Investigation of Subsurface Conditions at the Upper Embankment Within the Tasman Primary Solids Waste Disposal Area

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Project 57.03R

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EXECUTIVE SUMMARY

This report describes the results of environmental surveys carried out in the Upper Embankment at the western end of the primary solids disposal area operated by the Tasman Mill at Kawerau. The work was coordinated by Gwilym Environmental Services in association with Beca Simons, assistance and with advice from Trustees[1] of the land and Norske Skog Tasman.

The results of the following work are reported here:

- Evaluation of the contaminant levels in the area of the Upper Embankment.

The following are the main conclusions that can be drawn from this series of studies.

- The waste materials in the Upper Embankment contain contaminants generally similar to those in the Primary Solids, though at slightly higher concentrations.
- Contaminants other than those in Primary Solids are also present in the Upper Embankment at levels not generally acceptable in natural soils.
- The character of the waste material and its physical location is such that its removal would be likely to create significant environmental disturbance and possibly be detrimental to the local and regional environment.
- Groundwater and Leachability (USEPA-TCLP) testing indicates that very low levels of contaminants are mobile within the local groundwater system.

[1] **Acknowledgements**

The assistance of the Responsible Trustees, particularly Paora Hunia, was invaluable in selecting appropriate sites for sampling the depth and quality of the primary solids material and also in the sampling of the soils peripheral to the Urupa. Mr Bill Hunia was instrumental in assuring the team's correct access to this area.

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1. INTRODUCTION

Norske Skog Tasman is currently evaluating the rehabilitation options for the primary solids waste disposal area associated with the Tasman Mills at Kawerau. The site was previously a valley occupied by a small lake (Rotoitipaku), a wetland system and geothermal features. General waste materials were disposed of in the area to the west of the site, referred to here as the Upper Embankment, close to the A8 and Urupa ponds, for a period during early operation of the facility (after 1971 and ending in the mid 1980s). The lease expires in 2013 and prior to that agreement is to be reached regarding how the area is to be returned to the owners.

As part of this process it was considered necessary to assess whether any contamination issues existed that would restrict the options for rehabilitation of the area. In order to address this concern 42 investigative bores were completed, as illustrated on Figure 1. This is the second report to consider these issues in detail, and it addresses the quality of the material in the Upper Embankment and its significance to groundwater in the immediate vicinity.

1.1. Sampling Plan

The plan included the completion of 42 sampling bores to the base of the waste material with collection of representative cores at intervals of three metres. The anticipated depth of the waste material was 15m – 20m.

Shortly after initiating the fieldwork in July 2003 Mr. Paora Hunia, the representative of the Trustees, visited the site in the company of Norske Skog Environmental Manager Mr. Rob Donald. Mr. Hunia continued to supervise activities over the course of the field programme.

All investigations were planned and completed under the direct supervision of Rob D. Gwilym, an internationally accredited (Europe, UK, USA, Canada) Environmental Geologist with an extensive background in contaminated site investigation and remediation. Mr. Graham McIlory of Beca Simons also participated in the planning and implementation of the field programme, and completed studies associated with an engineering, evaluation of the same area.

In summary this report describes the following investigations:

- Evaluation of the contaminant levels in the area of the Upper Embankment.

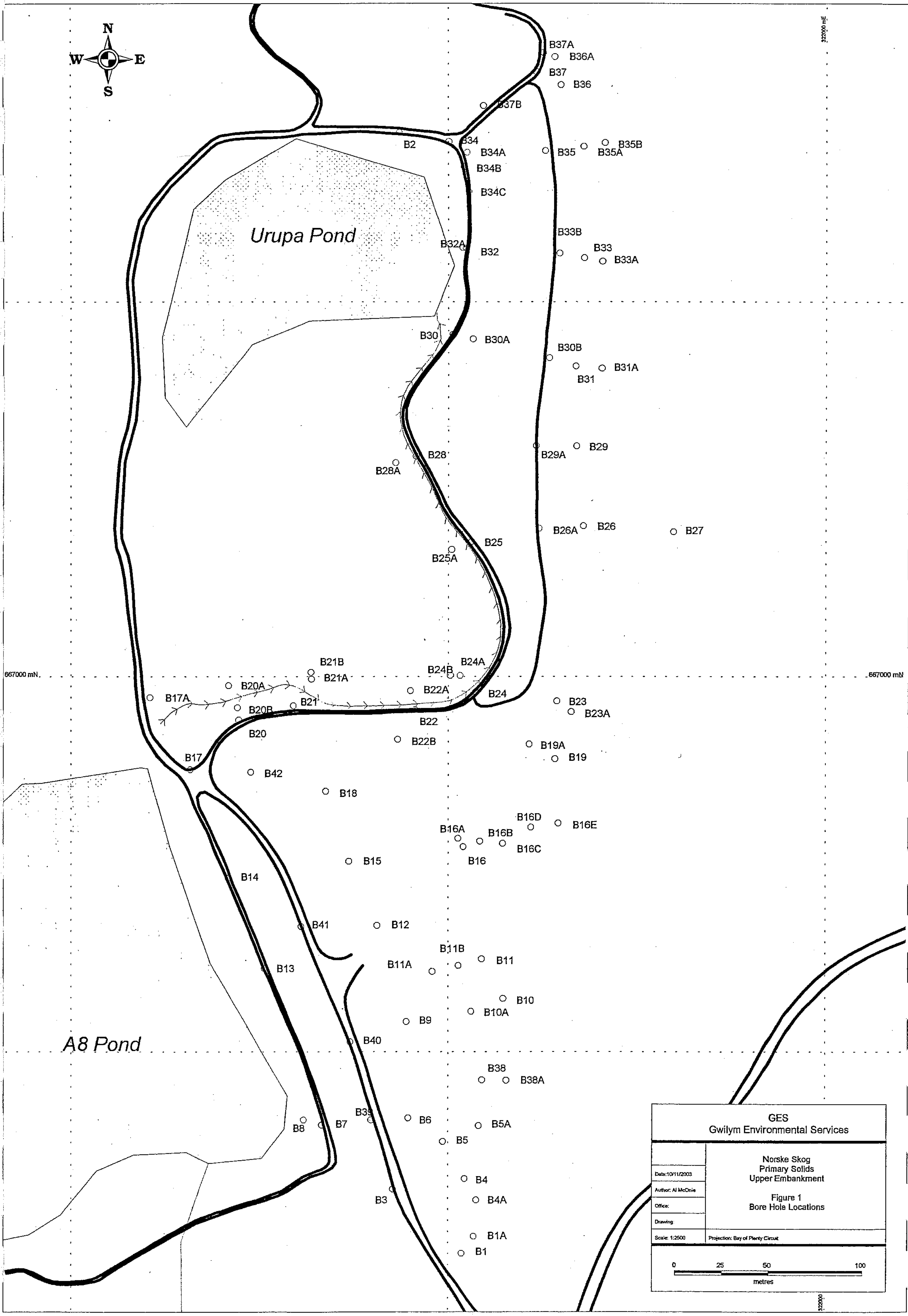
Conclusions and recommendations are given as a result of these investigations.

2. UPPER EMBANKMENT EVALUATON

2.1 Methodology

2.1.1. Auger and Drill Sampling

The equipment selected for this investigation was a track mounted hollow stem auger drill rig, which was mobilised to site on 24 July 2003. The tracked unit was selected due to the known soft conditions on the surface of the site and the marginal access track available. The hollow-stem auger, having 10" (200mm) outside diameter (OD) and a hollow inside barrel of 6" in diameter, allows access to the base of the bore for collection of undisturbed samples ahead of the drilled bore as well as access to any groundwater intersected during drilling for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GES
Gwilym Environmental Services
Norske Skog
Primary Solids
Upper Embankment
Date:10/11/2003
Author: Al McOnie
Office:
Drawing:
Figure 1
Bore Hole Locations
Scale: 1:2500
Projection: Bay of Plenty Circuit
0
25
50
100
metres

preliminary evaluation. It is recognised to be the most acceptable method of environmental evaluation for investigation of materials to a depth of 30m or less. Typical components of a hollow stem auger rig are illustrated on Figure 2.

Undisturbed samples were collected in a "split spoon" sampler. This sampler consists of a stainless steel cylinder which is sectioned vertically and secured with threaded constraints on either end, so allowing the sample to be exposed and removed for evaluation and correct preservation following retrieval. There is a "catcher" at the base of the sample container. This catcher is designed to minimise vertical loss of the sample to the bore. The catcher also encourages establishment of a plug in the base of the sampler, further minimising sample loss. Diagrammatic details of this system are included on Figure 3.

