SITE SUITABILITY FOR SPRAY IRRIGATION OF STORMWATER AND LOG SPRINKLER WASTEWATER IN STAGES 1 AND 2 AT THE SOUTHWOOD PROCESSING COMPLEX, SOUTHERN TASMANIA.

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SUMMARY

An investigation of soil and site attributes was carried out on land adjacent to the Southwood processing complex in southern Tasmania (Stage 1) and in a plantation located to the north (Stage 2) to determine site suitability for spray irrigation of stormwater and log sprinkler wastewater. Soil profiles were examined in 26 pits in Stage 1 and 9 pits in Stage 2 dug to depths up to 1.5m using a 7 tonne excavator. Soils in Stage 1 were generally shallow (< 45cm) or moderately deep (45-90cm) with only 8% of the sites inspected having deep (>90cm) soils. In contrast, deep (> 1.5m) soils predominated in Stage 2.

Qualitative ratings of soil drainage class, permeability class and stone content were used in conjunction with soil depth to assess soil limitations for irrigation suitability. Likewise, ratings of landform, slope angle, surface rock cover and flood risk were used to assess topographic limitations for irrigation suitability.

The results indicate that the land adjacent to the Southwood complex (Stage 1) is mostly marginally suitable for spray irrigation due to slow to very slow soil permeability and consequent risk of causing soil saturation and surface runoff. However, use of a larger land area would minimise this risk. Soils in Stage 2 were all deep with moderately slow permeability, and this area was rated as being suitable for spray irrigation.

INTRODUCTION

Stage 1 of the Southwood project in southern Tasmania proposed the disposal of stormwater and log sprinkler wastewater via a land-based irrigation scheme immediately adjacent to the sawmill. However, preliminary investigation revealed the presence of a massive, thick, impermeable, compact/cemented alluvial layer on or near the surface surrounding the sawmill site. This area is unsuitable for spray irrigation, even with the incorporation of a respread topsoil layer c. 150mm thick. Subsequent soil and site investigations were concentrated on undisturbed forest areas to the west of the sawmill site. Under Stage 1 the stormwater and wastewaters are to be stored over winter/spring for disposal by irrigation over the summer/autumn period.

Stage 2 of the project proposes extending the irrigation scheme northwards into a eucalypt/blackwood plantation (BB103F). This area was investigated at the same time as the area proposed under Stage 1.

METHODS

Using a 7 tonne excavator, inspection pits were dug to depths of about 1.5m or to shallower depths if bedrock was present. A total of 26 pits were examined in the Stage 1 area (Fig.1) together with 9 pits in the Stage 2 area (Fig. 2) to determine soil depth, texture and colour. These attributes were then used to assess soil drainage and permeability classes. At each site slope angle, landform and substrate were also recorded. A summary of depth to bedrock, topsoil and subsoil textures, drainage class, permeability class and slope angle for each site is appended (Appendix 1). Soil samples from representative sites (pits 3 and 25 from Stage 1, and pits 27 and 30 from Stage 2) were collected for laboratory analysis of pH, electrical conductivity, organic matter content, total phosphorous, cation exchange capacity and exchangeable sodium. These tests were recommended by Gutteridge, Haskins and Davey Pty Ltd (2003) for assessment of soil salinity, soil sodicity and dispersion hazards, and organic matter loadings. Wet-sieving tests were carried out on samples from pit 27 to determine the proportion of water-stable aggregates and derive a rating of soil erodibility.

Classification systems for assessing site suitability for effluent irrigation of plantations (Bond 2002, adapted from Hird *et al*. 1996) and suitability of land for irrigation with water (Griffiths 1975) were adapted for the purposes of this investigation. Both systems include topographic criteria as well as soil attributes that are taken into consideration when assessing the overall land (or site) suitability for irrigation. The system of Bond (2002) includes phosphate sorption properties of soils, but as this attribute is concerned solely with irrigation of effluent, it was deleted from the classification used for this report.

ENVIRONMENTAL ATTRIBUTES

At the Stage 1 area topography is dominated by undulating to easy rolling concave lower hill slopes in the eastern part inspected, with undulating to easy rolling convex hill slopes and subsidiary ridge crests in the western part. Substrates are mainly relatively strongly weathered Permian fine sandstones and siltstones with old (Tertiary/early Quaternary?)

alluvium overlying Permian sedimentary rocks occurring in some places in the western part of the area inspected. Native vegetation is mainly an open dry eucalypt forest with a thick cover of tea-tree and ferns with buttongrass in places. Mean annual rainfall is approximately 1000mm.

