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AGRICULTURAL & NATURAL RESOURCE MANAGEMENT

Via email; amy@grubbconsulting.com.au

27 February 2015

Dear Beau,

Land Capability for proposed Strathroy Agripark Industrial Subdivision

I have reviewed the following assessment report which contains Land Capability information relevant to the assessment area (proposed Strathroy Agripark Industrial Subdivision);

Armstrong, D. 2004, *Proposed rezoning and subdivision, Prospect Report on land and agricultural issues*, unpublished report by Armstrong Agricultural Services for Mr BP Grubb.

For the purposes of this assessment it was considered appropriate to re-assess the Land Capability of the current proposed development area at a scale of 1:10 000 and a site visit was undertaken by David Armstrong and Astrid Ketelaar on 24/02/15. Land Capability was assessed as per Grose (1999)[1] Land Capability Handbook of Tasmania. The results are shown in Appendix 1 - map and Land Capability definitions are in Appendix 2.

The development area (60ha) is a mix of Class 4, Class 4+5, Class 5 and Class 6 and is relatively limited for agricultural use due to Land Capability limitations, lack of an irrigation water resource and isolation from the main farming area. The most likely agricultural use is grazing with an occasional dryland cereal crop in the north western portion (approx 10 ha). There is no Prime Agricultural Land (Class 1 – 3) within the development area or in the vicinity of the development area.

Yours Sincerely,

A.Ketelaar

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[1] Grose, CJ 1999, *Land Capability Handbook. Guidelines for the classification of Agricultural Land in Tasmania* (Second Edition ed.). Tasmania, Australia, DPIWE

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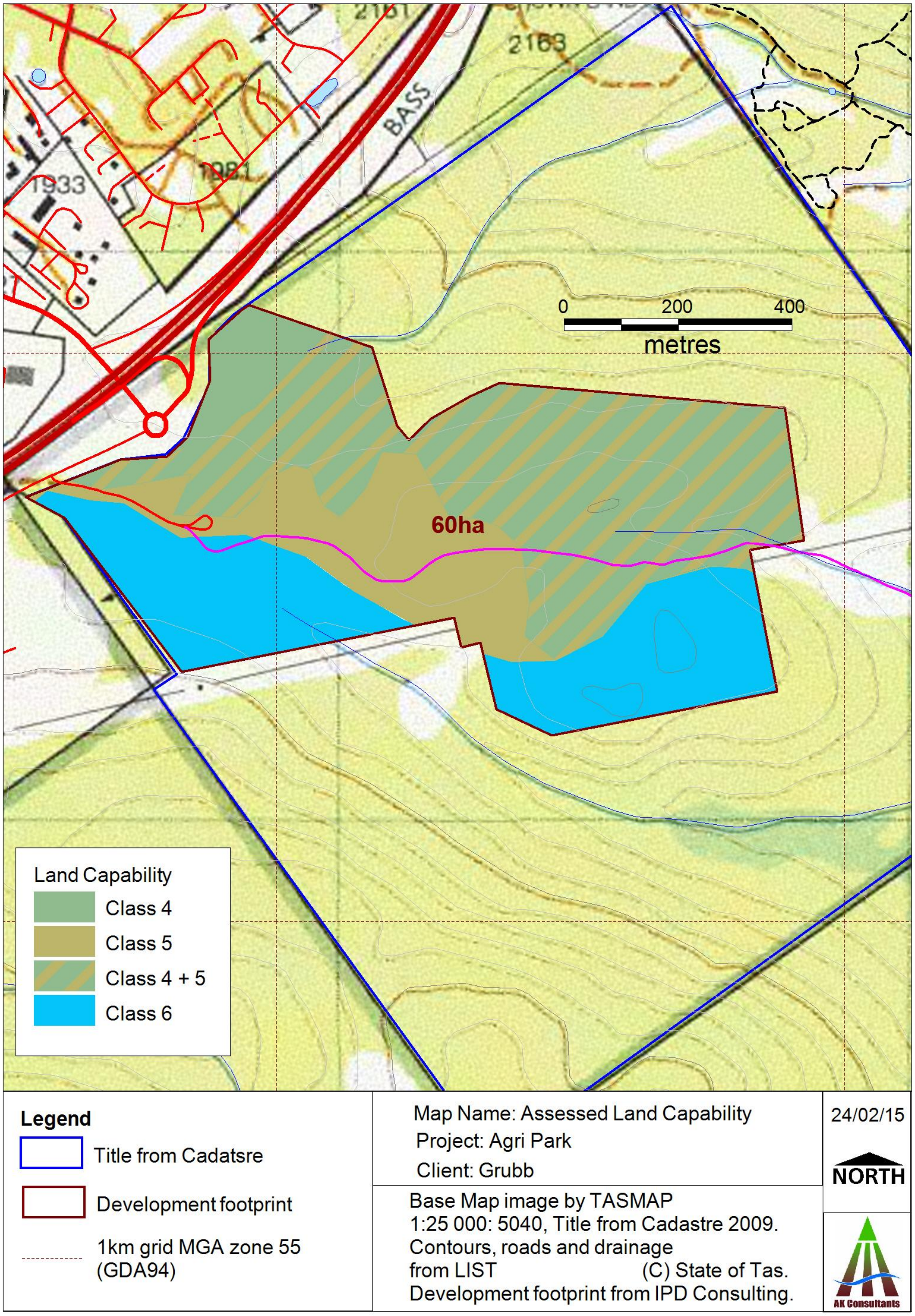
APPENDIX 1 – ASSESSED LAND CAPABILITY



