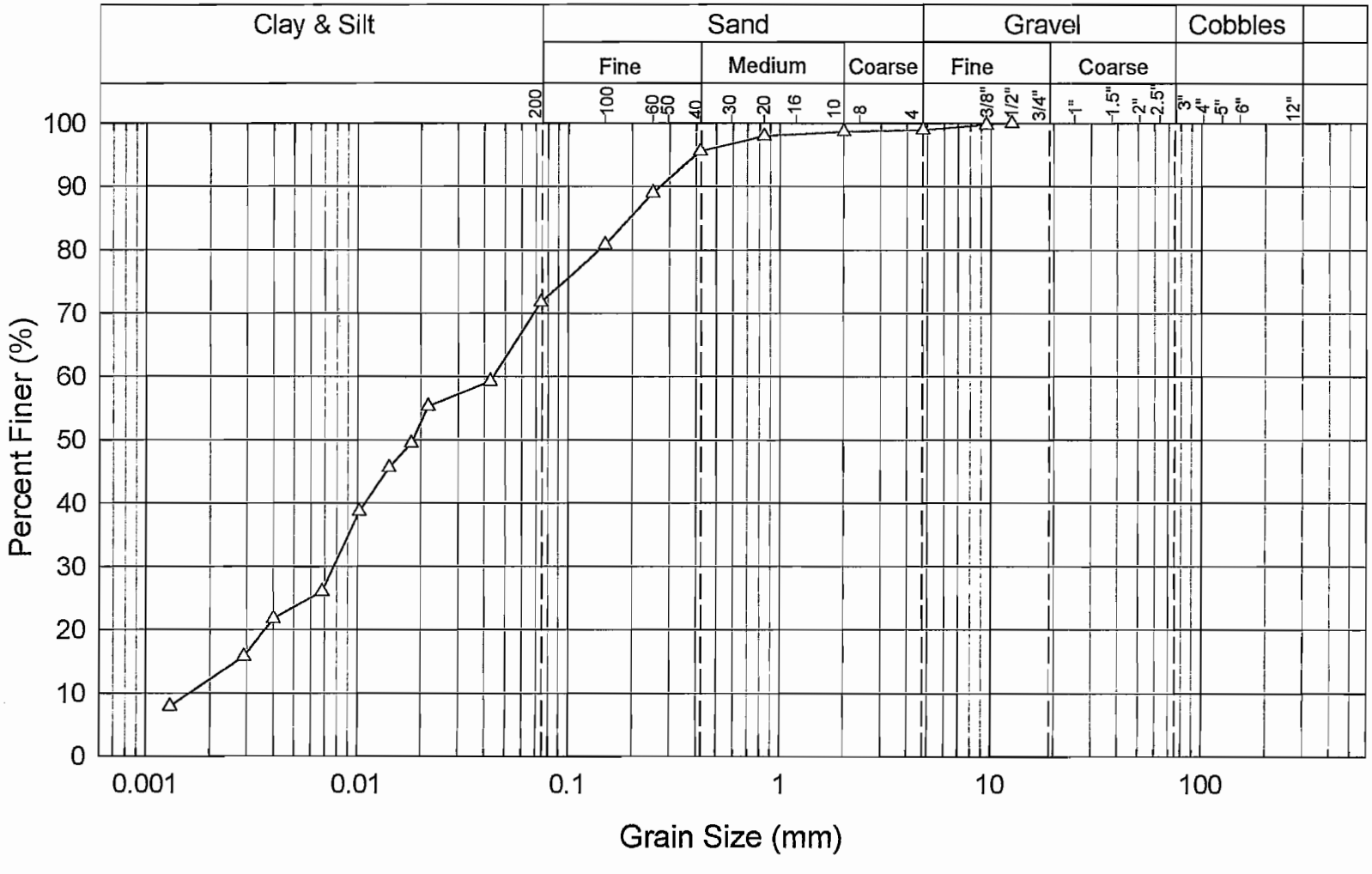
ACRES International



Crooks Hollow Dam Class EA

Grain Size Distribution - T1-A2

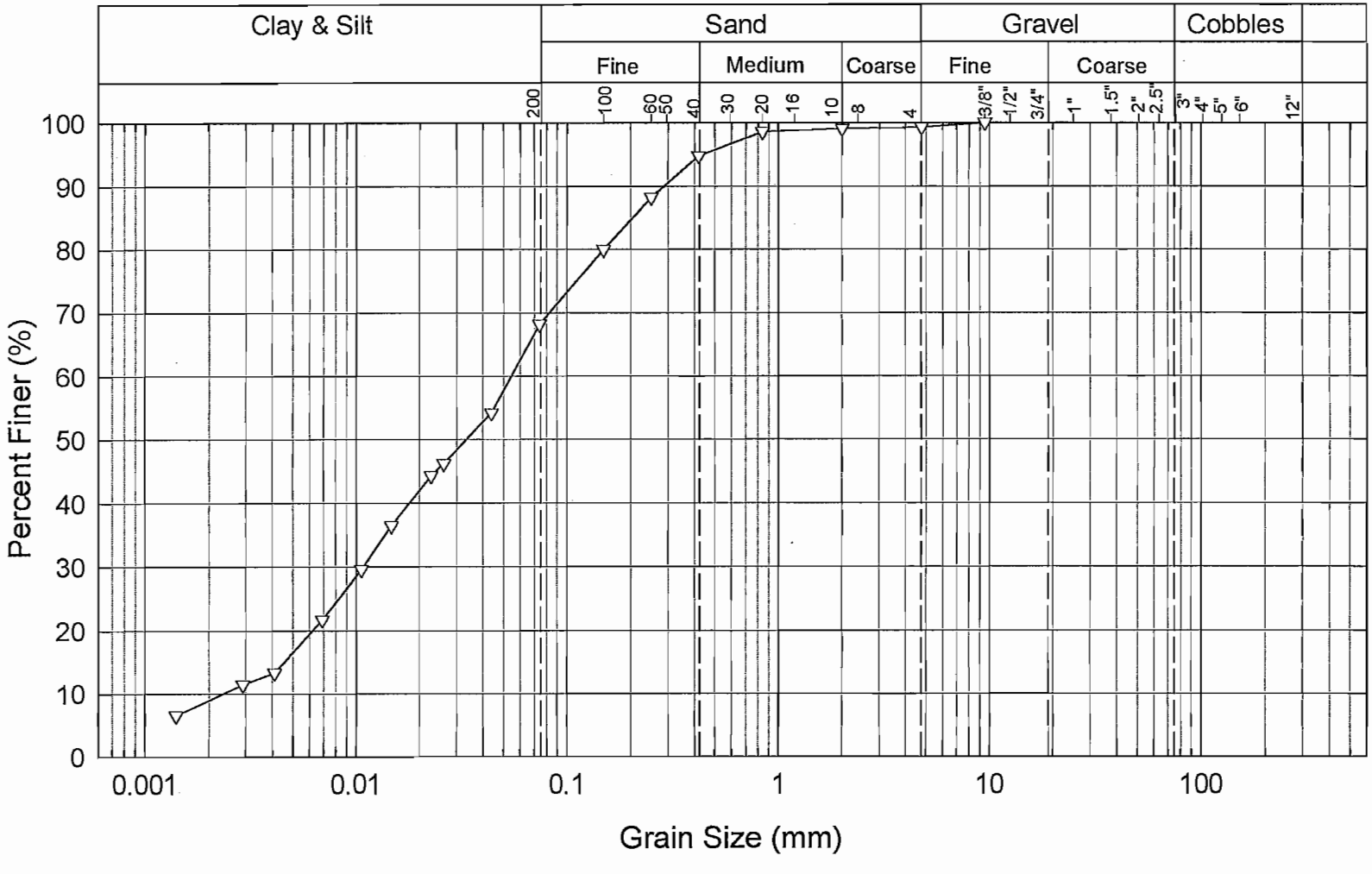
ACRES International



Crooks Hollow Dam Class EA

Grain Size Distribution - T1-B

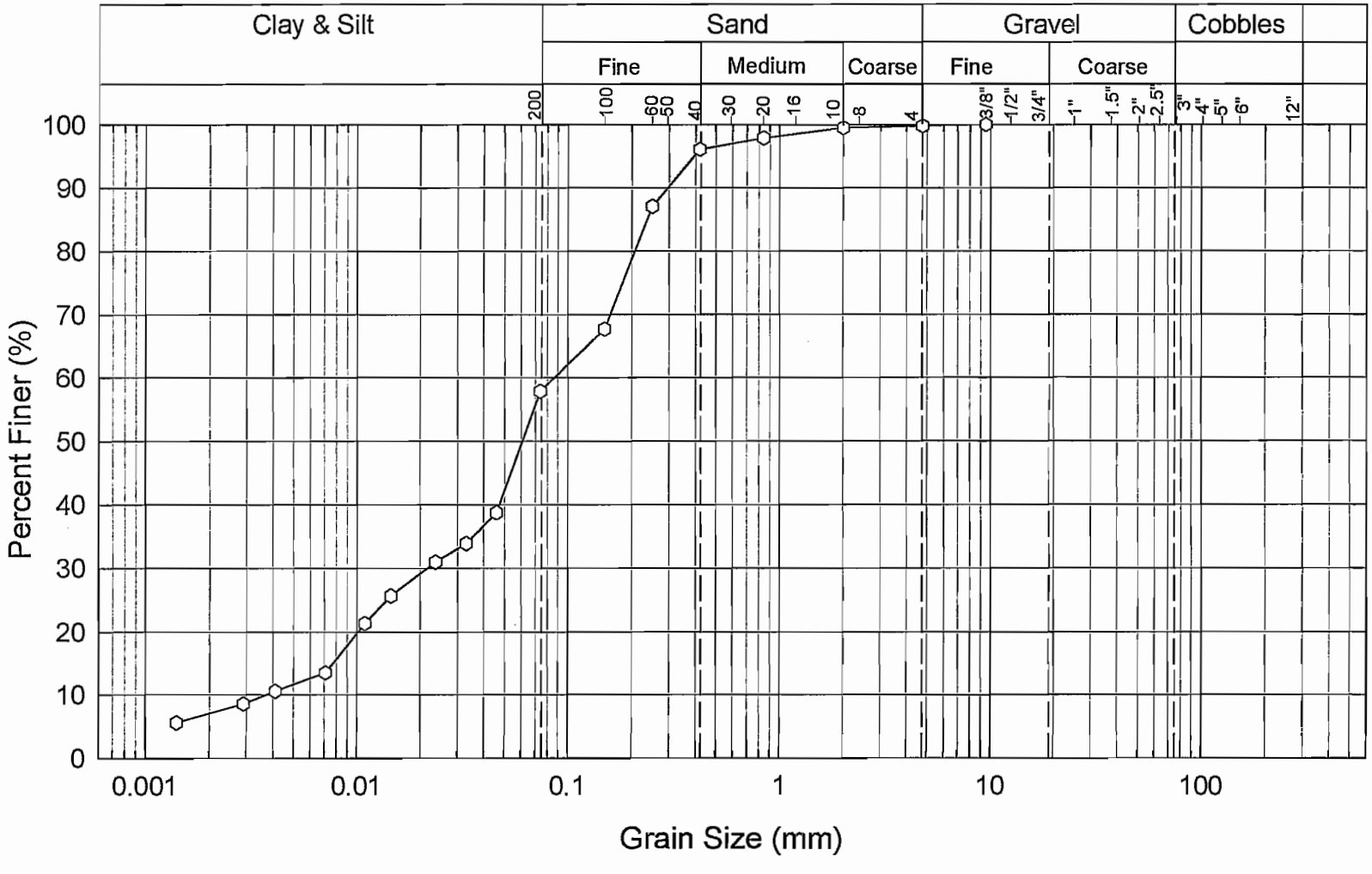
ACRES International



Crooks Hollow Dam Class EA

Grain Size Distribution - T2-A

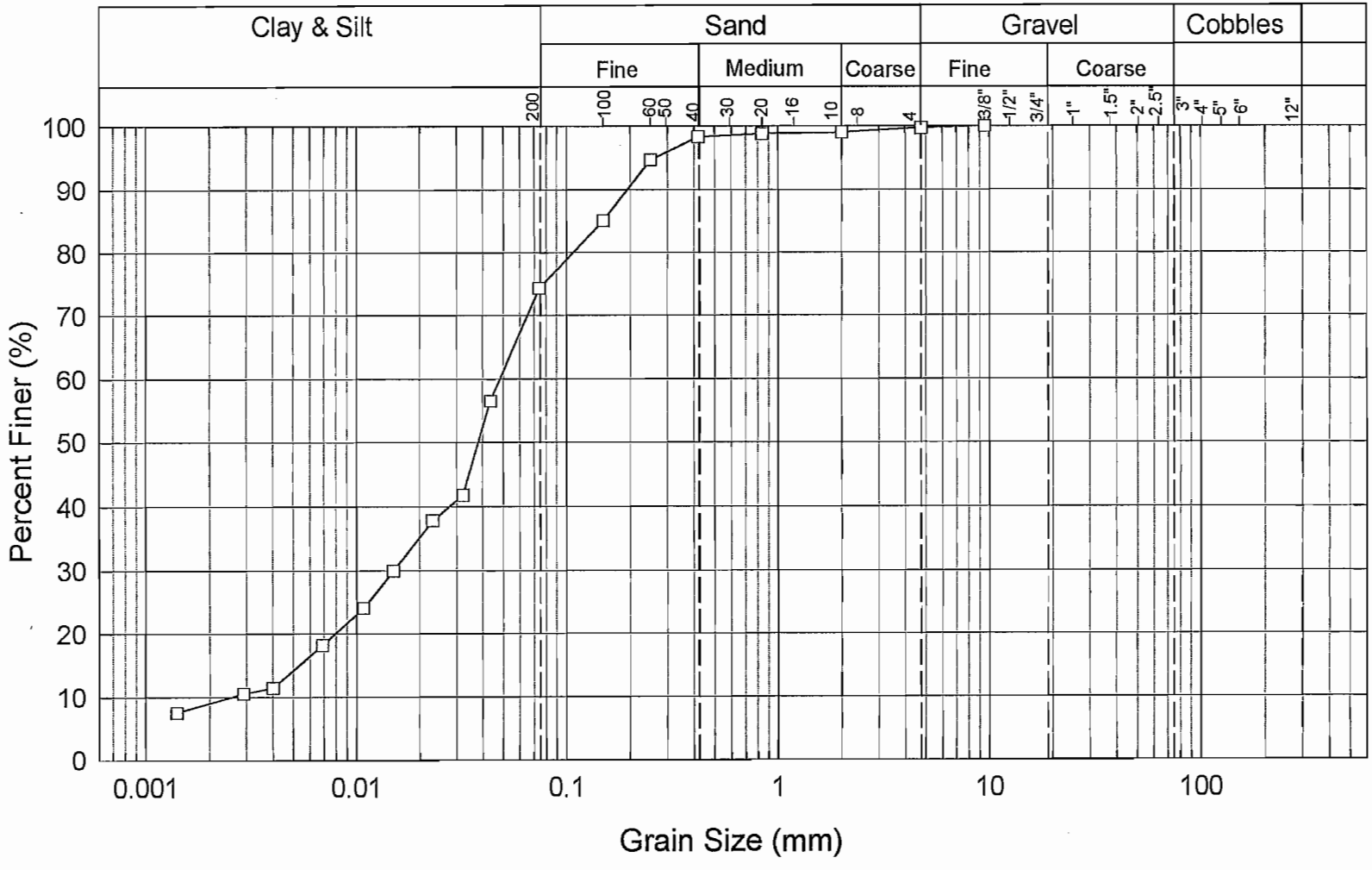
AGRES International



Crooks Hollow Dam Class EA

Grain Size Distribution - T3-A

AGRES International



Crooks Hollow Dam Class EA

Grain Size Distribution - T4-A

ACRES International

Appendix C

Laboratory Test Results

Maxxam Analytics Inc

Acres International Ltd
4342 Queen St
PO Box 1001
Niagara Falls, ON
L2E 6W1

Attention: Bruce McTavich

Report Date: 2005/06/14

Your Project #: 16681
Site: CROOKS HOLLOW DAM
Your C.O.C. #: NA

ANALYTICAL REPORT