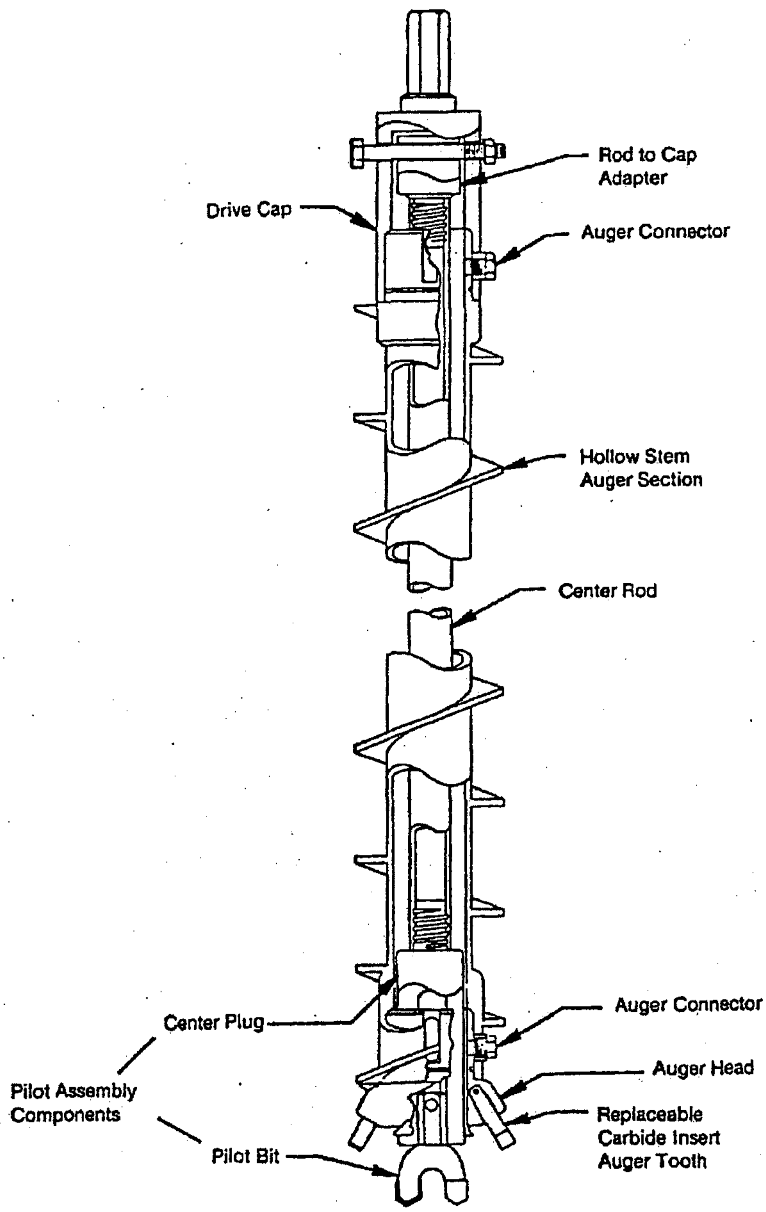
During sampling, when elevated temperature was noted, samples were tested for temperature at the time of collection using a specialised instrument. This was not possible when the sample was saturated, as occurred in some cases. In addition, groundwater monitoring points were installed in nine of the bores to allow evaluation of groundwater conditions.

2.1.2. Sampling

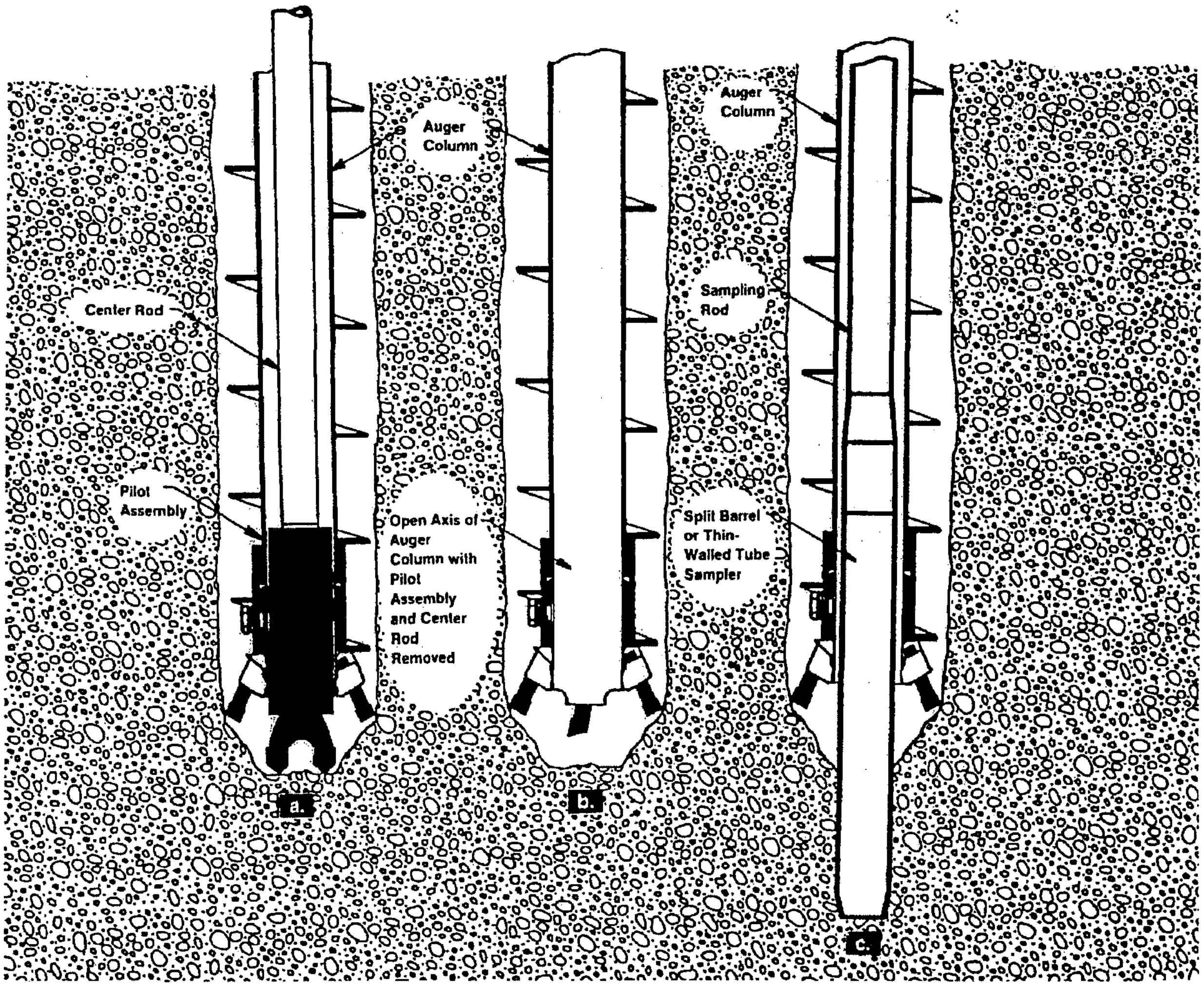
Fieldwork to install bores as discussed above, complete engineering tests and collect representative samples, commenced on 24 July 2003. The depth of the fill was found to vary, and to be less than the anticipated 15m with the exception of two bores (B18-18m, B40-16.5m).

The investigative process included the use of the hollow stem auger drill which was advanced with engineering testing being completed as advised by the project engineer, Graham McIlroy. Sampling required to establish a representative vertical cross section was established by the investigating environmental geologist, Rob Gwilym. This process was based upon the comparative lithology of the waste material, and normally included collection of a sample of approximately 0.75m in length every 2m to 3m of fill depth. The basal sample at each location was collected immediately above, and including a small portion of, the underlying material. In most cases this underlying, native, material was identified as a pale beige volcanic ashy material (pumice) and as such was easy to define. Groundwater was intersected in some bores, and in some cases made collection of representative samples difficult. This problem was circumvented by the catcher described in Section 2.1.1, which minimises loss of sample due to downwash or dribbling of fines. Samples collected by this means were transferred to plastic containers, labelled and stored in core boxes for later evaluation. The encapsulated samples were identified within labelled cores both by the traditional wooden marked mini-blocks and indelible numerical record on each end of the plastic sample containers.

As is crucial with such sampling programmes, great care was taken to decontaminate sampling equipment between each sampling event. The split spoon sampler was thoroughly scrubbed and triple rinsed using distilled water between each sampling event, and each core sample was individually sealed in clear plastic and labelled as to exact orientation and vertical location.



Client: Norske Skog Date: 11/2003 GES Project #57.03	**Figure 2** **Typical components of a hollow-stem auger column** Project: Tasman Primary Solids Upper Embankment Area Investigation



Sequential steps showing borehole advancement with pilot assembly and collection of a formation sample.

Client: Norske Skog Date: 11/2003 GES Project #57.03	**Figure 3** **Diagram of a split-spoon sampler** Project: Tasman Primary Solids Upper Embankment Area Investigation

Figure 1 illustrates the location of each bore, which was correctly identified by both elevation and grid reference by East Bay Surveys, Ltd. The location of each bore was selected to represent the location selected by the Trustees as closely as possible. This information was reviewed by the Trustees representative Mr. Hunia, on an ongoing basis throughout the field programme.

Table 2.1 gives the detailed field record including bore location, water level where applicable, and the field temperature of each sample.

Logs of individual bores are included as Appendix I.

2.1.3. Sample Preparation and Analysis

Following completion of the field program the boring and sample collection details were correlated and included in a 3D presentation graphic which compared the data gathered from each borehole. This involved comparison of the surface elevation of each boring collar (at surface) and the relative levels of each sample. By this means it was possible to estimate fill deposited in different areas during similar time periods (roughly horizontal), as well as to estimate the groundwater gradient across the site. This data is being prepared by Beca Simons in a report under separate cover.