APPENDIX 2. LAND CAPABILITY DEFINITIONS FROM GROSE (1999)

CLASS 1. Land well suited to a wide range of intensive cropping and grazing activities. It occurs on flat land with deep, well drained soils, and in a climate that favours a wide variety of crops. While there are virtually no limitations to agricultural usage, reasonable management inputs need to be maintained to prevent degradation of the resource. Such inputs might include very minor soil conservation treatments, fertiliser inputs or occasional pasture phases. Class 1 land is highly productive and capable of being cropped eight to nine years out of ten in a rotation with pasture or equivalent without risk of damage to the soil resource or loss of production, during periods of average climatic conditions.

CLASS 2. Land suitable for a wide range of intensive cropping and grazing activities. Limitations to use are slight, and these can be readily overcome by management and minor conservation practices. However the level of inputs is greater, and the variety and/or number of crops that can be grown is marginally more restricted, than for Class 1 land.

This land is highly productive but there is an increased risk of damage to the soil resource or of yield loss. The land can be cropped five to eight years out of ten in a rotation with pasture or equivalent during 'normal' years, if reasonable management inputs are maintained.

CLASS 3. Land suitable for cropping and intensive grazing. Moderate levels of limitation restrict the choice of crops or reduce productivity in relation to Class 1 or Class 2 land. Soil conservation practices and sound management are needed to overcome the moderate limitations to cropping use. Land is moderately productive, requiring a higher level of inputs than Classes I and 2. Limitations either restrict the range of crops that can be grown or the risk of damage to the soil resource is such that cropping should be confined to three to five yens out of ten in a rotation with pasture or equivalent during normal years.

CLASS 4. Land primarily suitable for grazing but which may be used for occasional cropping. Severe limitations restrict the length of cropping phase and/or severely restrict the range of crops that could be grown. Major conservation treatments and/or careful management is required to minimise degradation. Cropping rotations should be restricted to one to two years out of ten in a rotation with pasture or equivalent, during 'normal' years to avoid damage to the soil resource. In some areas longer cropping phases may be possible but the versatility of the land is very limited. (NB some parts of Tasmania are currently able to crop more frequently on Class 4 land than suggested above. This is due to the climate being drier than 'normal'. However, there is a high risk of crop or soil damage if 'normal' conditions return.)