At the Stage 2 area substrates are mainly Quaternary slope deposits (colluvium) derived from Jurassic dolerite and/or mixed dolerite and Permian sedimentary rocks. It is thought that the slope deposits overlie Permian sedimentary rocks at depths below about 2m. Topography comprises undulating and easy rolling mid and lower hill slopes with a pronounced hummocky relief that is probably related to deep-seated slumping. The vegetation is a young eucalypt and blackwood plantation.

CLASSIFICATION SYSTEM FOR ASSESSING SITE SUITABILITY FOR SPRAY IRRIGATION

Topographic attributes

The topographic attributes used to assess site suitability for irrigation are shown in Table 1. The key topographic features that affect site selection are; slope, landform, surface rock, and susceptibility to flooding or frequent waterlogging. Values of each attribute are listed according to increasing severity of limitation using the terms slight, moderate and severe. Sites with severe limitations are unlikely to be suitable for irrigation, whereas those with slight limitations are considered to be highly suitable. Sites with moderate limitations may require more costly on-site works and impose more restrictions on the design and management of irrigation.

Soil attributes

The soil attributes considered important for selecting sites for irrigation are outlined in Table 2. They include permeability class (hydraulic conductivity), depth to bedrock or thick, massive hardpan, soil drainage class and stone content. Permeability is independent of climate and drainage, and is controlled by the potential of the soil to transmit water (saturated hydraulic conductivity) of the least permeable layer in the soil. Permeability class is inferred from soil morphological characteristics such as texture, structure, porosity, cracks and shrink-swell properties. Permeability classes can be converted to approximate values of saturated hydraulic conductivity as follows:
Slowly permeable = <0.01m/day (McDonald *et al*. 1990) or 0.024m/day (McKenzie and Cresswell. 2002),
Moderately permeable = 0.01-1.0m/day (McDonald *et al.* 1990) or 0.24m/day (McKenzie and Cresswell 2002),
Highly permeable = >1.0m/day (McDonald *et al.* 1990) or >2.4m/day (McKenzie and Cresswell 2002).

The most suitable soils are deep, well drained and moderately permeable with a good water-holding capacity (not sandy or stony). The least suitable are deep sandy and gravelly soils with poor water-holding capacity, or shallow soils with slow permeability, heavy clay soils and poorly /very poorly drained soils which are all easily saturated.

Table 1. Topographic limitations for assessing suitability for spray irrigation (Bond, 2002)

Attribute	Limitation: Slight	Limitation: Moderate	Limitation: Severe	Comments
Slope (%)	<6	6 – 12	>12	Excess runoff, erosion risk
Flooding	none – rare	Occasional	Frequent	Erosion, waterlogging, increased recharge
Landform	Hillcrests, convex sideslopes, plains	Concave sideslopes, footslopes	Depressions incised channels	Erosion and waterlogging risk
Surface rock outcrop (% cover)	Nil	0 – 5	>5	Interferes with site preparation, may infer shallow and/or stony soils, risk of runoff

Table 2. Soil limitations for assessing suitability for irrigation (adapted from Bond 2002, Griffiths 1975).

Attribute	Limitation: Slight	Limitation: Moderate	Limitation: Severe	Comments
Permeability class	Moderate	Moderately slow or mod. fast	Slow to very slow	Affects runoff and risk of waterlogging.
			Fast to very fast	Acts as a poor filter
Soil depth (cm)	>90	45 – 90	<45	Affects soil water storage and risk of waterlogging.
Soil drainage class	Well or moderately well drained	Imperfectly drained	Poorly, very poorly drained	Affects risk of waterlogging
Stone content (%)	<20	20 – 40	>40	Affects soil water storage

ASSESSMENT OF SITE SUITABILITY OF STAGE 1 FOR IRRIGATION

Topographic limitations

Comparison of site characteristics at the Stage 1 area (Appendix 1) with criteria in Table 1 show that most sites inspected (69%) have moderate limitations of slopes between 6-12%. Only 2 sites (8%) have severe limitations due to relatively steep slopes >12%. Surface rock, flood risk and landform are not generally severely limiting in the Stage 1 area.