During the course of the drilling programme any material which offered visual indication of contamination was sampled. These samples were submitted for individual analysis as described in Section 2.2.

Based on visual examination of the cores by the project geologist, a number of composite samples were selected for analysis.

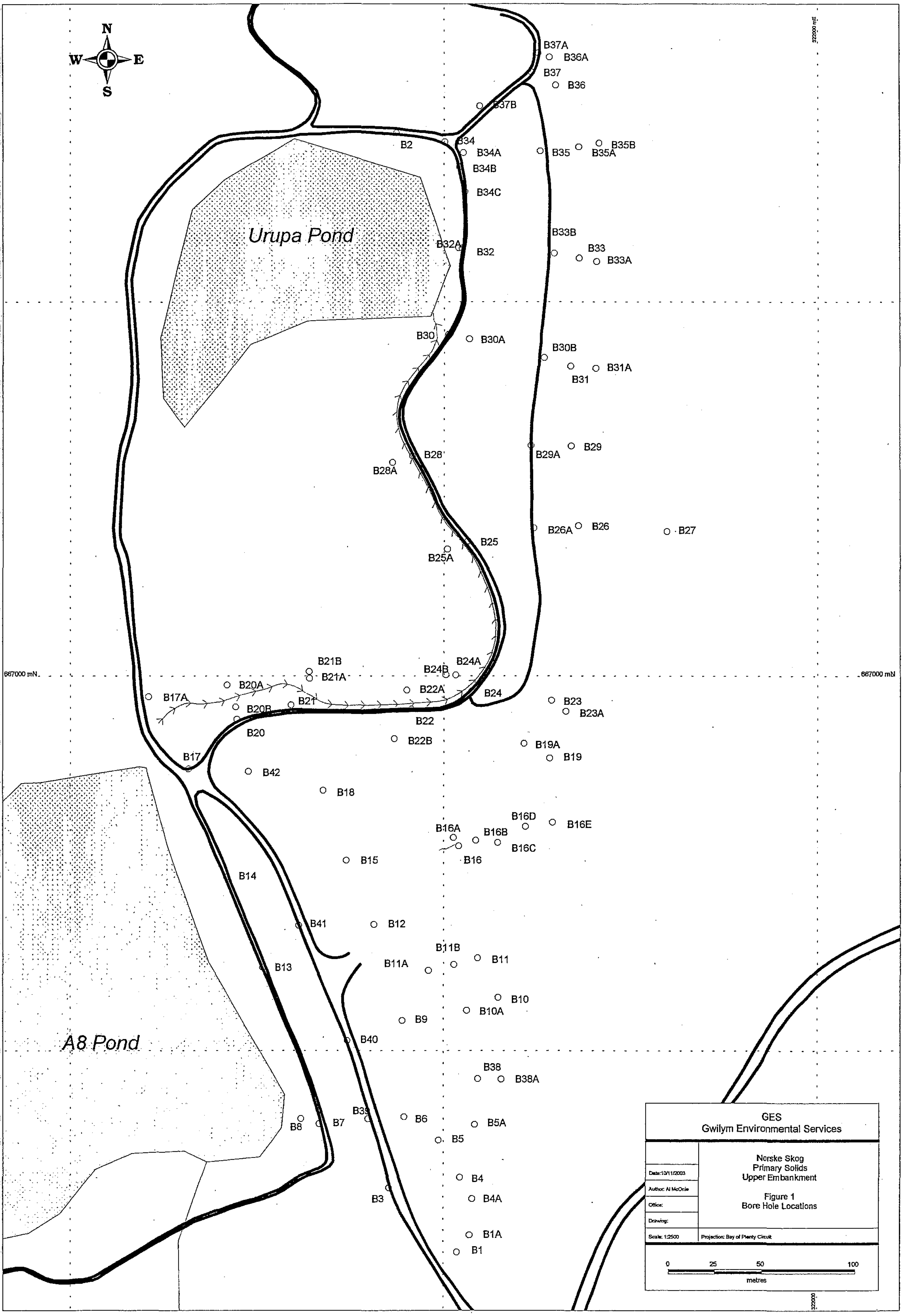
The composites selected for analysis are given in Tables 2.2 and 2.3 and the aerial coverage of the composites is illustrated on Figure 4 and the associated overlays which represent generalised depth groupings within the fill. The associated Chain-of-Custody records are included in Appendix II.

These samples were analysed by R.J. Hill Laboratories, a laboratory accredited by International Accreditation NZ. The following contaminants were analysed for:

- Ammonium N
- Arsenic
- Lead
- Magnesium
- Manganese
- Mercury
- PCBs
- PCP/TCP
- Sodium
- Total Boron
- tph
- Zinc

In addition, a discrete selection of composites was submitted to AgriQuality, for analysis of Dioxins by OCDD Screening. The composites selected are indicated in Table 2.4, and the associated Chain-of-Custody records are to be found in Appendix II.

During drilling, the water table was intersected in a number of the boreholes. Nine of these bores were cased in order to obtain water samples at a later date.



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GES
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Primary Solids
Upper Embankment
Figure 1
Bore Hole Locations
Date:10/11/2003
Author: Al McOrie
Office:
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Projection: Bay of Plenty Circuit
0
25
50
100
metres

Table 2.1
Borehole Summary Data

Borehole #	Location		RL(m)*	Groundwater Depth		Sample Temp °C/depth
	Northern	Eastern		RL	bgs**	
B1	666692.569	321806.968	35.050			36/4.5
B1A	666701.651	321813.632	33.920			
B2	667290.154	321774.353	25.048			
B3	666726.888	321770.887	24.450			
B4	666732.536	321808.637	34.254			
B4A	666721.06	321815.02	33.831			36/12.8
B5	666752.359	321797.326	34.378			42.5/3
B5A	666760.655	321816.265	33.406			30.5/4.8
B6	666764.752	321779.051	35.276	20.74	14.53	
B7	666761.012	321732.812	24.998			
B8	666763.777	321723.051	24.560			
B9	666816.03	321778.019	34.539			
B10	666828.375	321829.044	31.518			
B10A	666821.411	321812.211	32.298	20.46	11.84	
B11	666849.426	321817.76	31.553			23.7/4.2: 27.3/6.8: 26.2/10.6: 25.6/12.1: 23.6/15.1
B11A	666842.759	321791.981	32.499			24.2/7.2
B11B	666845.911	321805.133	32.119			
B12	666867.241	321762.583	33.742			
B13	666844.472	321702.148	24.000			
B14	666892.554	321682.733	23.873			
B15	666901.543	321747.585	32.540	22.63	9.91	
B16	666909.197	321807.832	31.406			
B16A	666913.643	321804.923	31.315			
B16B	666912.148	321816.781	31.364			
B16C	666911.048	321828.703	31.164	22.31	8.85	
B16D	666919.542	321843.612	30.801			
B16E	666921.808	321858.113	30.299			
B17	666950.407	321662.742	24.351			
B17A	666988.83	321641.457	23.618			
B18	666938.841	321735.033	28.893		10.8	
B19	666956.083	321856.375	29.455		11.0	
B19A	666963.912	321842.602	28.812		9.7	22.6/15.1:22/18
B20	666976.933	321688.378	23.978			
B20A	666995.156	321683.006	23.828			
B20B	666983.463	321687.751	24.163		4.1	
B21	666984.491	321717.468	23.771			
B21A	666998.72	321727.495	23.838			
B21B	667002.277	321727.206	24.102			
B22	666982.245	321782.721	24.064		1.1	
B22A	666992.457	321780.298	23.838			
B22B	666966.468	321773.376	23.831			
B23	666986.892	321857.327	25.447	21.35	3.9	
B23A	666981.236	321865.01	27.851			

*RL - Elevation Relative to Sea Level
**bgs – Below Ground Surface

Table 2.1 cont.