CLASS 5. This land is unsuitable for cropping, although some areas on easier slopes may be cultivated for pasture establishment or renewal and occasional fodder crops may be possible. The land may have slight to moderate limitations for pastoral use. The effects of limitations on the grazing potential may be reduced by applying appropriate soil conservation measures and land management practices.

CLASS 6. Land marginally suitable for grazing because of severe limitations. This land has low productivity, high risk of erosion, low natural fertility or other limitations that severely restrict agricultural use. This land should be retained under its natural vegetation cover.

CLASS 7. Land with very severe to extreme limitations which make it unsuitable for agricultural use.

Proposed rezoning and subdivision, Prospect

Report on land and agricultural issues

Report for: Mr.B.P.Grubb,
"Strathroy",
Launceston.

Prepared by: Mr. David Armstrong,
Agricultural Consultant,
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40 Tamar Street, LAUNCESTON. TAS 7250

Date: 31st March, 2004

Armstrong
AGRICULTURAL SERVICES PTY LTD

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Proposed rezoning and subdivision, Prospect

Report on land and agricultural issues

1. Executive Summary

A subdivision proposal for part of the "Strathroy" property at Prospect plans to create 27 residential titles averaging 2 hectares in area. This report reviews agricultural and particularly salinity issues associated with the proposed development.

The land has been inspected and is classified as Land Capability 4 and 6, and is currently used for grazing. There is no Prime Agricultural Land (Land Capability Classes 1-3) in the proposed area.

The potential for conflict of the subdivision with State policies on Coastal Land, Water Quality Management and the Protection of Agricultural Land has been considered, and no conflicts are apparent.

The agricultural potential of the land is limited to grazing, and occasional cropping of portion, although there is not a readily available source of water for irrigation of crops. Removal of the land from the grazing operations on the remainder of "Strathroy" will have minor impact, reducing the total carrying capacity by only 2-3%.

The potential for salinity risks has been investigated by excavation of test pits, conducting an Electromagnetic survey, and drilling of bores, with analyses of the soil and surface and groundwater for salinity. These investigations indicate there are some high levels of soil and water salinity, generally on the northern side of the proposed subdivision area. Of 16 bores drilled deeper than 2 metres, 6 developed free water. Only one bore showed a static water level shallower than 2 metres (although the water bearing layer was intercepted at drilling at ~4.5m), and this water was highly saline (4.9-7.1 dS/m).

A precautionary approach to the salinity risk is appropriate, with the following actions recommended:

- Monitoring of the water level and salinity in the existing bores over the coming winter.
- Home builders to be encouraged to build on the more elevated land on each title.
- Application of the building techniques described in the publication titled "Building in a saline environment", published by the NSW Department of Infrastructure, Planning and Natural Resources, 2003 (copy included with this report).

2. Background

Land at Prospect currently owned by Mr.B.P.Grubb is proposed to be rezoned and subdivided to provide 27 lots averaging approximately 2 hectares in area.

The land is currently in the "Rural Zone" of Launceston Municipality. This report has been prepared to address issues associated with the application for an amendment to the Launceston Planning Scheme.

The area proposed for subdivision is shown in Figure 1.

Figure 1. Proposed subdivision.

3. Existing conditions

3.1 Land

3.1.1 Slope

The land is gently undulating with slopes generally less than 15%. A portion of the total area on the southern boundary of lots 11 to 14 has steeper slopes up to 35%. All lots have some land that is level or nearly so.

3.1.2 Drainage

The Prospect Tasmap sheet (1:25,000 scale) shows three drainage lines commencing within the proposed subdivision area, including Kings Meadows Rivulet. These drainage lines are all ephemeral, carrying water for only a short time after rain.