MAXXAM JOB #: A548823
Received: 2005/06/02, 16:01

Sample Matrix: SOLID
Samples Received: 5

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Hot Water Extractable Boron	5	2005/06/09	2005/06/09	Ont SOP 0102	EPA 3050B
Chromium (VI) in Soil	5	2005/06/07	2005/06/07	Ont SOP 0104	EPA 7196
Acid Extractable Metals in Soil by GF	5	2005/06/08	2005/06/09	Ont SOP 0095	EPA 7010
Mercury in Soil by CVAA	5	2005/06/08	2005/06/09	Ont SOP 0112	EPA 7470
Total Metals Analysis in Soil by ICP	5	2005/06/09	2005/06/10	Ont SOP 0072	EPA 6010
MOISTURE	5	N/A	2005/06/07	Ont SOP-0114	MOE HANDBOOK(198
Polychlorinated Biphenyl in Soil	2	2005/06/07	2005/06/07	Ont SOP 0127	SW 846 3rd Edition
PH	5	2005/06/09	2005/06/09	Ont SOP 0067	APHA 4500H
Total Kjeldahl Nitrogen (TKN)	5	2005/06/09	2005/06/10	Ont SOP 0074	APHA 4500
Total Organic Carbon (TOC)	5	N/A	2005/06/13		EPA 410.4

MAXXAM ANALYTICS INC.