Soil limitations

For the 26 pits inspected at the Stage 1 disposal area, soil depth ranged from 28-110cm with a mean depth of 57cm to bedrock or thick, massive hardpan (Appendix 1). Of these, 10 (38% of total sites) were < 45cm thick, 14 (54%) were between 45-90cm and only 2 (8%) were > 90cm thick. Soil textures mainly varied from peaty loams and humic sandy loams in surface layers to sandy loams, silt loams and clay loams in subsurface layers. Deeper soils had light clay or clay loam textures in subsoils. These textures are considered to have good water-holding characteristics. At all sites the stone content in the profile above bedrock or hardpans was minor (<20%).

Soil drainage class varied from well drained to imperfectly/poorly drained with 20 sites (77%) having imperfect or imperfect to poor drainage. Soil permeability class ranged from moderately slow to very slow with 11 sites (42%) having slow permeability and 9 sites (35%) with slow/very slow permeability.

Laboratory analytical data (Appendix 2) show that the soils have very low electrical conductivity (EC) and low total phosphorus (P) throughout the profile, whereas organic carbon (C) ranges from high in surface layers to low in subsoils, and cation exchange capacity (CEC) varies from very high in topsoils to moderate in subsoils. The very low values for EC indicate that soluble salt contents are low/very low throughout the profiles. Levels of exchangeable cations range from very low to moderate in surface layers, with very low levels of exchangeable sodium throughout subsoils. The analytical data indicate that soil chemical properties are unlikely to adversely affect soil suitability for irrigation.

Most (81%) of the sites inspected are classified as having severe limitations for irrigation due to slow to very slow soil permeability, with 38% of these also having shallow (<45cm) soil depth. Only 5 sites (19%) have slight or moderate limitations for irrigation.

Figures 3 and 4 show typical soil profiles in the Stage 1 area. The profile in Figure 3 (pit no. 3) has relatively shallow depth (45cm) to bedrock. Figure 4 shows an imperfectly to poorly drained profile (Pit no. 18) with slow to very slow permeability.

ASSESSMENT OF SITE SUITABILITY OF STAGE 2 FOR IRRIGATION

Topographic limitations

At the Stage 2 area nearly all sites inspected had only slight or moderate limitations due to slope steepness. Only 1 site exceeded 12% slope (severe limitation). Landform, flood risk and surface rock outcrop generally are only slightly limiting.

Soil limitations

The 9 pits inspected are all deep (>1.5m) with mainly clay loam surface soil layers overlying light clay to light/medium clay subsoils (Appendix 1). Stone content is generally <20%. Drainage class varies from moderately well at 3 sites (33% of total) to imperfectly drained at 6 sites (67%). Permeability class was estimated as moderately slow at all sites.

Laboratory data (Appendix 2) show that the 2 soils analysed have somewhat similar chemical properties as those in Stage 1, although topsoils in Stage 2 have higher total P and lower organic C than topsoils in Stage 1. The subsoils in pit 27 also have high to very high levels of exchangeable sodium at depths below 50cm compared to low/very low levels in Stage 1 subsoils. The exchangeable sodium percentage (ESP) expressed as a percentage of the exchangeable sodium in relation to cation exchange capacity (CEC) is < 6 and the soils are considered not to be sodic. Sodic soils (ESP > 6) often have related physical limitations of poor permeability, high shrink/swell potential, waterlogging and are often highly dispersive and erodible. However, the results of wet-sieving tests (Appendix 2) show that pit 27 has moderate levels (30-70%) of water-stable aggregates throughout the profile. Taking into account the imperfect drainage soil erodibility is rated as moderate-high. These results are typical of other imperfectly drained forest soils.

The soils are classified as having moderate limitations for irrigation based on their moderately slow permeability and generally imperfect drainage. Typical soil profiles are shown in Figures 5 (pit no. 30) and 6 (pit no. 34).

CONCLUSIONS AND RECOMMENDATIONS

Stage 1 area

1. The high proportion (>80%) of sites with severe limitations infers that most of the area is marginally suitable for irrigation.

2. There is a risk that frequent irrigation could cause saturation of the soil and lead to surface runoff and increased recharge of groundwater during the drier summer/autumn period when evapotranspiration normally exceeds rainfall.

3. Selection of a larger land area for irrigation may be a feasible option to minimise the risk of soil saturation and surface runoff.

Stage 2 area

1. All the soils inspected have only moderate limitations and hence appear to be suitable for irrigation with stormwater/wastewater.