Borehole #	Location		RL(m)*	Groundwater Depth (ave)		Sample Temp °C/depth
	Northern	Eastern		RL	bgs**	
B24	666991.836	321814.419	24.327			
B24A	667000.477	321805.981	23.636			
B24B	667000.633	321800.895	23.871			
B25	667072.13	321812.416	24.222			
B25A	667067.705	321801.521	23.739			
B26	667080.274	321871.348	24.929			
B26A	667079.07	321847.881	27.877			
B27	667077.274	321918.956	24.466			
B28	667117.604	321783.279	23.964			
B28A	667114.135	321772.346	23.53		1.8	
B29	667122.944	321867.608	24.214		3.3	
B29A	667123.177	321846.251	27.174		6.7	
B30	667182.585	321802.198	24.483			
B30A	667180.177	321813.046	25.537			24.2/4.2: 21.9/6.7
B30B	667170.147	321853.22	26.946			
B31	667165.669	321867.271	24.461		5.90	29.9/1.0: 30.2/4.0: 19.9/6.0: 25.0/9.1
B31A	667164.457	321880.814	23.273			
B32	667228.67	321809.18	23.729		2.00	
B32A	667228.871	321807.342	23.882			
B33	667223.346	321871.73	23.615	20.58	3.04	
B33A	667221.531	321881.057	23.668		3.72	
B33B	667225.901	321858.665	26.1		6.20	
B34	667285.427	321800.205	24.552			
B34A	667279.733	321809.854	24.45			
B34B	667272.085	321807.99	24.047			
B34C	667258.954	321810.834	23.728			
B35	667280.564	321851.137	26.082			
B35A	667282.744	321871.487	23.955		2.30	
B35B	667284.729	321882.348	23.072			
B36	667315.557	321859.336	25.733		5.50	
B36A	667330.584	321856.077	25.655		5.50	
B37	667322.903	321846.046	27.538			
B37A	667332.823	321850.116	25.763			
B37B	667304.562	321818.5	26			
B38	666785.045	321818.03	32.634			
B38A	666784.824	321830.725	31.659			
B39	666763.78	321759.459	36.093			
B40	666805.238	321748.179	35.704	20.48	15.23	
B41	666866.793	321721.778	33.416	20.92	12.51	
B42	666949.069	321694.869	26.392	22.32	4.06	

*RL - Elevation Relative to Sea Level
**bgs – Below Ground Surface

Table 2.2

Waste Material Composites Selected for Analysis

Sample Submitted	Composited from Borehole	Sample Numbers (refer to bore logs)
NS1	B34C, B35, B36, B37	B34C-1, B35-1, B36-1, B37-1
NS2	B28, B29A, B30A, B30B, B31, B32, B33B, B36, B37, B37A	B28-1, B29A-1, B30A-1, B30B-1,B31-1, B32-1, B33B-1, B36-1, B37-2, B37A-1
NS3	B29A, B30A, B30B, B35, B35A, B37	B29A-2, B30A-2, B30B-2, B35-2, B35A-2, B37-3
NS4	B28, B30A, B31, B32, B35, B35A, B37	B28-2, B30A-4, B31-2, B32-2, B35-4, B35A-2, B37-4
NS5	B29A, B30A, B32, B33B, B35	B29A-3, B30A-4, B32-3, B33B-2, B35-5
NS6	B29A, B30B, B32, B33B, B35	B29A-6, B30B-5, B32-5, B33B-3, B35-5
NS7	B18, B20B, B22, B24, B26	B18-1, B20B-1, B22-1, B24-2, B26-1
NS8	B15, B19A, B20B, B21	B15-1, B19A-1, B20B-2, B21-1
NS9	B15, B21	B15-3, B21-2
NS10	B15, B16B, B16C, B19A	B15-4, B16B-1, B16C-1, B19A-2
NS11	B18, B19A	B18-3, B19A-3
NS12	B15, B16C, B18, B19A	B15-7, B16C-3, B18-5, B19A-5
NS13	B16B, B18, B19A	B16B-3, B18-4, B19A-5
NS14	B15, B16B, B16C, B18, B19A	B15-9, B16B-4, B16C-3, B18-6, B19A-5
NS15	B15, B18	B15-10, B18-7
NS16	B15, B18	B15-10, B18-8
NS17	B16B, B18	B16B-6, B18-9
NS18	B10A, B11A, B12	B10A-1, B11A-1, B12-1
NS19	B1, B5, B11B, B12, B38	B1-1, B5-1, B11B-1, B12-2, B38-1
NS20	B1, B6, B5	B1-2, B6-4.5, B5-2
NS21	B6, B11A, B12, B38, B38A	B6-6, B11A-2, B12-3, B38-3, B38A-1
NS22	B11A, B12, B38	B11A-3, B12-4, B38-4
NS23	B6, B12, B38	B6-10.5, B12-6, B38-9.5-10.2
NS24	B24, B26	B24-1, B26-1
NS25	B23, B25, B42	B23-1, B25-1, B42-2
NS26	B24, B24A	B24-2, B24A-1
NS27	B20, B23A, B42	B20-2, B23A-1, B42-3
NS28	B14, B42	B14-4.5, B42-5
NS29	B24, B42	B24-4, B42-6
NS30	B14, B42	B14-4.5, B42-7

Table 2.3

Composition of Each Composite Sample

Composite #	Sample #	Depth (m)
NS1	34C	0.3-0.8
	35	1.6-1.8
	36	1.8-3.0
	37	1.6-1.8
NS2	BH28	1.8-2
	BH29A	1.5-1.19
	30A	1.5-2
	30B	1.5-1.9
	31	1.2-1.4
	32	1.7-2.0
	33B	2.3-3.0
	36	1.8-3.0
	37A	2.0-3.0
NS3	29A	3.0-3.4
	30A	3.0-3.5
	30B	3.0-3.4
	35	3.6-4.2
	35A	3.8-4.0
	37	3.4-3.6
NS4	28	3.8-4.0
	30A	3.5-3.7
	31	3.8-4.0
	32	3.8-4.0
	35	4.0-4.2
	35A	3.8-4.0
	37	3.4-3.6
NS5	29A	4.5-4.9
	30A	4.2-4.5
	32	5.8-6.0
	33B	5.4-5.8
	35	4.8-6.0
NS6	29A	9.0-9.4
	30B	9.0-9.4
	32	8.0-8.2
	33B	7.7-8.0
	35	7.8-8.0
NS7	18	1.0-2.2
	20B	1.2-1.5
	22	1.6-2.0
	24	1.8-2.0
	26	0-1.5

Composite #	Sample #	Depth (m)
NS8	15	1.8-2.0
	19A	2.8-3.2
	20B	2.5-2.6
	21	1.8-2.3
NS9	15	3.8-4.0
	21	2.3-3.6
NS10	15	5.8-6.0
	16B	5.5-5.7
	16C	4.6-6.0
	19A	5.7-6.0
NS11	18	7.5-7.7
	19A	7.5-7.7
NS12	15	9.8-10
	16C	11.0-11.8
	18	10.7-11.0
	19A	10.5-10.8
NS13	16B	8.5-8.7
	18	9.0-9.2
	19A	9.0-9.2
NS14	15	11.8-12.0
	16B	14.5-14.7
	16C	11.0-11.8
	18	10.7-11.0
	19A	10.5-10.7
NS15	15	13.6-13.8
	18	12.5-13.2
NS16	15	13.6-13.8
	18	15-15.2
NS17	16B	15.5-16.0
	18	18-18.4
NS18	10A	1.8-2.5
	11A	2.5-3.0
	12	1.8-2.0

Composite #	Sample #	Depth (m)
NS19	38	3.5-4.2
	5	4.6-4.9
	1	3.2-3.8
	11B	3.5-4.5
	12	3.8-4.0
NS20	5	4.6-6.0
	6	4.5-4.9
	1	4.8-5.3
NS21	38	6-6.3
	38A	7-7.5
	6	6-7.5
	11A	5.5-6.0
	12	5.8-6.0
NS22	38	9.5-10.2
	11A	7.0-7.5
	12	9.8-10.0
NS23	38	12-12.4
	12	11.8-12.0
	6	16.5-16.9
NS24	24	1.8-2.0
	26	0-1.5
NS25	23	1.0-2.0
	25	1.8-2.0
	42	3.0-3.2
NS26	24	3.8-4.0
	24A	4.0-4.2
NS27	23A	4.0-5.0
	42	3.3-4.5
	20	2.5-3.5
NS28	42	4.5-6.0
	14	4.5-4.9
NS29	24	7.8-8.0
	42	6.6-7.2
NS30	42	7.5-7.7
	14	9.0-9.4

Table 2.4

Primary Solids Composites Selected for Dioxin Analysis.

Sample Submitted	Composited from Borehole Number*
NS2	B28, B29A, B30A, B30B, B31, B32, B33B, B36, B37, B37A
NS6	B29A, B30B, B32, B33B, B35
NS7	B18, B20B, B22, B24, B26
NS14	B15, B16B, B16C, B18, B19A
NS19	B1, B5, B11B, B12, B38

*See Table 2.2 for sample number details

2.2. Results

During drilling it was possible in most cases to determine the depth to the original ground surface. The indicator material for the bottom of the landfill was either pumice or lacustrine clays (lake sediments) and the depth to these strata varied between approximately 2.8m (B30A) and 16.5m (B39). In most cases the temperature at depth was low (approximately 20°C), however some exceeded 30° C (e.g. B1, B4A, B5, B5A) indicating the possible presence of geothermal heat. Temperature records are included in Table 2.1.

In the course of the field programme some materials of apparent concern were identified due to their visual characteristics. Samples of these materials were submitted for individual analysis. Chain-of-Custody for these samples is included in Appendix II, and analytical results are within Appendix III and tabulated below in Table 2.5.

These data indicated that significantly elevated levels of Magnesium, Sodium, Ammonia, Boron, Arsenic, Mercury, Lead and Zinc and petroleum hydrocarbons (tph) are present in the material under investigation in localised zones. Review of Table 2.6 indicates, however, that the general occurrence of these elements in less significant, though at a level elevated in comparison to the guidelines listed in Table 2.7. The results of these analyses were reviewed and utilised in the assessment of options for preparation of composite samples which have been selected to be representative of overall quality of the waste deposit.

Following completion of the field programme a selection of thirty composite samples was prepared as discussed in Section 2.1.3. The results of the analysis of composite solids samples are tabulated in Table 2.6. These results are compared with analyses of primary solids (NS 2001 (1998); GES 2002) and with appropriate environmental guidelines on Table 2.7.