TROY CARRIERE, B.Sc.
Environmental Scientific Specialist

TCA/all
encl.

Total cover pages: 1

Maxxam Analytics Inc

Maxxam Job #: A548823
Report Date: 2005/06/14

Acres International Ltd
Client Project #: 16681
Project name: CROOKS HOLLOW DAM
Sampler Initials:

ELEMENTS BY ATOMIC SPECTROSCOPY (SOLID)

Maxxam ID		G42136		
Sampling Date		2005/05/31 15:10		
COC Number		NA		
	Units	T4-A	DL	QC Batch
METALS				
Acid Extractable Antimony (Sb)	ug/g	ND	1	755237
Acid Extractable Arsenic (As)	ug/g	2	1	755237
Total Barium (Ba)	ug/g	120	2	755701
Total Beryllium (Be)	ug/g	ND	0.5	755701
Total Cadmium (Cd)	ug/g	1.0	0.5	755701
Total Chromium (Cr)	ug/g	8.9	1	755701
Total Cobalt (Co)	ug/g	4.7	2	755701
Total Copper (Cu)	ug/g	10	2	755701
Total Lead (Pb)	ug/g	37	5	755701
Acid Extractable Mercury (Hg)	ug/g	ND	0.05	755120
Total Molybdenum (Mo)	ug/g	ND	2	755701
Total Nickel (Ni)	ug/g	8.8	5	755701
Total Phosphorus (P)	ug/g	960	20	755701
Acid Extractable Selenium (Se)	ug/g	1	1	755237
Total Silver (Ag)	ug/g	ND	1	755701
Acid Extractable Thallium (Tl)	ug/g	1	1	755237
Total Vanadium (V)	ug/g	16	5	755701
Total Zinc (Zn)	ug/g	1100	5	755701
METALS				
Hot Water Ext. Boron (B)	ug/g	0.70	0.01	755411

ND = Not detected
QC Batch = Quality Control Batch
Please check for attached comments

Maxxam Analytics Inc

Maxxam Job #: A548823
Report Date: 2005/06/14

Acres International Ltd
Client Project #: 16681
Project name: CROOKS HOLLOW DAM
Sampler Initials:

POLYCHLORINATED BIPHENYLS BY GC-ECD (SOLID)

Maxxam ID		G42132	G42134		
Sampling Date		2005/05/31 09:00	2005/05/31 12:35		
COC Number		NA	NA		
	Units	T1-A	T2-A	DL	QC Batch
PCB'S					
Aroclor 1262	ug/g	ND	ND	0.01	753833
Aroclor 1016	ug/g	ND	ND	0.01	753833
Aroclor 1221	ug/g	ND	ND	0.02	753833
Aroclor 1232	ug/g	ND	ND	0.01	753833
Aroclor 1242	ug/g	ND	ND	0.02	753833
Aroclor 1248	ug/g	ND	ND	0.01	753833
Aroclor 1254	ug/g	0.02	0.02	0.01	753833
Aroclor 1260	ug/g	ND	ND	0.01	753833
Aroclor 1268	ug/g	ND	ND	0.01	753833
Total PCB	ug/g	0.02	0.02	0.02	753833
Surrogate Recovery (%)					
2,4,5,6-Tetrachloro-m-xylene	%	119	110		753833
Decachlorobiphenyl	%	46	45		753833

ND = Not detected
QC Batch = Quality Control Batch
Please check for attached comments

Maxxam Analytics Inc

Maxxam Job #: A548823
Report Date: 2005/06/14

Acres International Ltd
Client Project #: 16681
Project name: CROOKS HOLLOW DAM
Sampler Initials:

ELEMENTS BY ATOMIC SPECTROSCOPY (SOLID)

Acid Extractable Metals in Soil by GF: Due to instrumental difficulties with Graphite Furnace A.A. samples were analyzed by Trace ICP. Methods are equivalent and no impact on data quality is expected. RL for Ag has been adjusted where applicable.

Results relate only to the items tested.

Maxxam Analytics Inc

Acres International Ltd
Attention: Bruce McTavich
Client Project #: 16681
P.O. #:
Project name: CROOKS HOLLOW DAM

Quality Assurance Report

Maxxam Job Number: MA548823

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
753833 ANL	MATRIX SPIKE	2,4,5,6-Tetrachloro-m-xylene	2005/06/07		109	%	40 - 130
		Decachlorobiphenyl	2005/06/07		50	%	40 - 130
		Aroclor 1260	2005/06/07		96	%	8 - 127
	Spiked Blank	2,4,5,6-Tetrachloro-m-xylene	2005/06/07		107	%	40 - 130
		Decachlorobiphenyl	2005/06/07		49	%	40 - 130
		Aroclor 1260	2005/06/07		101	%	53 - 135
	Method Blank	2,4,5,6-Tetrachloro-m-xylene	2005/06/07		112	%	40 - 130
		Decachlorobiphenyl	2005/06/07		67	%	40 - 130
		Aroclor 1262	2005/06/07	ND, DL=0.01		ug/g	
		Aroclor 1016	2005/06/07	ND, DL=0.01		ug/g	
		Aroclor 1221	2005/06/07	ND, DL=0.02		ug/g	
		Aroclor 1232	2005/06/07	ND, DL=0.01		ug/g	
		Aroclor 1242	2005/06/07	ND, DL=0.02		ug/g	
		Aroclor 1248	2005/06/07	ND, DL=0.01		ug/g	
		Aroclor 1254	2005/06/07	ND, DL=0.01		ug/g	
		Aroclor 1260	2005/06/07	ND, DL=0.01		ug/g	
		Aroclor 1268	2005/06/07	ND, DL=0.01		ug/g	
		Total PCB	2005/06/07	ND, DL=0.02		ug/g	
	RPD	Aroclor 1262	2005/06/07	NC		%	50
		Aroclor 1016	2005/06/07	NC		%	50
		Aroclor 1221	2005/06/07	NC		%	50
		Aroclor 1232	2005/06/07	NC		%	50
		Aroclor 1242	2005/06/07	NC		%	50
		Aroclor 1248	2005/06/07	NC		%	50
		Aroclor 1254	2005/06/07	NC		%	50
		Aroclor 1260	2005/06/07	NC		%	50
		Aroclor 1268	2005/06/07	NC		%	50
		Total PCB	2005/06/07	NC		%	50
753986 TJO	MATRIX SPIKE	Chromium (VI)	2005/06/07		102	%	75 - 125
	QC STANDARD	Chromium (VI)	2005/06/07		100	%	85 - 115
	Spiked Blank	Chromium (VI)	2005/06/07		104	%	75 - 125
	Method Blank	Chromium (VI)	2005/06/07	ND, DL=0.005		ug/g	
	RPD	Chromium (VI)	2005/06/07	NC		%	35
754014 BMO	RPD	Moisture	2005/06/07	3.1		%	50
755120 MC	MATRIX SPIKE	Acid Extractable Mercury (Hg)	2005/06/09		93	%	75 - 125
	QC STANDARD	Acid Extractable Mercury (Hg)	2005/06/09		111	%	85 - 115
	Spiked Blank	Acid Extractable Mercury (Hg)	2005/06/09		87	%	75 - 125
	Method Blank	Acid Extractable Mercury (Hg)	2005/06/09	ND, DL=0.05		ug/g	
	RPD	Acid Extractable Mercury (Hg)	2005/06/09	NC		%	35
755237 GBU	MATRIX SPIKE	Acid Extractable Arsenic (As)	2005/06/09		91	%	75 - 125
		Acid Extractable Selenium (Se)	2005/06/09		107	%	75 - 125
	QC STANDARD	Acid Extractable Arsenic (As)	2005/06/09		107	%	30 - 170
	Method Blank	Acid Extractable Antimony (Sb)	2005/06/09	ND, DL=1		ug/g	
		Acid Extractable Arsenic (As)	2005/06/09	ND, DL=1		ug/g	
		Acid Extractable Selenium (Se)	2005/06/09	ND, DL=1		ug/g	
		Acid Extractable Thallium (Tl)	2005/06/09	ND, DL=1		ug/g	
	RPD	Acid Extractable Arsenic (As)	2005/06/09	NC		%	35
		Acid Extractable Selenium (Se)	2005/06/09	NC		%	35
755310 LS	QC STANDARD	pH	2005/06/09		99	%	90 - 110
	RPD	pH	2005/06/09	0.4		%	35
755411 ADA	QC STANDARD	Hot Water Ext. Boron (B)	2005/06/09		102	%	77 - 121
	Method Blank	Hot Water Ext. Boron (B)	2005/06/09	ND, DL=0.01		ug/g	
755659 CN	QC STANDARD	Total Kjeldahl Nitrogen (TKN)	2005/06/10		93	%	85 - 115
	Spiked Blank	Total Kjeldahl Nitrogen (TKN)	2005/06/10		94	%	75 - 125
	Method Blank	Total Kjeldahl Nitrogen (TKN)	2005/06/10	ND, DL=10		ug/g	
	RPD	Total Kjeldahl Nitrogen (TKN)	2005/06/10	2.8		%	35

