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December 18, 2006

Ministry of Natural Resources
Kemptville District
10 Campus Drive
Kemptville, ON
K0G 1J0

Dear Sir / Madam:

Re: **Hawkesbury Lagoon Survey**

As requested, we are providing you with a contour map of the bottom of the Hawkesbury lagoon and the corresponding sludge volume calculations, as specified in your Request for Proposals of Oct. 4, 2006. It is our understanding that the Ontario Ministry of Natural Resources is attempting to remediate this abandoned lagoon, filled with sludge from a former pulp and paper operation. The lagoon was formed in the early 1960's by connecting and partially excavating four islands in the Ottawa River. In order to develop a remediation strategy, it is now important to obtain an accurate assessment of the sludge volume in the wet section of the impoundment. Since accurate bathymetric information on the bottom topography following the creation of the lagoon is not available, a field survey had to be carried out. The results of our field investigation are provided below.

Background information

The lagoon has been filled in with various types of pulp and paper waste during the operation of the mill, and subsequently with construction and demolition waste from the shore along the western side of the lagoon. Part of the former lagoon is now vegetated and dry at all times. Other sections are wet or swampy, depending on the water level and the emergence of vegetation. This study only deals with sludge deposits in the wet parts of the former lagoon. Figure 1 shows the outline of the wet lagoon with its various distinct sections. The sludge reaches the water surface in most places inside the wet lagoon, and along the shore. Vegetated islands or sludge bars have formed inside the wet lagoon and access and navigation are challenging in these areas. Sections A, B and C are full of sludge up to the surface and inaccessible by foot or boat. Section D is the main part of the lagoon. There is one shallow channel in Section D that allows a flow of water from the western end of the lagoon to the outlet at the eastern end. The channel depth is only in the order of several centimetres. Only a few deeper pockets were observed in Section D.

Survey methodology

Field testing was carried out from November 13 to November 16, 2006. After attempts to determine the sludge thickness using remote survey techniques failed, NATECH used “rodding” to penetrate the sludge and to determine the original bottom elevation in the wetted part of the lagoon. Along the shore line and wherever access by foot was safe, bottom depths were determined by manually pushing a rod through the deposits at the water’s edge. A Garmin GPSmap 76 with external antenna was used to determine the position on land.

In the parts of the wet lagoon with open water, a flat bottom boat was used. The aluminium rods were sunk manually through the sludge until refusal, or until the resistance changed noticeably. The tips of the rods were slotted to allow retrieval of several centimetres of the bottom substrate. This technique allowed verification that the entire sludge layer had been penetrated.

In areas where it was possible to navigate freely (where water depths exceeded 0.25 m) a 200 kHz echo sounder, with GPS (Eagle Sea Charter 320) was used to map out the sludge surface. However, in most areas, navigation was difficult since the sludge was within centimetres of the surface. The boat had to be pushed through the sludge and the echo sounder did not provide useful information where the sensor was in contact with the deposits.

By manually ‘feeling’ for the sludge depth, the echo sounder readings were found to be in the +/- 5 cm range. By repeatedly returning to previously placed waypoints, the horizontal GPS accuracy was found to be within one metre accuracy in open areas. In tree covered areas, the horizontal GPS accuracy was found to be in the +/- three metre range.

A water level gauge was placed in the lagoon and the water level was recorded twice a day during the investigation. The water level was surveyed and tied to a benchmark located at the north-east corner of the outlet structure (top of corner brick with an elevation of 44.20 m on the 2006 Schultz Barrette Surveying drawing). All measured bottom and sludge surface elevations were tied to the same geodetic datum.

Results

The wet lagoon covers an area of 86,735 m^2. Of that, approximately 35,000 m^2 are vegetated, the remainder being sludge banks or open water surface. Over the course of the investigation, the water level increased from 41.24 to 41.26 m due to rainfall.