The guidelines referenced include primarily New Zealand based guidelines which apply to the quality of soils in areas where industrial use is anticipated or stipulated and end use may be agricultural (MfE/MoH 1997), general soil conditions in areas of public use (ARC 2002 Draft) or guidelines for sediments (ANZECC 2000 Sediments). This latter guideline was anticipated to be more stringent, though review indicates otherwise. A US guideline is also included (NOAA 1999) since it offers good background information regarding soils.

Table 2.5

Results of Analyses of Individual Samples from the Upper Embankment

Sample #	Mg	Na	NH_4	B	As	Hg	Pb	Zn	PCB	PCP	tph	Description
B1-2	743	175	51	30	122	10.7	50.8	173	0.3	0.07	130	Dark oily woodwaste
B6-4.5	1910	850	6	<20	5	0.3	22	29	0.5	<0.05	370	
B6-6.0	1400	1730	<5	<20	9	0.3	38.4	154	0.5	<0.05	1430	Oily waste
B6-10.5	1580	1970	<5	<20	13	0.1	23.7	116	0.4	<0.05	240	
B8-4.5	1160	702	<5	<20	3	21.3	9.9	26	0.7	<0.05	750	Oily waste
B13-7	1560	1900	<5	23	35	4.9	106	98	0.7	<0.05	380	Oily waste
B18-1	826	214	8	<20	37	125	14.3	41	<0.3	0.05	60	Scrapings with white sludge
B18 comp	1230	2280	<5	27	21	3.0	32.8	159	0.3	<0.03	620	Saturated woodwaste with sludge
B29A-3A	451	217	19	<20	<2	22.7	5.8	21	0.5	<0.05	420	Scrapings with white sludge
B29-4	457	243	30	<20	3	55.4	5.4	19	<0.3	0.06	140	Redbark fragments with white sludge
B35-2	757	904	15	<20	5	<0.1	4.8	30	<0.3	<0.05	4480	Oily waste - sludge
B35-5	1450	2670	5	<20	<2	<0.1	98.9	14	<0.3	<0.05	150	Blue/grey sludge
B36-1A	1420	4890	<5	<40	<4	0.5	32.9	14	<0.3	<0.05	<50	Scrapings with grey sludge
B37-2	1360	2660	72	<20	3	0.1	18.9	21	<0.3	<0.05	150	Lime mud
B38-2	1990	2640	18	<40	<4	<0.2	20.3	27	<0.3	0.05	<40	Grey sludge
B38 9.5-10.2	1790	1280	6	22	67	0.2	110	1160	<0.3	<0.05	350	Dark woodwaste
B35A-4	1580	1870	31	31	12	0.6	23.7	96	0.9	<0.05	5900	Oily waste

All analyses in mg/kg

Table 2.6

Comparison of Contaminant Levels in Waste from the Upper Embankment Wastes

Composite Sample Number	Mg	Na	NH4	B	Mn	As	Hg	Pb	Zn	PCB	PCP/TCP	tph	Dioxin
NS1	754	630	<5	<20	124	12	1.1	22.1	72	<0.03	0.10	490	
NS2	1010	1030	31	<20	128	6	3.3	13.0	36	<0.03	0.07	600	0.0245
NS3	1090	540	<5	20	124	9	0.4	22.1	58	<0.03	<0.05	640	
NS4	972	578	<5	<20	120	5	0.2	8.3	26	<0.03	<0.05	400	
NS5	1230	1100	<5	<20	127	6	0.2	38.1	56	<0.03	<0.05	480	
NS6	1000	860	9	<20	129	26	3.2	22.5	161	<0.03	0.14	1050	0.1020
NS7	1130	415	<5	21	166	10	3.1	31.2	93	0.30	0.22	2600	0.2220
NS8	1040	583	<5	<20	131	8	2.5	20.7	47	0.40	<0.05	1580	
NS9	975	628	<5	<20	107	10	<0.1	9.5	39	<0.03	<0.05	190	
NS10	1560	631	39	67	211	17	2.0	57.8	182	0.90	0.08	250	
NS11	1360	390	17	22	181	28	1.0	87.3	387	0.60	<0.05	90	
NS12	1400	1070	<5	40	213	24	0.8	51.6	189	0.50	0.05	420	
NS13	1850	1000	<5	21	193	15	0.6	18.9	92	0.30	0.49	880	
NS14	1540	1390	<5	42	212	49	1.7	55.2	366	0.50	0.16	410	0.0200
NS15	1560	2360	<5	25	209	48	3.6	31.9	75	2.20	<0.05	260	
NS16	841	1200	<5	<20	132	29	1.2	27.1	70	0.50	<0.05	590	
NS17	538	1190	<5	<20	81	59	51.0	4.5	28	<0.03	<0.05	100	
NS18	1100	826	<5	<20	163	18	1.0	22.7	46	0.30	0.12	920	
NS19	978	669	14	<20	237	46	2.7	31.9	120	<0.03	0.73	480	0.0043
NS20	1440	668	<5	<20	304	9	0.8	12.9	35	0.30	<0.05	480	
NS21	1540	862	<5	<20	288	10	0.8	179.0	214	5.20	<0.05	1070	
NS22	1310	1630	<5	<20	230	39	3.4	55.1	404	<0.03	<0.05	1500	
NS23	1660	1590	10	<20	215	73	33.7	136.0	69	0.40	<0.05	990	
NS24	1180	858	<5	<20	158	16	2.6	18.1	66	0.30	<0.05	1840	
NS25	1290	832	15	23	295	13	1.3	61.1	125	1.30	0.15	1370	
NS26	388	1100	<5	<20	86	5	0.4	7.7	24	<0.03	0.06	1110	
NS27	1320	891	<5	<20	192	5	0.4	22.7	132	4.60	<0.05	1140	
NS28	762	440	<5	<20	107	13	28.1	15.9	99	<0.03	<0.05	530	
NS29	395	246	9	<20	56	17	0.6	3.4	17	<0.03	<0.05	220	
NS30	1040	838	<5	<20	133	25	3.0	32.8	55	0.30	0.05	980	

All units in mg/kg except dioxin – OCDD Screen; µg/kg
Shaded results were utilised in preparation of zones of concern.

Table 2.7

Guideline Summary for Analytes

	Mg	Na	NH4	B	As	Hg	Pb	Zn	PCB	PCP/TCP	tph	PCDD/PCDF
Level of Concern NOAA Soil					0-97	0-4.6	0-700	229	0.5agric 5 parks			
ANZECC 2000 Sediments					20-70	0.15-1	50-220	200-410	23			
MfE/MoH 1997 Timber - Agric				3	30					0.7	MfE 1999 1-4m Pumice 6700	0.01µg/kg=10ng/kg
MfE Draft – October 2003												0.12 µg/kg =120ng/kg parks
ARC 2002 Draft	470-10300	-	-	2-45	0.4-12	<0.03-0.45	<1.5-65	<180	-	-	-	-
NS Primary Solids - 1998	1400	3500	0.24	-	1.8	0.11	12	55	<0.05	-	-	3.62ng/kg
NS Primary Solids Ave 2002	1008	1371	0.26	10.1	44.75	54	15.3	57.9	-	0.32	-	36.6ng/kg
Upper Embankment* - Ave 2003	1142	901	6.6	16.4	21.7	5.2	37.4	112.8	0.64	0.09	788.7	
Upper Embankment* - Max 2003	1850	2360	39	67	73	51	179	404	5.2	0.73	2600	
All Data (Composite and individual)												
Upper Embankment - Ave 2003	1189	1154	10.1	16.3	21.0	8.51	37.01	118.7	0.53	0.07	835.6	0.0746µg/kg=74.6ng/kg
Upper Embankment - Max 2003	1990	4890	72	67	122	125	179	1160	5.2	0.73	5900	0.222µg/kg=222ng/kg

*Only includes composite sample data.
All units in mg/kg except dioxin – OCDD Screen; µg/kg=ng/g=ppb
NOAA – USA – National Oceanographic and Atmospheric Institute (1999)
ANZECC – Australia/New Zealand
MfE/MoH – Ministry for Environment/Ministry of Health, New Zealand
ARC – Auckland Regional Council
NS – Norske-Skog

Table 2.7 also includes information regarding the quality of the Primary Solids disposed immediately adjacent to, and in some cases contiguous with, the Upper Embankment. Primary Solids quality reported in 1998 and also resulting from an extensive 2002 investigation are included, and allow direct comparison with the information in Table 2.6. Comparison is also facilitated by inclusion of summary data for the Upper Embankment in Table 2.7.

2.2.1 Metals, Nutrients and Cations

Arsenic

Arsenic levels ranged between 5mg/kg and 73 mg/kg. The average concentration (excluding 6 samples above 39mg/kg) was 15 mg/kg (25 samples). The average level reported in recently deposited primary solids (1998) is 1.8 mg/kg.

Arsenic levels are typically above the MfE/MoH (1997) guidelines for agricultural soils (30mg/kg), but almost entirely (one exception) below the guideline for industrial sites (500 mg/kg).