Maxxam Analytics Inc

Acres International Ltd
Attention: Bruce McTavich
Client Project #: 16681
P.O. #:
Project name: CROOKS HOLLOW DAM

Quality Assurance Report (Continued)

Maxxam Job Number: MA548823

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
755701 MME	MATRIX SPIKE	Total Beryllium (Be)	2005/06/09		102	%	75 - 125
		Total Cadmium (Cd)	2005/06/09		103	%	75 - 125
		Total Chromium (Cr)	2005/06/09		105	%	75 - 125
		Total Cobalt (Co)	2005/06/09		99	%	75 - 125
		Total Copper (Cu)	2005/06/09		124	%	75 - 125
		Total Lead (Pb)	2005/06/09		105	%	75 - 125
		Total Molybdenum (Mo)	2005/06/09		94	%	75 - 125
		Total Nickel (Ni)	2005/06/09		99	%	75 - 125
		Total Silver (Ag)	2005/06/09		97	%	75 - 125
		Total Vanadium (V)	2005/06/09		112	%	75 - 125
		Total Zinc (Zn)	2005/06/09		121	%	75 - 125
	QC STANDARD	Total Barium (Ba)	2005/06/09		111	%	70 - 130
		Total Chromium (Cr)	2005/06/09		90	%	40 - 160
		Total Cobalt (Co)	2005/06/09		97	%	75 - 125
		Total Copper (Cu)	2005/06/09		105	%	73 - 127
		Total Lead (Pb)	2005/06/09		101	%	54 - 146
		Total Nickel (Ni)	2005/06/09		99	%	61 - 139
		Total Phosphorus (P)	2005/06/09		109	%	89 - 111
		Total Vanadium (V)	2005/06/09		118	%	50 - 150
		Total Zinc (Zn)	2005/06/09		111	%	72 - 128
	Method Blank	Total Barium (Ba)	2005/06/09	ND, DL=2		ug/g	
		Total Beryllium (Be)	2005/06/09	ND, DL=0.5		ug/g	
		Total Cadmium (Cd)	2005/06/09	ND, DL=0.5		ug/g	
		Total Chromium (Cr)	2005/06/09	ND, DL=1		ug/g	
		Total Cobalt (Co)	2005/06/09	ND, DL=2		ug/g	
		Total Copper (Cu)	2005/06/09	ND, DL=2		ug/g	
		Total Lead (Pb)	2005/06/09	ND, DL=5		ug/g	
		Total Molybdenum (Mo)	2005/06/09	ND, DL=2		ug/g	
		Total Nickel (Ni)	2005/06/09	ND, DL=5		ug/g	
		Total Phosphorus (P)	2005/06/09	ND, DL=20		ug/g	
		Total Silver (Ag)	2005/06/09	ND, DL=1		ug/g	
		Total Vanadium (V)	2005/06/09	ND, DL=5		ug/g	
		Total Zinc (Zn)	2005/06/09	ND, DL=5		ug/g	
	RPD	Total Barium (Ba)	2005/06/09	4.3		%	35
		Total Beryllium (Be)	2005/06/09	NC		%	35
		Total Cadmium (Cd)	2005/06/09	NC		%	35
		Total Chromium (Cr)	2005/06/09	3.9		%	35
		Total Cobalt (Co)	2005/06/09	3.3		%	35
		Total Copper (Cu)	2005/06/09	3.0		%	35
		Total Lead (Pb)	2005/06/09	9.7		%	35
		Total Molybdenum (Mo)	2005/06/09	NC		%	35
		Total Nickel (Ni)	2005/06/09	3.8		%	35
		Total Silver (Ag)	2005/06/09	NC		%	35
		Total Vanadium (V)	2005/06/09	4.6		%	35
		Total Zinc (Zn)	2005/06/09	1.0		%	35
758187 MGH	QC STANDARD	Total Organic Carbon (TOC)	2005/06/13		100	%	85 - 115
	Spiked Blank	Total Organic Carbon (TOC)	2005/06/13		101	%	75 - 125
	Method Blank	Total Organic Carbon (TOC)	2005/06/13	ND, DL=300		ug/g	
	RPD	Total Organic Carbon (TOC)	2005/06/13	3.8		%	35

ND = Not detected
NC = Non-calculable
RPD = Relative Percent Difference
QC Standard = Quality Control Standard
SPIKE = Fortified sample

1266/07.04

Your Project #: 16681/CROOKS HOLLOW DAM
Site: HAMILTON
Your C.O.C. #: 00421797

Acres International Ltd
4342 Queen St
PO Box 1001
Niagara Falls, ON
L2E 6W1

Report Date: 2005/12/01

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: A5C0305
Received: 2005/11/24, 10:20

Sample Matrix: Soil
Samples Received: 16

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Hot Water Extractable Boron	16	2005/11/30	2005/11/30	Ont SOP 0102	EPA 3050B
Chromium (VI) in Soil	9	2005/11/28	2005/11/28	Ont SOP 0104	EPA 7196
Chromium (VI) in Soil	7	2005/11/29	2005/11/29	Ont SOP 0104	EPA 7196
Mercury in Soil by CVAA	16	2005/11/30	2005/11/30	Ont SOP 0112	EPA 7470
Total Metals in Soil by Axial ICP-AES	16	2005/11/29	2005/11/30	SOP ING-101	EPA SW846-M6010B
MOISTURE	16	N/A	2005/11/27	Ont SOP-0114	MOE HANDBOOK(1983)
Total Kjeldahl Nitrogen - Soil (1)	16	N/A	2005/12/01	CAL SOP-0198	SM - 4500N

(1) SCC/CAEAL

MAXXAM ANALYTICS INC.

TROY CARRIERE, B.Sc.
Environmental Scientific Specialist

TCA/lt
encl.

Total cover pages: 1

6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel: 905-817-5700 Toll free:800-563-6266 Fax: 905-817-5777

Maxxam Job #: A5C0305
Report Date: 2005/12/01

Acres International Ltd
Client Project #: 16681/CROOKS HOLLOW DAM
Project name: HAMILTON
Sampler Initials:

O'REG 153 METALS PACKAGE (SOIL)

Maxxam ID		J60004			J60005		
Sampling Date		2005/11/09 11:30			2005/11/09 10:30		
COC Number		004217			004217		
	Units	**S-1A**	**RDL**	**QC Batch**	**S-2A**	**RDL**	**QC Batch**
INORGANICS							
Moisture	%	52	0.2	874446	49	0.2	874446
METALS							
Total Antimony (Sb)	ug/g	ND	1	876186	ND	1	875945
Total Arsenic (As)	ug/g	7	1	876186	3	1	875945
Total Barium (Ba)	ug/g	93	0.5	876186	60	0.5	875945
Total Beryllium (Be)	ug/g	0.5	0.5	876186	ND	0.5	875945
Hot Water Ext. Boron (B)	ug/g	0.63	0.01	876449	0.48	0.01	876449
Total Cadmium (Cd)	ug/g	1.0	0.3	876186	0.7	0.3	875945
Total Chromium (Cr)	ug/g	16	0.5	876186	12	0.5	875945
Chromium (VI)	ug/g	ND	0.25	874775	ND	0.1	874775
Total Cobalt (Co)	ug/g	7.9	0.5	876186	4.8	0.5	875945
Total Copper (Cu)	ug/g	32	0.5	876186	23	0.5	875945
Total Lead (Pb)	ug/g	63	1	876186	35	1	875945
Acid Extractable Mercury (Hg)	ug/g	0.15	0.05	876447	0.08	0.05	876447
Total Molybdenum (Mo)	ug/g	ND	0.5	876186	0.7	0.5	875945
Total Nickel (Ni)	ug/g	16	0.5	876186	8.7	0.5	875945
Total Phosphorus (P)	ug/g	1200	20	876186	810	20	875945
Total Selenium (Se)	ug/g	1	1	876186	1	1	875945
Total Silver (Ag)	ug/g	ND	0.3	876186	ND	0.3	875945
Total Thallium (Tl)	ug/g	ND	1	876186	ND	1	875945
Total Vanadium (V)	ug/g	22	0.5	876186	13	0.5	875945
Total Zinc (Zn)	ug/g	670	3	876186	490	3	875945