2. However, the moderately slow permeability and imperfect drainage of the soils infers that only limited irrigation will be feasible during the winter/spring period due to the high risk of saturating the soils and inducing surface runoff and/or recharge of groundwaters.

3. Advice should be sought from an engineering geologist or similar earth science specialist regarding the impact of irrigation on slope stability. It is possible that irrigation with stormwater/wastewater could cause prolonged saturation of deeper subsoil layers and initiate further slumping or other forms of mass movement, and appropriate risk assessments should be obtained.

ACKNOWLEDGEMENTS

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Figure 1: Locations of soil pits at Stage 1 site

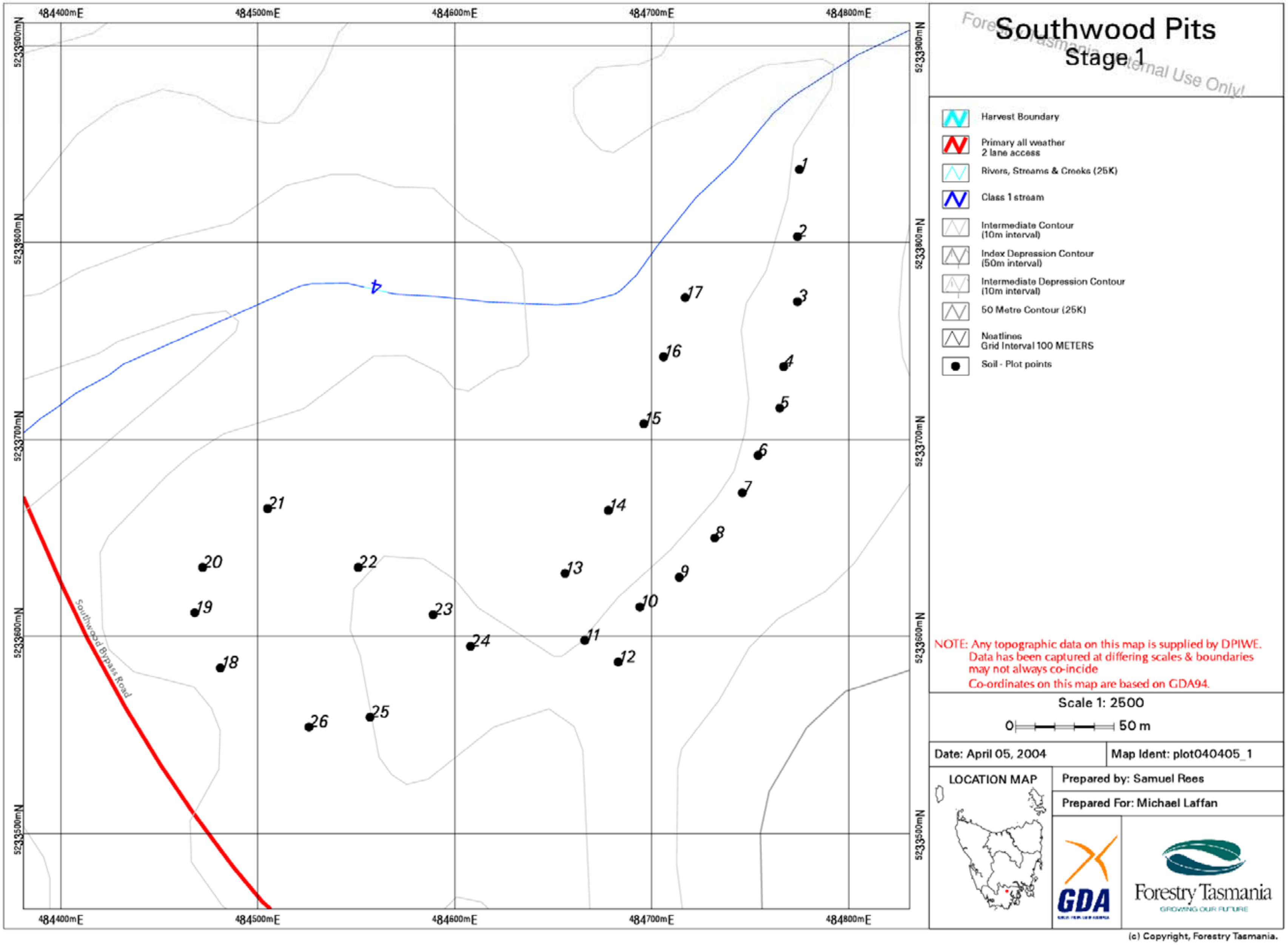


Figure 2: Location of soil pits at Stage 2.