Boron

Boron levels ranged between undetectable (<20) mg/kg and 67 mg/kg. With the exception of two samples above 25 mg/kg, 21 of the remaining samples were below the detection limit of 20mg/kg and the remaining sample was at the 20mg/kg level. Boron levels are typically above the MfE/MoH (1997) guideline for agricultural soils of 3mg/kg.

Mercury

Mercury levels ranged between <0.1mg/kg and 51mg/kg (a level of 125mg/kg was recorded in an individual sample). However, only three analyses (5 inclusive of individual analyses) exceeded 17mg/kg and the majority of samples (13) had levels between <0.1 and 3.6mg/kg.

The general global occurrence of mercury in surface soils is approximately 0.05 mg/kg. The higher concentrations expressed locally within the area probably reflect past and present geothermal activity beneath the fill. It is also likely that any mercury migrating via geothermal pathways would condense in the Primary Solids material, which behave similarly to peat as an organic filter. Guidelines generally indicate that levels of between 0mg/kg and 4.6mg/kg (NOAA) are acceptable, and comparison with the site results indicates that less than 5% of the samples exceeded that level. This in turn correlates with the presence of heat likely associated with geothermal anomalies, as is discussed in Section 2.2.

Lead

Lead levels ranged between 3.4mg/kg and 179mg/kg. Apart from NS21 and NS23 (179 and 136mg/kg), the highest recorded concentrations include 6 samples between 51 and 87 mg/kg and 12 samples between 20 and 51mg/kg. The remainder of the samples all exhibited less than 32.8mg/kg (NS30), with an average of 11.4mg/kg (10 samples).

With exception of one sample these levels are below the 140mg/kg maximum recommended in the ARC (2001) draft guidelines and generally below the ANZECC (2000) sediment guidelines of 50 and 220mg/kg (ISQG low and high respectively).

Zinc

Zinc levels generally exceed the level reported in Primary Solids (55mg/kg). Levels range between 17 and 404mg/kg, with four samples exceeding the ANZECC 200mg/kg level (Low ISQG). The average excluding these analyses was 77.38mg/kg, and the range was between 17 and 189mg/kg.

The average content of zinc in the earth's crust is approximately 70mg/kg (CCREM 1989), and the recommended sediment quality guidelines given by ANZECC (2000) are 200mg/kg (ISQG - low) to 410mg/kg (ISQG - high).

2.2.2 Organic Compounds

Investigation of organic compounds included analysis for PCBs, tph and pentachlorophenol (PCP) as well as screening for dioxins and furans. The following subsections discuss the results of these evaluations.

Polychlorinated BiPhenyls (PCBs)
Levels of PCBs were generally extremely low (<0.03mg/kg). Of the four samples exceeding 1mg/kg only two were close to the level suggested by the U.S. National Oceanographic and Atmospheric Academy (NOAA) guideline for public parkland (5mg/kg). One sample, NS21, recorded 5.2mg/kg and the other NS27, 4.6mg/kg.

tph (total petroleum hydrocarbons)
Although levels as high as 2600mg/kg were recorded, and 9 samples indicated in excess of 1000mg/kg, soil acceptance criteria for agricultural use in Peats and Organic Soils and Pumice exceed 6500mg/kg (MfE 1999).

Pentachlorophenol (PCP)
PCP levels are presented in Table 2.6 and these indicate that the waste material generally falls within the MfE/MoH (1997) guidelines for agricultural soils (0.7mg/kg). One sample (NS19) did however return a result of 0.73mg/kg PCP. These levels fall within the guideline for residential use (1.4mg/kg).

Dioxins and Furans
A summary of the dioxin and furan (PCDD/PCDF) results for the composited samples is presented in Table 2.8.

Table 2.8

PCDD/PCDF Content of Tasman Primary Solids Dump Materials

Sample	**OCDD Screen I-TEQ (μg/kg) Maximum**
NS2 – composite from 9 samples – see table 2.3	0.0245
NS6 – composite from 5 samples – see table 2.3	0.102
NS7 – composite from 5 samples – see table 2.3	0.222
NS14 – composite from 5 samples – see table 2.3	0.0200
NS19 – composite from 5 samples – see table 2.3	0.0243

With reference to samples NS2, NS6, NS7, NS14 and NS19, the following is noted:

- Composites NS6 and NS7 had the highest I-TEQ (total toxic equivalence) at 0.102μg/kg and 0.222μg/kg (TEQ) respectively. Since both of the composites were composed of samples from three drill holes, it is possible that an individual sample within the composite contained up to 0.51μg/kg (NS6) and 1.11μg/kg (NS7) (510 and 1110ng/kg).

- The remaining three composites, N2S, NS14 and NS19, had low levels of I-TEQ, recorded at 0.0245, 0.0200 and 0.0243µg/kg respectively, which correspond to 24.5, 20 and 24.3ng/kg)

- These composites were comprised of five samples, hence it is possible that an individual sample within the composites could contain up to 0.1225µg/kg (1225ng/kg).

Three of the five samples tested are within the range of that reported as typical for New Zealand urban soils which range between 0.17 and 33µg/kg (MfE 2001). The New Zealand Ministry for the Environment (MfE) have reported little general ecological significance or risk associated with such concentrations (MfE, 2001). This is because dioxins show little potential for leaching or volatilisation from soils, although they may enter the atmosphere and/or degrade when present near the soil surface (MfE, 2001). Also, they are mainly associated with particulates and organic matter and have low water solubility; once they enter the water column they generally become associated with aquatic sediments.

Even so, as discussed, dioxins are persistent in soils and are not readily leached or removed by physico-chemical processes. It is therefore considered likely that the samples that comprise the composites under evaluation will not readily release dioxin congeners into the wider environment.

In summary, the following point is most significant in regard to the Dioxin/Furan evaluation of the Upper Embankment. Although two of the five samples collected generally had dioxin concentrations which exceed those found in urban New Zealand soils, there is little evidence that dioxin concentrations in these soils pose any risk to the general environment.

An overview of the areas of each analyte having levels considered to be somewhat elevated in relation to general background levels, New Zealand and international guidelines, and the known composition of the Primary Solids material, is included on Table 2.6 and 2.7, and indicates that the majority of the waste area includes some elevated levels. This circumstance is graphically illustrated on Figure 5, which is compiled from data presented in Appendix IV.

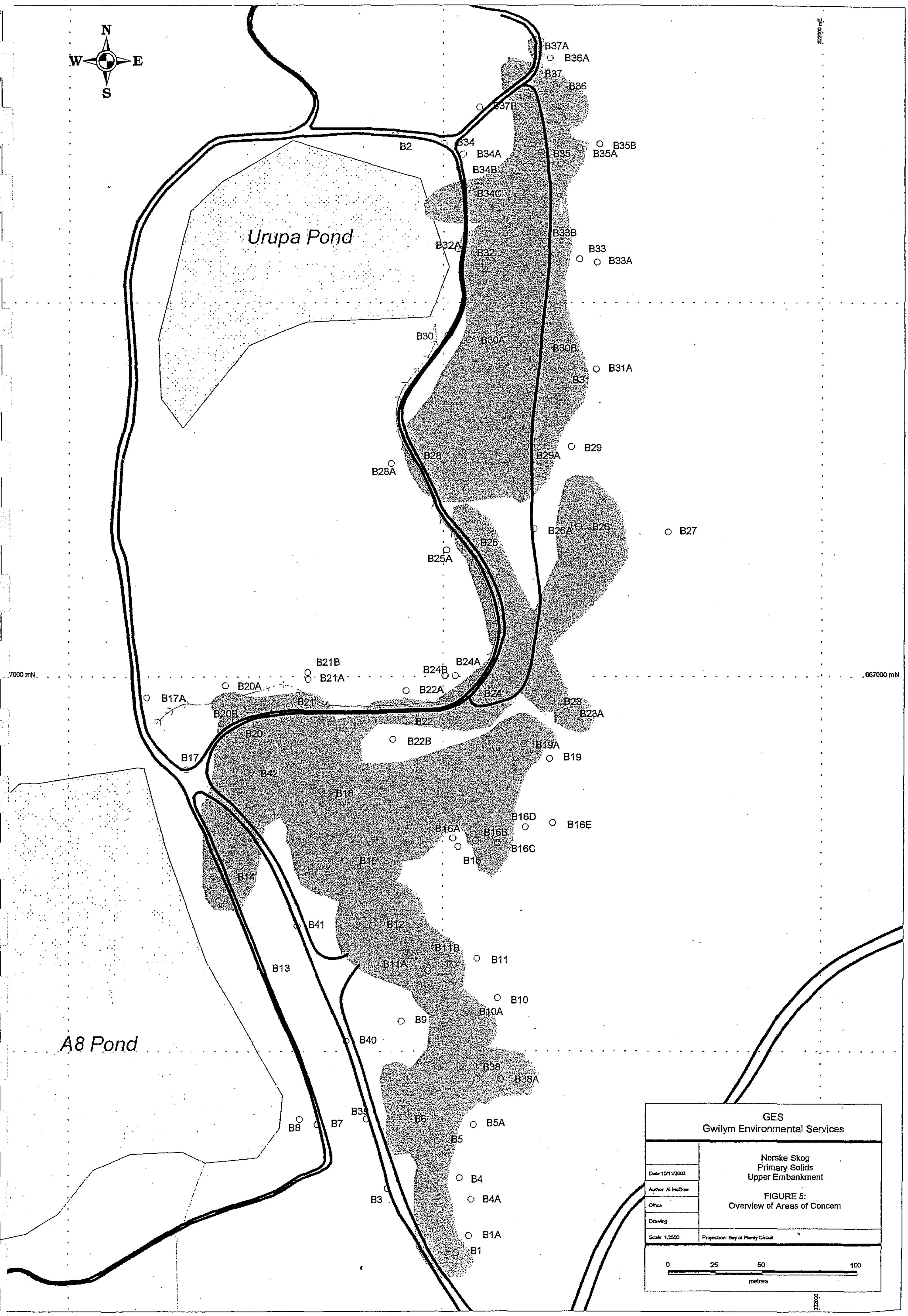
3. Waste Leachate Generation Evaluation

3.1 Introduction

In order to aid in the assessment of the potential mobility of contaminants reported to be contained within the Upper Embankment wastes certain of the samples were subjected to USEPA Toxicity Characteristic Leaching Procedure (TCLP) testing. This procedure offers guidance regarding the mobility of each analyte assessed in the soil waters and as a result aids in evaluation of the significance of elevated concentrations in the soils.