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel: 905-817-5700 Toll free:800-563-6266 Fax: 905-817-5777

Maxxam Job #: A5C0305
Report Date: 2005/12/01

Acres International Ltd
Client Project #: 16681/CROOKS HOLLOW DAM
Project name: HAMILTON
Sampler Initials:

O'REG 153 METALS PACKAGE (SOIL)

Maxxam ID		J60006		J60007		
Sampling Date		2005/11/09 09:10		2005/11/09 08:30		
COC Number		004217		004217		
	Units	**S-3A**	**RDL**	**S-4A**	**RDL**	**QC Batch**
INORGANICS						
Moisture	%	36	0.2	21	0.2	874446
METALS						
Total Antimony (Sb)	ug/g	ND	1	ND	1	876186
Total Arsenic (As)	ug/g	2	1	2	1	876186
Total Barium (Ba)	ug/g	33	0.5	39	0.5	876186
Total Beryllium (Be)	ug/g	ND	0.5	ND	0.5	876186
Hot Water Ext. Boron (B)	ug/g	0.86	0.01	0.18	0.01	876449
Total Cadmium (Cd)	ug/g	ND	0.3	0.3	0.3	876186
Total Chromium (Cr)	ug/g	5.6	0.5	6.1	0.5	876186
Chromium (VI)	ug/g	ND	0.1	ND	0.05	875622
Total Cobalt (Co)	ug/g	2.8	0.5	3.1	0.5	876186
Total Copper (Cu)	ug/g	7.8	0.5	7.2	0.5	876186
Total Lead (Pb)	ug/g	16	1	16	1	876186
Acid Extractable Mercury (Hg)	ug/g	ND	0.05	ND	0.05	876447
Total Molybdenum (Mo)	ug/g	ND	0.5	ND	0.5	876186
Total Nickel (Ni)	ug/g	4.8	0.5	4.8	0.5	876186
Total Phosphorus (P)	ug/g	490	20	540	20	876186
Total Selenium (Se)	ug/g	ND	1	ND	1	876186
Total Silver (Ag)	ug/g	ND	0.3	ND	0.3	876186
Total Thallium (Tl)	ug/g	ND	1	ND	1	876186
Total Vanadium (V)	ug/g	8.0	0.5	10	0.5	876186
Total Zinc (Zn)	ug/g	250	3	300	3	876186

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel: 905-817-5700 Toll free:800-563-6266 Fax: 905-817-5777

Maxxam Job #: A5C0305
Report Date: 2005/12/01

Acres International Ltd
Client Project #: 16681/CROOKS HOLLOW DAM
Project name: HAMILTON
Sampler Initials:

O'REG 153 METALS PACKAGE (SOIL)

Maxxam ID		J60008			J60009		
Sampling Date		2005/11/09 11:50			2005/11/09 08:45		
COC Number		004217			004217		
	Units	**S-5A**	**RDL**	**QC Batch**	**S-6A**	**RDL**	**QC Batch**
INORGANICS							
Moisture	%	51	0.2	874446	28	0.2	874446
METALS							
Total Antimony (Sb)	ug/g	2	1	875945	ND	1	876186
Total Arsenic (As)	ug/g	3	1	875945	3	1	876186
Total Barium (Ba)	ug/g	52	0.5	875945	48	0.5	876186
Total Beryllium (Be)	ug/g	ND	0.5	875945	ND	0.5	876186
Hot Water Ext. Boron (B)	ug/g	0.73	0.01	876449	0.33	0.01	876449
Total Cadmium (Cd)	ug/g	0.6	0.3	875945	0.4	0.3	876186
Total Chromium (Cr)	ug/g	9.4	0.5	875945	8.3	0.5	876186
Chromium (VI)	ug/g	ND	0.05	875622	ND	0.1	874775
Total Cobalt (Co)	ug/g	4.1	0.5	875945	3.9	0.5	876186
Total Copper (Cu)	ug/g	16	0.5	875945	15	0.5	876186
Total Lead (Pb)	ug/g	30	1	875945	26	1	876186
Acid Extractable Mercury (Hg)	ug/g	0.07	0.05	876447	0.08	0.05	876447
Total Molybdenum (Mo)	ug/g	ND	0.5	875945	ND	0.5	876186
Total Nickel (Ni)	ug/g	7.6	0.5	875945	7.3	0.5	876186
Total Phosphorus (P)	ug/g	890	20	875945	650	20	876186
Total Selenium (Se)	ug/g	ND	1	875945	ND	1	876186
Total Silver (Ag)	ug/g	ND	0.3	875945	ND	0.3	876186
Total Thallium (Tl)	ug/g	ND	1	875945	ND	1	876186
Total Vanadium (V)	ug/g	11	0.5	875945	12	0.5	876186
Total Zinc (Zn)	ug/g	400	3	875945	380	3	876186

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel: 905-817-5700 Toll free:800-563-6266 Fax: 905-817-5777

Maxxam Job #: A5C0305
Report Date: 2005/12/01

Acres International Ltd
Client Project #: 16681/CROOKS HOLLOW DAM
Project name: HAMILTON
Sampler Initials:

O'REG 153 METALS PACKAGE (SOIL)

Maxxam ID		J60010			J60011		
Sampling Date		2005/11/09 09:40			2005/11/09 11:00		
COC Number		004217			004217		
	Units	**S-7A**	**RDL**	**QC Batch**	**S-8A**	**RDL**	**QC Batch**
INORGANICS							
Moisture	%	43	0.2	874446	45	0.2	874446
METALS							
Total Antimony (Sb)	ug/g	ND	1	875945	ND	1	876186
Total Arsenic (As)	ug/g	3	1	875945	3	1	876186
Total Barium (Ba)	ug/g	52	0.5	875945	57	0.5	876186
Total Beryllium (Be)	ug/g	ND	0.5	875945	ND	0.5	876186
Hot Water Ext. Boron (B)	ug/g	0.23	0.01	876449	0.755	0.013	876449
Total Cadmium (Cd)	ug/g	0.6	0.3	875945	0.6	0.3	876186
Total Chromium (Cr)	ug/g	9.7	0.5	875945	9.8	0.5	876186
Chromium (VI)	ug/g	ND	0.1	875622	ND	0.1	874775
Total Cobalt (Co)	ug/g	4.1	0.5	875945	4.4	0.5	876186
Total Copper (Cu)	ug/g	15	0.5	875945	16	0.5	876186
Total Lead (Pb)	ug/g	26	1	875945	27	1	876186
Acid Extractable Mercury (Hg)	ug/g	0.05	0.05	876447	0.08	0.05	876447
Total Molybdenum (Mo)	ug/g	ND	0.5	875945	ND	0.5	876186
Total Nickel (Ni)	ug/g	7.2	0.5	875945	8.3	0.5	876186
Total Phosphorus (P)	ug/g	740	20	875945	760	20	876186
Total Selenium (Se)	ug/g	ND	1	875945	ND	1	876186
Total Silver (Ag)	ug/g	ND	0.3	875945	ND	0.3	876186
Total Thallium (Tl)	ug/g	ND	1	875945	ND	1	876186
Total Vanadium (V)	ug/g	12	0.5	875945	13	0.5	876186
Total Zinc (Zn)	ug/g	400	3	875945	420	3	876186

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel: 905-817-5700 Toll free:800-563-6266 Fax: 905-817-5777

Maxxam Job #: A5C0305
Report Date: 2005/12/01

Acres International Ltd
Client Project #: 16681/CROOKS HOLLOW DAM
Project name: HAMILTON
Sampler Initials:

O'REG 153 METALS PACKAGE (SOIL)