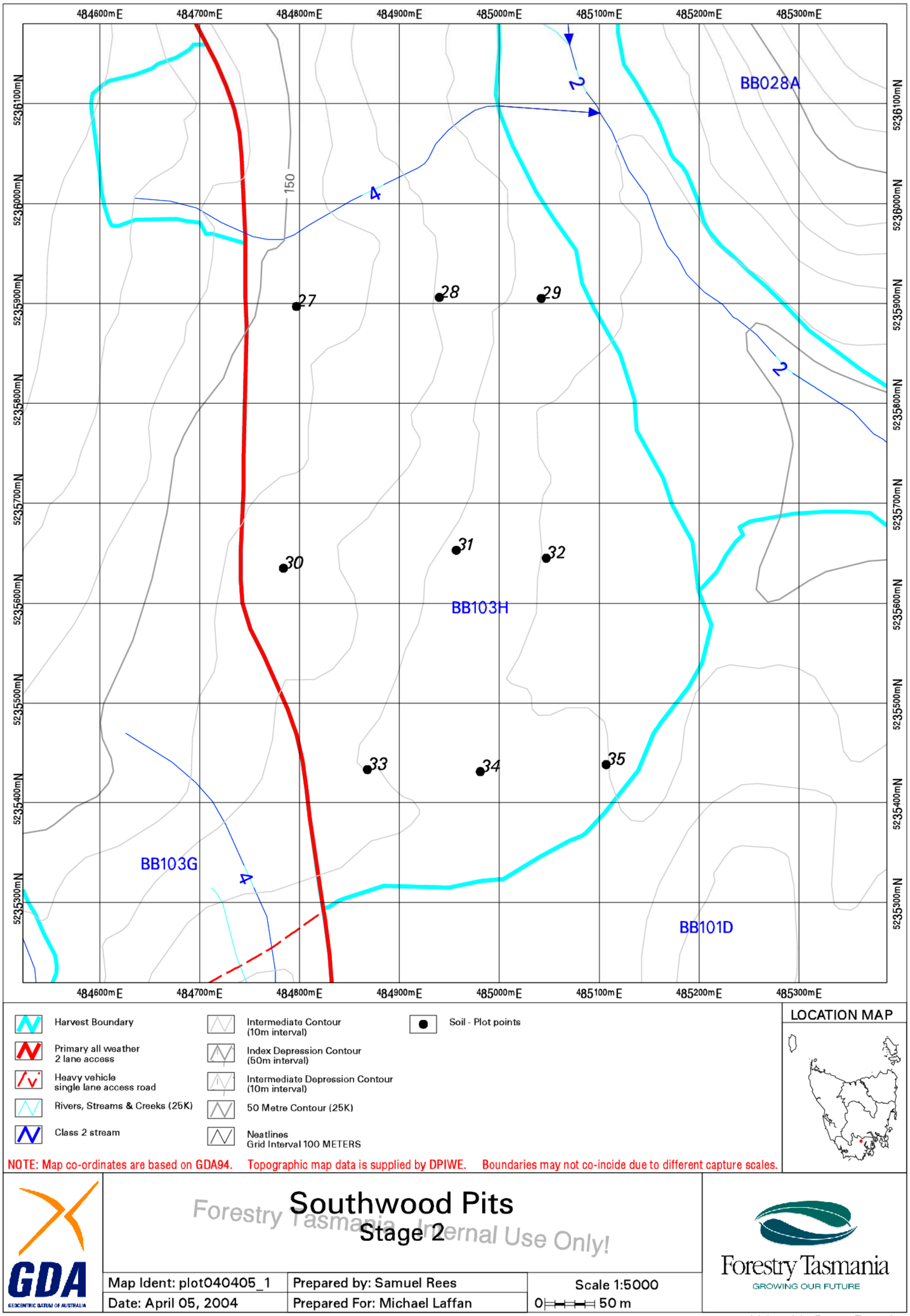


Figure 3: Typical Soil Profile at Stage 1 (Pit 3)

Figure 4: Secondary Soil Profile at Stage 1 (Pit 18)

Figure 5: Typical Soil Profile at Stage 2 (Pit 30)