3.2 Analytical Results and Discussion

Table 3.1 compares concentrations of contaminants in selected samples with the leachable concentration in waters using the conservative TCLP test procedure. Analytical results are included in Appendix C.


N
S
E
W
Urupa Pond
A8 Pond
667000 mN
B1
B1A
B2
B3
B4
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B5
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B37A
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B38A
B39
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B41
B42
GES
Gwilym Environmental Services
Norske Skog
Primary Solids
Upper Embankment
FIGURE 5:
Overview of Areas of Concern
Date 10/11/2003
Office
Drawing
Scale 1:2500
Projection: Bay of Plenty Circuit
0
25
50
100
metres

Table 3.1

Waste Analyses and TCLP Results

	Arsenic		Cadmium		Mercury		Lead		PCP/TCP	
Sample	**Solid**	**TCLP**	**Solid**	**TCLP**	**Solid**	**TCLP**	**Solid**	**TCLP**	**Solid**	**TCLP**
NS7	10	<0.02	-	<0.001	3.1	<0.007	31.2	0.007	0.22	<0.0005
NS11	28	0.03	-	0.001	1.0	<0.002	87.3	0.037	<0.05	<0.0005
NS15	48	0.09	-	<0.001	3.6	<0.002	31.9	0.004	<0.05	<0.0005
NS17	59	0.06	-	<0.001	51.0	<0.002	4.5	<0.002	<0.05	<0.0005
NS21	10	0.03	-	<0.001	0.8	<0.002	179	0.010	<0.05	<0.0005
NS22	39	0.03	-	0.002	3.4	<0.002	55.1	0.005	<0.05	<0.0005
NS23	73	0.03	-	0.001	33.7	<0.002	136	<0.002	<0.05	<0.0005
NS25	13	<0.02	-	<0.001	1.3	<0.002	61.1	0.006	0.15	<0.0005

Note: Solids – mg/kg: TCLP – g/m^3

These results indicate that although concentrations of analytes of concern in solid materials in the project area may be high, including Arsenic, 73mg/kg; Mercury 51mg/kg; and Lead 179mg/kg, the amount of those elements available to percolating waters is extremely low, as indicated by the TCLP results for Arsenic 73mg/kg offers 0.03g/m^3; Mercury 51mg/kg offers <0.002g/m^3 and Lead 179mg/kg offers 0.010g/m^3.

It is, however, important to note that if an element is at a concentration of 100mg/kg the TCLP result <u>maximum</u> would be 5g/m^3 due to the dilution process used in the TCLP procedure. Taking this circumstance into consideration the results in Table 3.1 nonetheless indicate low potential for mobility of contaminants.

The TCLP testing indicates that the contaminants are attenuated in the waste material and are not highly available to percolating waters.

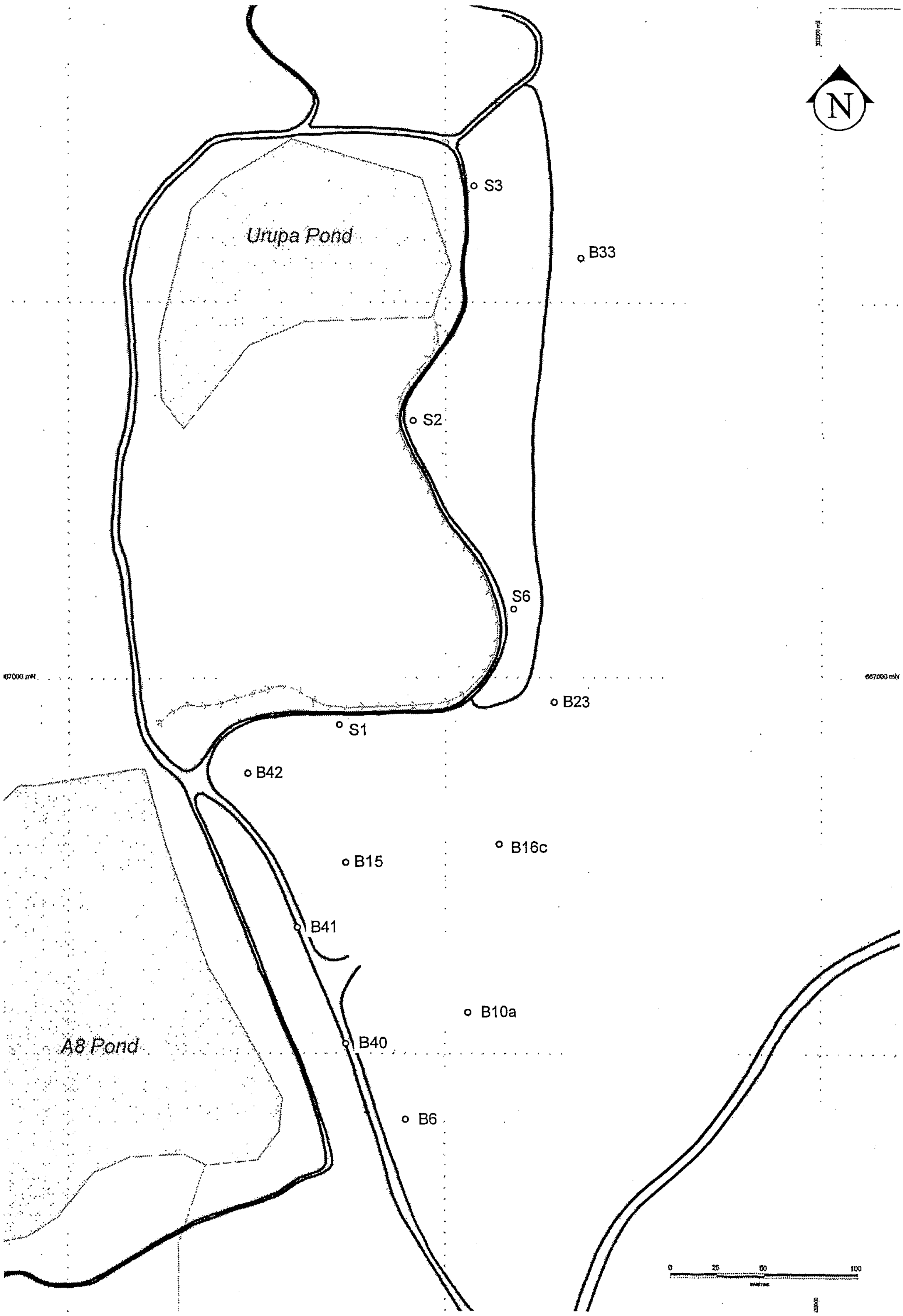
4. Groundwater and Surface Water Evaluation

4.1 Introduction

In order to address the potential of migration of waste related contaminants into the groundwaters beneath and peripheral to the site, development of the monitoring bores described in 2.1.3 was conducted. The monitor wells and surface waters adjacent to the site were then sampled and samples submitted for analysis. This section addresses the procedure, includes the analytical results (Appendix VC) and discusses those results.

4.2 Approach

During the comprehensive investigative auger boring programme completed during 2003 at the Upper Embankment a selection of 9 bores were established as monitoring bores to allow determination of groundwater levels within and adjacent to the waste and allow collection of groundwater samples for evaluation. These bores included B6, B10a, B15, B16c, B23, B33, B40, B41 and B42, as illustrated on Figure 6.



GES
Gwilym Environmental Services

NORSKE SKOG TASMAN - KAWERAU
PROJECT: Primary Solids Upper Embankment
Figure 6: Monitoring Bore Locations

SCALE: See Scale Bar
DRAWN BY: MPS
DATE: 15/03/04
FILE: urupa_pond.fh9

On 26 November 2003 GES completed the development and sampling of these wells. Samples were also collected of the leachate generated from the leachate collection system along with surface water samples from the outlets of both the A8 Pond and the Urupa Pond.