The undulating topography ensures that most areas have good surface drainage but with some evidence of surface waterlogging of the topsoil on the flatter land northeast of the existing house. No areas are flood-prone.

3.1.3 Soil types

Soils are predominantly Duplex, with loam, sandy loam to clay loam texture over mottled clay commonly at 45-50 cm (see Photograph 4, typical Duplex profile).

There was no evidence of bleaching of the A2 soil horizon in any of the test pits excavated by others for assessment of septic tank suitability.

The soil characteristics indicate that drainage through most profiles is "imperfect".

3.1.4 Land capability

The key limitations to land capability are:

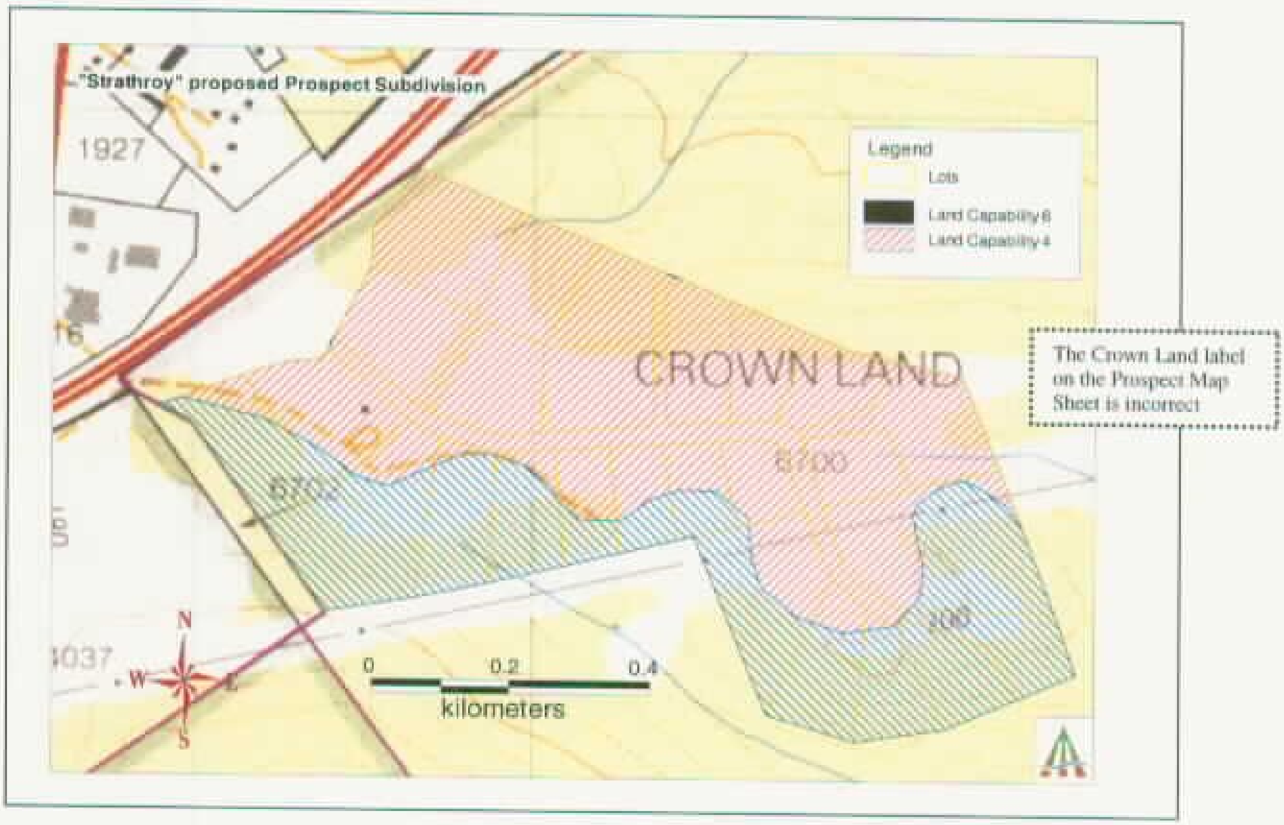
Seasonal waterlogging.
Surface stone and rock.
Slopes.