Maxxam ID		J60012		J60013		
Sampling Date		2005/11/09 11:30		2005/11/09 10:30		
COC Number		004217		004217		
	Units	**S-1B**	**RDL**	**S-2B**	**RDL**	**QC Batch**
INORGANICS						
Moisture	%	32	0.2	47	0.2	874446
METALS						
Total Antimony (Sb)	ug/g	ND	1	ND	1	876186
Total Arsenic (As)	ug/g	2	1	9	1	876186
Total Barium (Ba)	ug/g	29	0.5	100	0.5	876186
Total Beryllium (Be)	ug/g	ND	0.5	0.5	0.5	876186
Hot Water Ext. Boron (B)	ug/g	0.68	0.01	0.80	0.01	876449
Total Cadmium (Cd)	ug/g	0.3	0.3	0.8	0.3	876186
Total Chromium (Cr)	ug/g	6.2	0.5	17	0.5	876186
Chromium (VI)	ug/g	ND	0.1	ND	0.25	874775
Total Cobalt (Co)	ug/g	3.0	0.5	7.8	0.5	876186
Total Copper (Cu)	ug/g	11	0.5	40	0.5	876186
Total Lead (Pb)	ug/g	19	1	69	1	876186
Acid Extractable Mercury (Hg)	ug/g	ND	0.05	0.19	0.05	876447
Total Molybdenum (Mo)	ug/g	ND	0.5	0.5	0.5	876186
Total Nickel (Ni)	ug/g	5.2	0.5	16	0.5	876186
Total Phosphorus (P)	ug/g	670	20	1000	20	876186
Total Selenium (Se)	ug/g	ND	1	2	1	876186
Total Silver (Ag)	ug/g	ND	0.3	ND	0.3	876186
Total Thallium (Tl)	ug/g	ND	1	ND	1	876186
Total Vanadium (V)	ug/g	8.2	0.5	21	0.5	876186
Total Zinc (Zn)	ug/g	280	3	590	3	876186

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel: 905-817-5700 Toll free:800-563-6266 Fax: 905-817-5777

Maxxam Job #: A5C0305
Report Date: 2005/12/01

Acres International Ltd
Client Project #: 16681/CROOKS HOLLOW DAM
Project name: HAMILTON
Sampler Initials:

O'REG 153 METALS PACKAGE (SOIL)

Maxxam ID		J60014			J60015		
Sampling Date		2005/11/09 09:10			2005/11/09 08:30		
COC Number		004217			004217		
	Units	**S-3B**	**RDL**	**QC Batch**	**S-4B**	**RDL**	**QC Batch**
INORGANICS							
Moisture	%	57	0.2	874446	39	0.2	874446
METALS							
Total Antimony (Sb)	ug/g	ND	1	875945	ND	1	876186
Total Arsenic (As)	ug/g	7	1	875945	3	1	876186
Total Barium (Ba)	ug/g	88	0.5	875945	86	0.5	876186
Total Beryllium (Be)	ug/g	ND	0.5	875945	ND	0.5	876186
Hot Water Ext. Boron (B)	ug/g	1.90	0.02	876449	0.85	0.01	876449
Total Cadmium (Cd)	ug/g	0.6	0.3	875945	0.4	0.3	876186
Total Chromium (Cr)	ug/g	15	0.5	875945	12	0.5	876186
Chromium (VI)	ug/g	ND	0.1	874775	ND	0.05	875622
Total Cobalt (Co)	ug/g	5.5	0.5	875945	5.7	0.5	876186
Total Copper (Cu)	ug/g	24	0.5	875945	19	0.5	876186
Total Lead (Pb)	ug/g	43	1	875945	33	1	876186
Acid Extractable Mercury (Hg)	ug/g	0.25	0.05	876447	0.07	0.05	876447
Total Molybdenum (Mo)	ug/g	ND	0.5	875945	ND	0.5	876186
Total Nickel (Ni)	ug/g	10	0.5	875945	11	0.5	876186
Total Phosphorus (P)	ug/g	780	20	875945	790	20	876186
Total Selenium (Se)	ug/g	1	1	875945	1	1	876186
Total Silver (Ag)	ug/g	ND	0.3	875945	ND	0.3	876186
Total Thallium (Tl)	ug/g	ND	1	875945	ND	1	876186
Total Vanadium (V)	ug/g	15	0.5	875945	16	0.5	876186
Total Zinc (Zn)	ug/g	380	3	875945	450	3	876186

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel: 905-817-5700 Toll free:800-563-6266 Fax: 905-817-5777

Maxxam Job #: A5C0305
Report Date: 2005/12/01

Acres International Ltd
Client Project #: 16681/CROOKS HOLLOW DAM
Project name: HAMILTON
Sampler Initials:

O'REG 153 METALS PACKAGE (SOIL)

Maxxam ID		J60016			J60017		
Sampling Date		2005/11/09 11:50			2005/11/09 08:45		
COC Number		004217			004217		
	Units	**S-5B**	**RDL**	**QC Batch**	**S-6B**	**RDL**	**QC Batch**
INORGANICS							
Moisture	%	50	0.2	874446	47	0.2	874446
METALS							
Total Antimony (Sb)	ug/g	ND	1	875945	ND	1	875945
Total Arsenic (As)	ug/g	7	1	875945	10	1	875945
Total Barium (Ba)	ug/g	110	0.5	875945	86	0.5	875945
Total Beryllium (Be)	ug/g	0.7	0.5	875945	ND	0.5	875945
Hot Water Ext. Boron (B)	ug/g	0.98	0.01	876449	0.925	0.015	876449
Total Cadmium (Cd)	ug/g	1.2	0.3	875945	0.7	0.3	875945
Total Chromium (Cr)	ug/g	20	0.5	875945	16	0.5	875945
Chromium (VI)	ug/g	ND	0.1	875622	ND	0.25	874775
Total Cobalt (Co)	ug/g	8.8	0.5	875945	6.5	0.5	875945
Total Copper (Cu)	ug/g	48	0.5	875945	28	0.5	875945
Total Lead (Pb)	ug/g	85	1	875945	58	1	875945
Acid Extractable Mercury (Hg)	ug/g	0.16	0.05	876816	0.25	0.05	876447
Total Molybdenum (Mo)	ug/g	0.5	0.5	875945	ND	0.5	875945
Total Nickel (Ni)	ug/g	17	0.5	875945	11	0.5	875945
Total Phosphorus (P)	ug/g	1300	20	875945	880	20	875945
Total Selenium (Se)	ug/g	2	1	875945	1	1	875945
Total Silver (Ag)	ug/g	ND	0.3	875945	ND	0.3	875945
Total Thallium (Tl)	ug/g	ND	1	875945	ND	1	875945
Total Vanadium (V)	ug/g	24	0.5	875945	16	0.5	875945
Total Zinc (Zn)	ug/g	820	3	875945	460	3	875945

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel: 905-817-5700 Toll free:800-563-6266 Fax: 905-817-5777

Maxxam Job #: A5C0305
Report Date: 2005/12/01

Acres International Ltd
Client Project #: 16681/CROOKS HOLLOW DAM
Project name: HAMILTON
Sampler Initials:

O'REG 153 METALS PACKAGE (SOIL)

Maxxam ID		J60018			J60019		
Sampling Date		2005/11/09 09:40			2005/11/09 11:00		
COC Number		004217			004217		
	Units	**S-7B**	**RDL**	**QC Batch**	**S-8B**	**RDL**	**QC Batch**
INORGANICS							
Moisture	%	47	0.2	874446	50	0.2	874446
METALS							
Total Antimony (Sb)	ug/g	ND	1	876186	ND	1	876186
Total Arsenic (As)	ug/g	16	1	876186	5	1	876186
Total Barium (Ba)	ug/g	120	0.5	876186	90	0.5	876186
Total Beryllium (Be)	ug/g	0.6	0.5	876186	0.5	0.5	876186
Hot Water Ext. Boron (B)	ug/g	1.16	0.01	876449	0.702	0.013	876449
Total Cadmium (Cd)	ug/g	0.7	0.3	876186	0.9	0.3	876186
Total Chromium (Cr)	ug/g	20	0.5	876186	17	0.5	876186
Chromium (VI)	ug/g	ND	0.05	874775	ND	0.1	875622
Total Cobalt (Co)	ug/g	8.2	0.5	876186	7.4	0.5	876186
Total Copper (Cu)	ug/g	31	0.5	876186	43	0.5	876186
Total Lead (Pb)	ug/g	61	1	876186	68	1	876186
Acid Extractable Mercury (Hg)	ug/g	0.50	0.05	876447	0.12	0.05	876447
Total Molybdenum (Mo)	ug/g	ND	0.5	876186	ND	0.5	876186
Total Nickel (Ni)	ug/g	16	0.5	876186	15	0.5	876186
Total Phosphorus (P)	ug/g	1300	20	876186	1000	20	876186
Total Selenium (Se)	ug/g	2	1	876186	2	1	876186
Total Silver (Ag)	ug/g	ND	0.3	876186	ND	0.3	876186
Total Thallium (Tl)	ug/g	ND	1	876186	ND	1	876186
Total Vanadium (V)	ug/g	22	0.5	876186	20	0.5	876186
Total Zinc (Zn)	ug/g	460	3	876186	660	3	876186