4.3 Field Programme

4.3.1 Groundwater

Each of the bores was evacuated until the field parameters of pH, conductivity and temperature stabilised. Record of this procedure for each well is included in Appendix VA. As can be seen in review of this record, a considerable volume of water was evacuated from each well before stable conditions were achieved and a representative sample could be collected for submission to the analytical laboratory.

Water samples were transferred from each well directly to three laboratory supplied containers which were individually labelled and transferred to a chilly bin maintained at ±4°C for courier delivery to an accredited laboratory (RJ Hill Laboratory, Hamilton) for analysis. Sample management followed strict Chain-of-Custody procedures, and record is included in Appendix VB.

Sampling of selected bores (B15, B16C, B33 and B42) also included samples for dioxin screening. These samples required separate containment and shipment under Chain-of-Custody to Agriquality Laboratory in Lower Hutt. This Chain-of-Custody is also included in Appendix VB.

A leachate collection system is in place at the Upper Embankment in order to mitigate the potential of groundwater migration toward A8 Pond or the canal conducting A8 Pond waters to the Urupa Pond. Samples from the collection sump of this system were collected prior to initiating the groundwater monitor programme and additionally following completion of the programme, a time interval of approximately 10 hours. These samples, LS1 and LS2, were collected from the sump using a clean disposable monitoring bailer and transferred to laboratory supplied containers in an identical manner to that described above. The samples were stored and shipped together with the groundwater samples to RJ Hill Laboratories under the same Chain-of-Custody.

4.3.2 Surface water

Two small lakes were also sampled during this field programme, A8 Pond and Urupa Pond. These ponds are adjacent to, though upgradient of the Upper Embankment area, and are connected by a small drain which is segregated from any potential of seepage from the Upper Embankment materials by the subdrain system sampled in our groundwater programme via samples LS1 and LS2 as discussed above.

These samples were collected directly into laboratory supplied containers and documented via an identical Chain-of-Custody manifest system to the other samples described above.

4.4 Analytical Results and Discussion

4.4.1 Groundwater

Groundwater samples were collected to gain an understanding of the overall groundwater quality in the Upper Embankment area, to assess the variability between different areas of the fill, and to allow comparison between general groundwater quality and that which is collected in the leachate collection system currently operating.

Groundwater quality beneath the Primary Solids Upper Embankment is represented by samples collected from nine locations as illustrated on Figure 6. In addition, four established monitoring wells, S1, S2, S3 and S6, form part of the consent compliance monitoring system and are monitored on a quarterly basis for a broad suite of parameters. Table 4.1 below includes analyses compatible to all bores.

These data indicate that the groundwaters exceed ANZECC 2000 guideline limits for protection of 95% of aquatic species to a limited extent only for Ammonia, Boron and Zinc.

The Ammonia (NH_4) ANZECC 2000 level for 95% protection is 0.9 g/m^3. Levels in B10A (1.02g/m^3), B16C (4.57g/m^3), B23 (1.79g/m^3), S2 (2.92g/m^3), S3 (2.91g/m^3), and S6 (2.18g/m^3) exceed this limit, though levels in all other bores (7) are well within this criteria.

Boron levels exceed the ANZECC 2000 95% criteria (0.37g/m^3) in most cases, and also exceed ANZECC 1992 guidelines for stock watering (0.5g/m^3).

Zinc levels also exceeded the ANZECC 2000 95% protection level (0.008g/m^3).

In general terms, however, no indication of significant contamination was observed, nor was there indication in the leachate collection system (see Table 4.2) of any elevated contaminants. It is therefore reasonable to say that the low levels of contamination present in the groundwaters directly associated with the embankment materials are being attenuated within the fill and are not migrating to the canal or the leachate collection system.

4.4.2 Surface waters

Surface water samples were collected at the outlets of both the A8 Pond and the Urupa Pond. The Urupa Pond lies downgradient of the A8 Pond, though both ponds are upgradient of the Upper Embankment wastes area. As described above, the potential for seepage from the Upper Embankment wastes is mitigated by the leachate collection system.

Analytical results are tabulated below in Table 4.3, which also includes average results from Table 4.2 to aid in comparison.

Table 4.3

Analyses of Surface Waters – A8 and Urupa Ponds (g/m^3)

	Mg	Na	B	As	Cd	Cr	Hg	Pb	Zn
A8 Pond	1.63	10.3	0.013	0.003	<0.00005	0.0010	<0.00008	0.0003	0.004
Urupa Pond	1.61	10.1	0.015	0.003	<0.00008	<0.0005	<0.00008	0.0001	0.001
Average Leachate	23.0	121.0	0.761	0.0045	<0.00005	<0.0005	0.00004	<0.0001	0.0085

These results indicate that very low levels of contaminants of concern are present in pond waters and that there is very little, if any, movement of contaminated groundwaters from the Upper Embankment wastes into the ponds. The slightly elevated levels of Chromium, Lead and Zinc in A8 Pond are not of environmental significance and may reflect the geothermal nature of the area.

Table 4.1
Analyses from all Upper Embankment Groundwater Bores

	pH	Mg	Na	NH_4	B	As	Cd	Cr	Hg	Pb	Zn	PCB	PCP/TCP	tph	OCDD** Screen	
Bore															min	max
B6	7.5	81.6	415	<0.01	1.19	0.01	<0.0001	<0.001	<0.00008	<0.0002	0.027	0.003	<0.0005	<0.2		
B10a	7.4	64.2	208	1.02	1.21	<0.01	<0.0001	<0.001	<0.00008	0.0007	0.019	<0.003	<0.0005	0.2		
B15	7.4	47.5	464	0.42	1.61	0.01	<0.0001	<0.001	<0.00008	<0.0002	0.012	<0.003	<0.0005	<0.4	0.193	0.193
B16C	7.2	43.3	84.3	4.57	1.43	<0.01	<0.00005	<0.0005	<0.00008	<0.0001	0.017	<0.003	<0.0005	0.6	0.520	0.520
B23	7.0	37.4	216	1.79	0.43	0.01	<0.0001	<0.001	<0.00008	<0.0002	0.012	<0.003	<0.0005	<0.4		
B33	7.1	19.9	44.9	0.53	0.414	0.005	<0.00005	<0.0005	<0.00008	<0.0001	0.012	<0.003	<0.0005	<0.4	0.0113	0.0113
B40	7.9	9.79	176	<0.01	0.129	0.003	<0.00005	<0.0005	<0.00008	0.0003	0.007	<0.003	0.0007	0.2		
B41	7.5	18.4	46.7	0.27	0.293	0.004	<0.00005	0.0010	<0.00008	0.0007	0.018	<0.003	<0.0005	<0.02		
B42	7.6	42.4	872	<0.01	1.57	<0.02	<0.0001	0.002	<0.00008	<0.0002	0.013	<0.003	<0.0005	<0.4	0.141	0.141
S1*	-	-	141	0.74	-	-	-	-	-	-	0.12	-	-	-		
S2*	-	-	43	2.92	-	-	-	-	-	-	0.08	-	-	-		
S3*	-	-	197	2.91	-	-	-	-	-	-	0.08	-	-	-		
S6*			35	2.18							0.11					

*Average data, ** OCDD ng/L (ITEQ), all other data g/m^3

Table 4.2
Analyses of Leachate Collection System Waters (g/m^3)

	pH	Mg	Na	NH_4	B	As	Cd	Cr	Hg	Pb	Zn	PCB	PCP/TCP	tph
Bore														
LS1	7.5	22.8	122	0.47	0.766	0.004	<0.00006	<0.0005	0.00008	<0.0001	0.013	<0.003	<0.0005	<0.2
LS2	7.4	23.2	120	0.46	0.756	0.005	<0.00005	<0.0005	<0.00006	<0.0001	0.004	<0.003	<0.0005	<0.2

5. Conclusions

As can be seen in review of Figure 5 and in review of the figures presented in Appendix IV, the area in which the waste material is stored has somewhat elevated levels of one or more of the chemicals evaluated in this investigation. In many cases the levels exceeded those generally present in the Primary Solids material.

This waste has been in place for fifteen to thirty years, and ongoing monitoring peripheral to the site has not indicated that significant groundwater contamination is occurring from the contained wastes. Disturbance of these materials by excavation may initiate release of contaminants bound within the fill and create a contaminant plume within local groundwaters and potentially surface waters.

Excavation and removal of the wastes contained in the Upper Embankment would require pumping and removal of adequate volumes of groundwater to assure safe working conditions. This in turn may require removal of waters in the A8 Pond in order to minimise the risk of flood inundation of the area of excavation. Transport of saturated excavated waste to an alternative disposal area may be extremely difficult to facilitate, and the quality of the waste material may require a specialised waste disposal facility.

The contrast between the level of contaminants in the waste groundwaters and the leachate waters indicates that the groundwater is, as should be expected, not moving toward the ponds or the canal more than marginally. It is, however, likely that the leachate collection system is receiving inflow both from the Primary Solids groundwaters and the Urupa Canal, which would explain the low level of contaminants in these waters. Nonetheless, the quality of the groundwaters as represented in the Upper Embankment bores does not indicate significant contamination.

The TCLP testing also indicates that the contaminants are attenuated in the waste material and are not highly available to percolating waters.

The levels of contamination in the Upper Embankment groundwaters do not preclude its pumping and disposal to the Norske Skog water treatment ponds.

6.0 References

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