<u>Bottom of the lagoon</u>

A total of 41 bottom elevations in the navigable part of the lagoon and 81 elevations along the shore were collected, resulting in an average point spacing of approximately 25 metres. The corresponding bottom elevations are listed in Table 1. The Surfer Software Version 8.05 was used to map the bathymetry of the bottom. In order to produce accurate maps, the software requires several hundred input points. Interpolation of additional points was done using different techniques, before using Surfer:

Table 1. Manual bottom depth measurements

	From the boat			From the shore					
	X	Y	Z	X	Y	Z	X	Y	Z
	(UTM)	(UTM)	(m)	(UTM)	(UTM)	(m)	(UTM)	(UTM)	(m)
1	530,094	5,050,916	38.57	529,922	5,050,949	40.45	530,247	5,051,080	40.19
2	530,096	5,050,914	39.26	529,910	5,050,967	40.38	530,277	5,051,076	40.50
3	530,122	5,050,912	38.62	529,892	5,050,989	39.51	530,296	5,051,058	39.81
4	530,114	5,050,881	37.79	529,869	5,051,034	40.02	530,320	5,051,048	40.12
5	530,084	5,050,870	36.82	529,861	5,051,043	39.18	530,331	5,051,039	40.04
6	530,063	5,050,864	40.33	529,846	5,051,066	40.94	530,344	5,051,064	39.94
7	530,030	5,050,872	38.95	529,865	5,051,115	40.78	530,356	5,051,064	39.69
8	529,996	5,050,874	40.02	529,865	5,051,131	40.63	530,351	5,051,036	39.36
9	529,975	5,050,881	38.29	529,868	5,051,151	39.61	530,375	5,051,026	38.44
10	529,954	5,050,902	37.58	529,892	5,051,136	39.41	530,354	5,050,990	40.07
11	530,140	5,050,922	38.99	529,905	5,051,123	39.41	530,334	5,050,978	39.51
12	530,164	5,050,905	39.47	529,934	5,051,095	39.51	530,291	5,050,959	39.25
13	530,177	5,050,922	38.66	529,966	5,051,070	40.17	530,276	5,050,951	40.27
14	530,189	5,050,924	38.35	529,972	5,051,065	39.94	530,268	5,050,935	39.81
15	530,061	5,050,918	37.29	529,982	5,051,050	40.12	530,444	5,050,990	39.86
16	530,013	5,050,935	37.08	530,005	5,051,032	38.98	530,231	5,050,901	40.04
17	529,988	5,050,946	35.99	530,007	5,051,025	39.27	530,201	5,050,875	40.47
18	529,954	5,050,940	35.87	530,028	5,050,998	39.01	530,200	5,050,896	40.50
19	530,051	5,050,962	36.84	530,063	5,051,001	39.35	530,191	5,050,907	40.12
20	530,120	5,050,965	39.23	530,075	5,050,987	39.98	530,187	5,050,897	40.19
21	530,160	5,050,961	38.59	530,093	5,050,977	39.62	530,173	5,050,891	40.24
22	530,203	5,050,980	38.95	530,102	5,050,973	39.19	530,190	5,050,890	40.04
23	530,244	5,050,981	38.47	530,076	5,050,995	38.99	530,199	5,050,868	39.20
24	530,283	5,050,976	39.08	530,112	5,051,012	39.57	530,185	5,050,857	39.38
25	530,321	5,051,008	38.21	530,127	5,051,007	39.42	530,166	5,050,852	39.58
26	530,338	5,051,036	39.53	530,137	5,051,008	39.65	530,161	5,050,852	39.58
27	530,327	5,050,994	38.34	530,141	5,051,024	40.01	530,150	5,050,864	39.74
28	530,296	5,050,991	39.58	530,152	5,051,039	39.65	530,135	5,050,856	39.61
29	530,300	5,051,007	38.52	530,163	5,051,048	39.73	530,109	5,050,859	40.17
30	530,231	5,050,965	38.72	530,177	5,051,057	39.80	530,088	5,050,859	40.65
31	530,185	5,050,969	38.44	530,207	5,051,070	40.16	530,070	5,050,857	40.35
32	530,143	5,050,959	38.47	530,167	5,051,078	38.97	530,046	5,050,857	39.43
33	530,089	5,050,966	38.97	530,133	5,051,090	39.02	530,028	5,050,859	39.81
34	529,985	5,051,032	39.02	530,158	5,051,123	38.85	530,006	5,050,860	39.53
35	530,002	5,050,932	36.54	530,205	5,051,126	39.96	529,979	5,050,864	39.63
36	529,956	5,050,918	35.85	530,245	5,051,111	39.58	529,939	5,050,869	39.79
37	529,989	5,050,903	35.77	530,259	5,051,088	39.81	529,924	5,050,871	39.89
38	529,915	5,050,981	38.97	530,229	5,051,081	39.99	529,918	5,050,874	39.74
39	529,961	5,050,993	38.82	530,218	5,051,074	39.43	529,918	5,050,892	39.58
40	529,995	5,050,980	37.17	530,218	5,051,071	38.67	529,915	5,050,911	40.65

41	529,931	5,050,953	38.97	530,226	5,051,075	40.40			

- Along the shore line, 140 points were added between the successive bottom depth measurements using linear interpolation between closest neighbours.