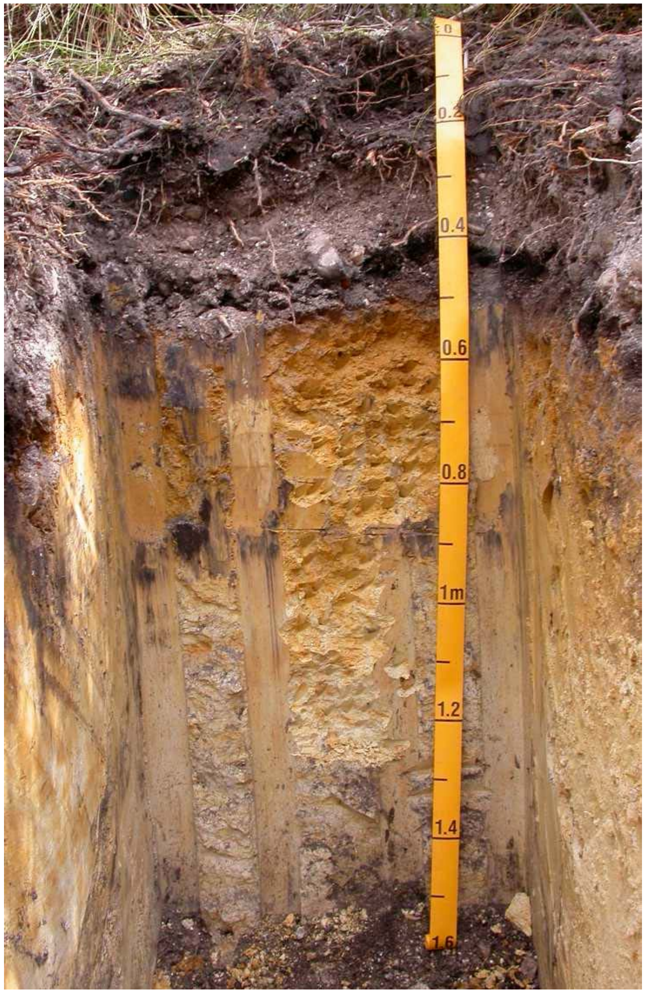
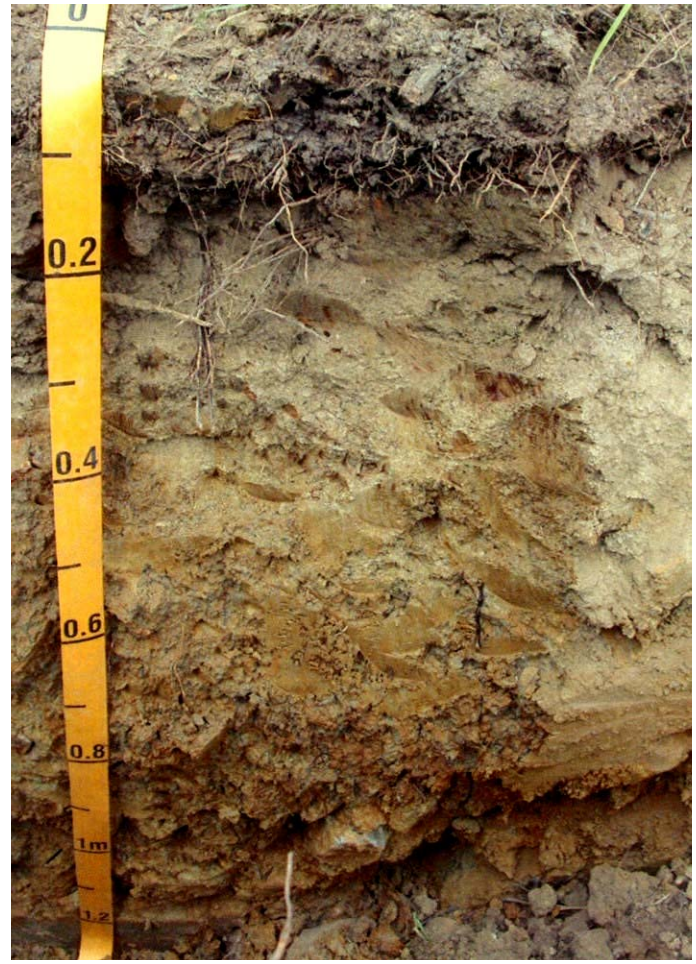


Figure 6: Secondary Soil Profile at Stage 2 (Pit 34)