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel: 905-817-5700 Toll free:800-563-6266 Fax: 905-817-5777

Maxxam Job #: A5C0305
Report Date: 2005/12/01

Acres International Ltd
Client Project #: 16681/CROOKS HOLLOW DAM
Project name: HAMILTON
Sampler Initials:

RESULTS OF ANALYSES OF SOIL

Maxxam ID		J60004	J60005	J60006		
Sampling Date		2005/11/09 11:30	2005/11/09 10:30	2005/11/09 09:10		
COC Number		004217	004217	004217		
	Units	**S-1A**	**S-2A**	**S-3A**	**RDL**	**QC Batch**
INORGANICS						
Total Kjeldahl Nitrogen	ug/g	3140	2920	1880	100	876780

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam ID		J60007		J60008	J60009		
Sampling Date		2005/11/09 08:30		2005/11/09 11:50	2005/11/09 08:45		
COC Number		004217		004217	004217		
	Units	**S-4A**	**RDL**	**S-5A**	**S-6A**	**RDL**	**QC Batch**
INORGANICS							
Total Kjeldahl Nitrogen	ug/g	352	10	2470	1400	100	876780

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam ID		J60010	J60011	J60012	J60013		
Sampling Date		2005/11/09 09:40	2005/11/09 11:00	2005/11/09 11:30	2005/11/09 10:30		
COC Number		004217	004217	004217	004217		
	Units	**S-7A**	**S-8A**	**S-1B**	**S-2B**	**RDL**	**QC Batch**
INORGANICS							
Total Kjeldahl Nitrogen	ug/g	2110	2350	1560	2920	100	876780

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel: 905-817-5700 Toll free:800-563-6266 Fax: 905-817-5777

Maxxam Job #: A5C0305
Report Date: 2005/12/01

Acres International Ltd
Client Project #: 16681/CROOKS HOLLOW DAM
Project name: HAMILTON
Sampler Initials:

RESULTS OF ANALYSES OF SOIL

Maxxam ID		J60014	J60015	J60016	J60017		
Sampling Date		2005/11/09 09:10	2005/11/09 08:30	2005/11/09 11:50	2005/11/09 08:45		
COC Number		004217	004217	004217	004217		
	Units	**S-3B**	**S-4B**	**S-5B**	**S-6B**	**RDL**	**QC Batch**
INORGANICS							
Total Kjeldahl Nitrogen	ug/g	3370	2180	3600	2590	100	876780

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam ID		J60018	J60019		
Sampling Date		2005/11/09 09:40	2005/11/09 11:00		
COC Number		004217	004217		
	Units	**S-7B**	**S-8B**	**RDL**	**QC Batch**
INORGANICS					
Total Kjeldahl Nitrogen	ug/g	2900	3410	100	876780

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel: 905-817-5700 Toll free:800-563-6266 Fax: 905-817-5777

Maxxam Job #: A5C0305
Report Date: 2005/12/01

Acres International Ltd
Client Project #: 16681/CROOKS HOLLOW DAM
Project name: HAMILTON
Sampler Initials:

GENERAL COMMENTS

Results relate only to the items tested.

6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel: 905-817-5700 Toll free:800-563-6266 Fax: 905-817-5777

Acres International Ltd
Attention:
Client Project #: 16681/CROOKS HOLLOW DAM
P.O. #:
Project name: HAMILTON

Quality Assurance Report

Maxxam Job Number: MA5C0305

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
874446 DAN	RPD [J60014-01]	Moisture	2005/11/27	6.4		%	50
874775 TJO	MATRIX SPIKE	Chromium (VI)	2005/11/28		97	%	75 - 125
	QC STANDARD	Chromium (VI)	2005/11/28		103	%	85 - 115
	Spiked Blank	Chromium (VI)	2005/11/28		102	%	75 - 125
	Method Blank	Chromium (VI)	2005/11/28	ND, DL=0.05		ug/g	
875622 TJO	MATRIX SPIKE	Chromium (VI)	2005/11/29		108	%	75 - 125
	QC STANDARD	Chromium (VI)	2005/11/29		99	%	85 - 115
	Spiked Blank	Chromium (VI)	2005/11/29		100	%	75 - 125
	Method Blank	Chromium (VI)	2005/11/29	ND, DL=0.05		ug/g	
	RPD	Chromium (VI)	2005/11/29	NC		%	35
875945 CON	MATRIX SPIKE	Total Antimony (Sb)	2005/11/30		104	%	75 - 125
		Total Arsenic (As)	2005/11/30		101	%	75 - 125
		Total Barium (Ba)	2005/11/30		113	%	75 - 125
		Total Beryllium (Be)	2005/11/30		105	%	75 - 125
		Total Cadmium (Cd)	2005/11/30		94	%	75 - 125
		Total Chromium (Cr)	2005/11/30		110	%	75 - 125
		Total Cobalt (Co)	2005/11/30		104	%	75 - 125
		Total Copper (Cu)	2005/11/30		104	%	75 - 125
		Total Lead (Pb)	2005/11/30		102	%	75 - 125
		Total Molybdenum (Mo)	2005/11/30		109	%	75 - 125
		Total Nickel (Ni)	2005/11/30		101	%	75 - 125
		Total Phosphorus (P)	2005/11/30		110	%	75 - 125
		Total Selenium (Se)	2005/11/30		100	%	75 - 125
		Total Silver (Ag)	2005/11/30		100	%	75 - 125
		Total Thallium (Tl)	2005/11/30		106	%	75 - 125
		Total Vanadium (V)	2005/11/30		112	%	75 - 125
		Total Zinc (Zn)	2005/11/30		102	%	75 - 125
	QC STANDARD	Total Arsenic (As)	2005/11/30		108	%	30 - 170
		Total Barium (Ba)	2005/11/30		98	%	70 - 130
		Total Chromium (Cr)	2005/11/30		86	%	40 - 160
		Total Cobalt (Co)	2005/11/30		92	%	75 - 125
		Total Copper (Cu)	2005/11/30		102	%	73 - 127
		Total Lead (Pb)	2005/11/30		93	%	54 - 146
		Total Nickel (Ni)	2005/11/30		98	%	61 - 139
		Total Phosphorus (P)	2005/11/30		94	%	89 - 111
		Total Vanadium (V)	2005/11/30		88	%	50 - 150
		Total Zinc (Zn)	2005/11/30		105	%	72 - 128
	Method Blank	Total Antimony (Sb)	2005/11/30	ND, DL=1		ug/g	
		Total Arsenic (As)	2005/11/30	ND, DL=1		ug/g	
		Total Barium (Ba)	2005/11/30	ND, DL=0.5		ug/g	
		Total Beryllium (Be)	2005/11/30	ND, DL=0.5		ug/g	
		Total Cadmium (Cd)	2005/11/30	ND, DL=0.3		ug/g	
		Total Chromium (Cr)	2005/11/30	0.6, DL=0.5		ug/g	
		Total Cobalt (Co)	2005/11/30	ND, DL=0.5		ug/g	
		Total Copper (Cu)	2005/11/30	ND, DL=0.5		ug/g	
		Total Lead (Pb)	2005/11/30	ND, DL=1		ug/g	
		Total Molybdenum (Mo)	2005/11/30	ND, DL=0.5		ug/g	
		Total Nickel (Ni)	2005/11/30	ND, DL=0.5		ug/g	
		Total Phosphorus (P)	2005/11/30	ND, DL=20		ug/g	
		Total Selenium (Se)	2005/11/30	ND, DL=1		ug/g	
		Total Silver (Ag)	2005/11/30	ND, DL=0.3		ug/g	
		Total Thallium (Tl)	2005/11/30	ND, DL=1		ug/g	
		Total Vanadium (V)	2005/11/30	ND, DL=0.5		ug/g	
		Total Zinc (Zn)	2005/11/30	ND, DL=3		ug/g	
	RPD	Total Antimony (Sb)	2005/11/30	NC		%	20
		Total Arsenic (As)	2005/11/30	0.4		%	20