- Inside the wet lagoon, 30 points were added in areas where the sludge was so close to the surface that no manual measurements could be taken, and where automatic software interpolation would have led to inaccurate results. Best guesses were applied to estimate the likely bottom depth. Historic design drawings and other mapping information were consulted during this task, primarily to account for the location of former islands or deep channels.

- 60 more points were then placed to even out the overall density of points, and their elevations were calculated using linear interpolation between closest neighbours.

The various types of points and their elevations are shown on Figure 2. Figures 3 shows bottom contours, and Figure 4 depicts a three-dimensional view of the bottom. A 1:750 scaled drawing of the bottom contours is attached as well.

Adding more points increased the point density from one point per 710 m^2 to one point per 250 m^2, or approximately 15 m spacing. To account for potential uneven topography that was not picked up by the rodding technique, we assigned likely high and low depth values to the various sections. A larger range in elevations was chosen for Sections A, B and C due to the lack of direct bottom measurements. The capacity calculations for each section, under consideration of the various depth ranges, are detailed in Table 2.

Based on those computations, the average bottom depth of the “wet lagoon” without the sludge would have been 2.30 m +/- 0.13m, corresponding to a total capacity of 199,000 m^3 +/- 11,500 m^3 (see Table 2).

Table 2. Lagoon capacity calculations

Section	Area	Average depth	Likely Depth Range (+/-)	Capacity	Capacity Range (+/-)	
Unit	m^2	m	m	m^3	m^3	%
A (NW corner)	12,700	1.6	0.20	20,800	2,540	12%
B	5,700	1.5	0.25	8,500	1,425	17%
C	14,500	1.8	0.15	25,600	2,175	8%
D (main)	53,835	2.7	0.10	144,100	5,384	4%
Total	**86,735**	**2.3**	**0.13**	**199,000**	**11,524**	**6%**

Sludge volume calculations

Sections A, B and C are completely full of sludge. Within section D, the total volume of water above the sludge was calculated to be 16,000 m^3 +/- 2,000 m^3. Consequently, the sludge volume within the entire wet lagoon is calculated to be 183,000 m^3 (+/- 13,500 m^3 or +/- 7%). Figure 5 shows contours of the sludge surface, and Figure 6 a three-dimensional view of the same surface. The amount of solid deposits (partially vegetated), above the water level is estimated to be in the order of 4,000 to 8,000 m^3. This is based on visual observations only.

Other observations

Methane and other gaseous compounds were encountered in all sections of the lagoon. Whether the gas was being released continuously, or just as a result of disturbing the deposits with the rods could not be ascertained.

We did not notice a significant outflow from the lagoon and it is likely that the lagoon is hydraulically connected with the Ottawa River, allowing a free exchange of water between the two water bodies.

The substrate under the sludge consists predominantly of grey clay. In some areas, granular material was detected on top of the clay. Occasionally, a very hard surface, likely to be rock or concrete, was encountered, in particular on the western edge where demolition debris is present. The sludge material is not consistent, and varies from light, fluffy black sludge at the surface to saw dust and paper fibres below.

Conclusions and recommendations

Cellulose built up above the water line has not been quantified, nor has the amount of demolition waste been included in the computations. The intent of the study was to determine the sludge volume in the wet pond of the Hawkesbury lagoon, below the water line.

While the site is **difficult** site to work on, manual probing appeared to be the most reliable method to determine the sludge thickness.

Bottom elevations and volume calculations could be refined by adding more spot elevations. This would require developing a technique to survey the three sections that were full of sludge and inaccessible at the time of the survey (sections A, B, and C). Possibly, this could be achieved by significantly lowering or increasing the water level in the lagoon (depending on wether these areas would be visited by foot or boat). Alternatively, a hover craft or a swamp boat may be able access those areas. Upgrading of the access road may be required to bring such a vessel to the site.

We have enjoyed working with you on this **challenging** project and we trust that our findings meet your requirements. Please do not hesitate to call, should you have any questions.

Yours sincerely,

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President, NATECH Environmental Services, Inc.

JS/vb
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