Appendix 1: Summary of site and soil features for Stages 1 and 2, Southwood site

Pit No. *	Depth to Bedrock	Topsoil texture	Subsoil texture	Drainage	Permeability	Slope %
1	48	HSL/CL-	LC	I/P	S	10
2	39	PL/HCL		I/P	S/VS	8
3	45	PL/CL	CL	I	S	5
4	41	PL/CL-		I/P	S/VS	6
5	67	HL/CL-	L	I/P	S/VS	8
6	60	PSL/SL	HL/CL	I	S	9
7	56	PL/HZL		I/P	S/VS	11
8	45	PL/CL-	LC	MW/W	S	12
9	62	PL/ZL	LC	W	MS	12
10	40	PL/ZL	LC	W	MS	18
11	39	FSL/CL+	CL+	W	S	5
12	85	PL/ZL	CL/LC	W	MS	5
13	28	HZL/ZCL	LC	I/P	VS	10
14	42	HZL/ZCL	ZLC	I	S	8
15	86	HL/HZL		I/P	S	9
16	36	HL/ZL	LC	I/P	S/VS	6
17	70	ZL/ZCL	ZLC	MW	MS	10
18	60	HSL/LS		I/P	S/VS	5
19	44	HSL/SL		I/P	S/VS	5
20	42	HSL/SL		I/P	S/VS	5
21	100	HSL/ZL+	CL	I	MS	8
22	110	PL/SL	LC	I	MS/S	12
23	60	HL/ZL	HZL	I/P	S	7
24	38	HL/ZCL	ZCL	I/P	S	13
25	80	HL/SL	ZLC	I	S	10
26	56	HSL/LS	CL	I	S	12
27	>150	L/CL	LMC	I	MS	10
28	>150	CL	LC/LMC	MW	M/MS	15
29	>150	CL	LC/LMC	I	MS	8
30	>150	ZL	CL/LMC	I	MS	7
31	>150	CL	LC/LMC	I/P	MS/S	0
32	>150	CL	LC/LMC	I	MS	3
33	>150	CL	LC	MW	MS	5
34	>150	CL	LC/LMC	MW	M/MS	2
35	>150	CL	LC/LMC	I	MS	2

* Pits 1-26 refer to Stage 1, pits 27-35 refer to Stage 2.

Appendix 2. Laboratory analyses for soil samples from Stage 1 (pits 3 and 25) and Stage 2 (pits 27 and 30).

Depth	pH	EC	Org C	Total P	CEC	Ex.[1]Ca	Ex.[1]Mg	Ex.[1]K	Ex.[1]Na	Aggreg[2]
(cm)		(dS/m)	%	%		mequiv./100g				%
Pit 3 (Stage 1)										
0-15	3.8	0.074	9.1	0.0086	44	0.25	1.8	0.29	0.34	
15-26	3.9	0.026	2.8	0.0053	16	-	-	-	0.05	
26-45	4.4	0.022	1.6	0.0044	27	-	-	-	0.04	
Pit 25 (Stage 1)										
0-20	3.8	0.054	11.8	0.0055	44	0.84	3.1	0.24	0.48	
20-36	4.3	0.013	1.6	0.0022	2.9	-	-	-	0.05	
36-43	4.0	0.028	4.9	0.0053	29	-	-	-	0.05	
43-80	4.4	0.014	0.5	0.0037	19	-	-	-	0.03	
80-120	4.4	0.015	0.1	0.0047	13	-	-	-	0.06	
Pit 27 (Stage 2)										
0-10	4.7	0.058	5.9	0.0210	25	-	-	-	0.19	70
10-25	5.1	0.023	1.0	0.0074	9.8	-	-	-	0.14	-
25-50	5.4	0.020	0.6	0.0063	16	-	-	-	0.40	66
50-80	5.4	0.027	0.5	0.0047	35	3.3	8.2	0.14	1.16	64
80-100	5.3	0.038	0.4	0.0039	40	4.3	12.3	0.17	2.08	52
Pit 30 (Stage 2)										
0-10	4.5	0.028	4.5	0.0179	28	-	-	-	0.16	
10-30	4.7	0.014	1.9	0.0087	13	-	-	-	0.07	
30-55	4.8	0.012	0.7	0.0057	11	-	-	-	0.09	
55-100	4.9	0.015	0.4	0.0042	18	-	-	-	0.19	
100-150	5.0	0.019	0.2	0.0032	18	-	-	-	0.26	

[1] Exchangeable cations
[2] Water-stable aggregates > 0.25mm from wet-sieving tests