6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel: 905-817-5700 Toll free:800-563-6266 Fax: 905-817-5777

Acres International Ltd
Attention:
Client Project #: 16681/CROOKS HOLLOW DAM
P.O. #:
Project name: HAMILTON

Quality Assurance Report (Continued)

Maxxam Job Number: MA5C0305

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
875945 CON	RPD	Total Barium (Ba)	2005/11/30	4.5		%	20
		Total Beryllium (Be)	2005/11/30	NC		%	20
		Total Cadmium (Cd)	2005/11/30	NC		%	20
		Total Chromium (Cr)	2005/11/30	2.4		%	20
		Total Cobalt (Co)	2005/11/30	1.6		%	20
		Total Copper (Cu)	2005/11/30	2.1		%	20
		Total Lead (Pb)	2005/11/30	2.6		%	20
		Total Molybdenum (Mo)	2005/11/30	NC		%	20
		Total Nickel (Ni)	2005/11/30	5.3		%	20
		Total Phosphorus (P)	2005/11/30	7.4		%	20
		Total Selenium (Se)	2005/11/30	NC		%	20
		Total Silver (Ag)	2005/11/30	NC		%	20
		Total Thallium (Tl)	2005/11/30	NC		%	20
		Total Vanadium (V)	2005/11/30	0.4		%	20
		Total Zinc (Zn)	2005/11/30	0.6		%	20
876186 CON	MATRIX SPIKE [J60015-01]	Total Antimony (Sb)	2005/11/30		104	%	75 - 125
		Total Arsenic (As)	2005/11/30		105	%	75 - 125
		Total Barium (Ba)	2005/11/30		97	%	75 - 125
		Total Beryllium (Be)	2005/11/30		105	%	75 - 125
		Total Cadmium (Cd)	2005/11/30		100	%	75 - 125
		Total Chromium (Cr)	2005/11/30		105	%	75 - 125
		Total Cobalt (Co)	2005/11/30		103	%	75 - 125
		Total Copper (Cu)	2005/11/30		101	%	75 - 125
		Total Lead (Pb)	2005/11/30		96	%	75 - 125
		Total Molybdenum (Mo)	2005/11/30		105	%	75 - 125
		Total Nickel (Ni)	2005/11/30		103	%	75 - 125
		Total Selenium (Se)	2005/11/30		97	%	75 - 125
		Total Silver (Ag)	2005/11/30		102	%	75 - 125
		Total Thallium (Tl)	2005/11/30		109	%	75 - 125
		Total Vanadium (V)	2005/11/30		107	%	75 - 125
		Total Zinc (Zn)	2005/11/30		77	%	75 - 125
	QC STANDARD	Total Arsenic (As)	2005/11/30		121	%	30 - 170
		Total Barium (Ba)	2005/11/30		109	%	70 - 130
		Total Chromium (Cr)	2005/11/30		95	%	40 - 160
		Total Cobalt (Co)	2005/11/30		107	%	75 - 125
		Total Copper (Cu)	2005/11/30		113	%	73 - 127
		Total Lead (Pb)	2005/11/30		103	%	54 - 146
		Total Nickel (Ni)	2005/11/30		111	%	61 - 139
		Total Phosphorus (P)	2005/11/30		104	%	89 - 111
		Total Vanadium (V)	2005/11/30		110	%	50 - 150
		Total Zinc (Zn)	2005/11/30		111	%	72 - 128
	Method Blank	Total Antimony (Sb)	2005/11/30	ND, DL=1		ug/g	
		Total Arsenic (As)	2005/11/30	ND, DL=1		ug/g	
		Total Barium (Ba)	2005/11/30	ND, DL=0.5		ug/g	
		Total Beryllium (Be)	2005/11/30	ND, DL=0.5		ug/g	
		Total Cadmium (Cd)	2005/11/30	ND, DL=0.3		ug/g	
		Total Chromium (Cr)	2005/11/30	ND, DL=0.5		ug/g	
		Total Cobalt (Co)	2005/11/30	ND, DL=0.5		ug/g	
		Total Copper (Cu)	2005/11/30	ND, DL=0.5		ug/g	
		Total Lead (Pb)	2005/11/30	ND, DL=1		ug/g	
		Total Molybdenum (Mo)	2005/11/30	0.5, DL=0.5		ug/g	
		Total Nickel (Ni)	2005/11/30	ND, DL=0.5		ug/g	
		Total Phosphorus (P)	2005/11/30	ND, DL=20		ug/g	
		Total Selenium (Se)	2005/11/30	ND, DL=1		ug/g	
		Total Silver (Ag)	2005/11/30	ND, DL=0.3		ug/g	

6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel: 905-817-5700 Toll free:800-563-6266 Fax: 905-817-5777

Acres International Ltd
Attention:
Client Project #: 16681/CROOKS HOLLOW DAM
P.O. #:
Project name: HAMILTON

Quality Assurance Report (Continued)

Maxxam Job Number: MA5C0305

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
876186 CON	Method Blank	Total Thallium (Tl)	2005/11/30	ND, DL=1		ug/g	
		Total Vanadium (V)	2005/11/30	ND, DL=0.5		ug/g	
		Total Zinc (Zn)	2005/11/30	ND, DL=3		ug/g	
	RPD [J60015-01]	Total Antimony (Sb)	2005/11/30	NC		%	20
		Total Arsenic (As)	2005/11/30	NC		%	20
		Total Barium (Ba)	2005/11/30	1.7		%	20
		Total Beryllium (Be)	2005/11/30	NC		%	20
		Total Cadmium (Cd)	2005/11/30	NC		%	20
		Total Chromium (Cr)	2005/11/30	2.6		%	20
		Total Cobalt (Co)	2005/11/30	1.7		%	20
		Total Copper (Cu)	2005/11/30	0.9		%	20
		Total Lead (Pb)	2005/11/30	0.3		%	20
		Total Molybdenum (Mo)	2005/11/30	NC		%	20
		Total Nickel (Ni)	2005/11/30	0.9		%	20
		Total Phosphorus (P)	2005/11/30	8.8		%	20
		Total Selenium (Se)	2005/11/30	NC		%	20
		Total Silver (Ag)	2005/11/30	NC		%	20
		Total Thallium (Tl)	2005/11/30	NC		%	20
		Total Vanadium (V)	2005/11/30	5.5		%	20
		Total Zinc (Zn)	2005/11/30	4.3		%	20
876447 MC	MATRIX SPIKE [J60012-01]	Acid Extractable Mercury (Hg)	2005/11/30		89	%	75 - 125
	QC STANDARD	Acid Extractable Mercury (Hg)	2005/11/30		94	%	85 - 115
	Spiked Blank	Acid Extractable Mercury (Hg)	2005/11/30		97	%	75 - 125
	Method Blank	Acid Extractable Mercury (Hg)	2005/11/30	ND, DL=0.05		ug/g	
	RPD [J60012-01]	Acid Extractable Mercury (Hg)	2005/11/30	NC		%	35
876449 MIL	QC STANDARD	Hot Water Ext. Boron (B)	2005/11/30		98	%	77 - 121
	Method Blank	Hot Water Ext. Boron (B)	2005/11/30	ND, DL=0.01		ug/g	
876780 SBU	MATRIX SPIKE [J60016-01]	Total Kjeldahl Nitrogen	2005/12/01		77	%	N/A
	QC STANDARD	Total Kjeldahl Nitrogen	2005/12/01		90	%	N/A
	Spiked Blank	Total Kjeldahl Nitrogen	2005/12/01		94	%	N/A
	Method Blank	Total Kjeldahl Nitrogen	2005/12/01	ND, DL=10		ug/g	
	RPD [J60016-01]	Total Kjeldahl Nitrogen	2005/12/01	0.9		%	N/A
876816 MC	MATRIX SPIKE	Acid Extractable Mercury (Hg)	2005/11/30		104	%	75 - 125
	QC STANDARD	Acid Extractable Mercury (Hg)	2005/11/30		102	%	85 - 115
	Spiked Blank	Acid Extractable Mercury (Hg)	2005/11/30		103	%	75 - 125
	Method Blank	Acid Extractable Mercury (Hg)	2005/11/30	ND, DL=0.05		ug/g	
	RPD	Acid Extractable Mercury (Hg)	2005/11/30	NC		%	35

ND = Not detected
N/A = Not Applicable
NC = Non-calculable
RPD = Relative Percent Difference
QC Standard = Quality Control Standard
SPIKE = Fortified sample

6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel: 905-817-5700 Toll free:800-563-6266 Fax: 905-817-5777