The land along the southern boundary of the area commonly has 20% surface stones (200-600 mm diameter) and boulders (>600 mm diameter). As such this land can not be cultivated for pasture development or cropping, and is therefore classified as Land Capability Class 6.

Part of the area has slopes greater than 18%, particularly the southeastern portion. The soils here have "low" erodibility, based on soil texture (predominantly loam and sandy loam) and moderate pedality (structure). As a result the erosion risk of slopes greater than 18% is "high", indicating Land Capability Class 5. These erodible areas are also stony and are therefore mapped as LC 6.

The majority of the area has an erosion risk classed as Moderate, with Imperfect drainage. These limitations indicate Land Capability 4.

Figure 2. Distribution of the two Land Capability Classes.



3.2 Existing landuse

The majority of the land is either fully cleared and supporting pasture, or woodland with a low density of Eucalypts with pasture under-story. There are several gorse infestations.

The area has been subdivided with fencing for grazing by sheep and cattle.

Part of the area has been cultivated in the last year, for sowing a fodder crop for grazing by stock. This area has been sown to improved pasture species (autumn 2004).

4. State Policies

4.1 Tasmanian State Coastal Policy, 1996

The three main principles of the State Coastal Policy are:

- Natural and cultural values of the coast shall be protected.
- The coast shall be used and developed in a sustainable manner.
- Integrated management and protection of the coastal zone is a shared responsibility.

The Coastal Zone is defined as the land to a distance of one kilometre inland from the high-water mark.

The land proposed for sub-division is more than one kilometre inland and thus excluded from this policy.

4.2 State Policy on Water Quality Management 1997

The purpose of this Policy is "to achieve sustainable management of Tasmania's surface water and groundwater resources by protecting or enhancing their qualities while allowing sustainable development....".

Specific objectives focus on maintaining or enhancing water quality, avoiding pollution, sharing management responsibility and the promotion of integrated catchment management.

The proposed subdivision is in the upper catchment of Kings Meadows Rivulet. While there are no permanent streams, runoff in winter and from summer storms could be contaminated. The hard surfaces resulting from urban development will increase the quantity and speed of runoff, and the potential for water to be polluted.

It is concluded that the risks of pollution from this subdivision are low because of the low density of development (lots average about 2 hectares).

4.3 State Policy on the Protection of Agricultural Land 2000

The purpose of this policy is to foster sustainable agriculture in Tasmania by ensuring the continued productive capacity of the State's agricultural land resource. The key principle of the policy is to protect prime agricultural land from conversion to non-agricultural use and development, and to ensure non-agricultural use and development does not unreasonably fetter agricultural uses.

Prime agricultural land is defined as Class 1, 2 or 3 using the Class Definitions from the Land Capability Handbook (KE Noble, Department of Primary Industry, Tasmania, 1992).

None of the land in the proposed subdivision is classified as Prime Agricultural land. As a result, conversion of the land to non-agricultural use is not in conflict with the State Policy.

5. Agricultural potential of the land

The land has been classified as predominantly Land Capability Class 4 and Class 6.

The Class 4 land could be used for occasional cropping (the recommended intensity is two years cropping in ten, in rotation with pasture). The Class 6 land has major limitations for grazing as cultivation to sow improved pasture species is not feasible.

Without irrigation, cropping would be limited to dryland crops such as cereals, grain legumes and fodder crops. The catchment is too small for the construction of irrigation dams, and the relatively low land capability does not justify irrigation development.

The current land use is close to the potential. While there is potential for clearing some of the remaining trees, and improving the quality of the pastures, such development is expensive relative to the financial returns, and the removal of the trees on the steeper and rocky areas is not recommended on economic or environmental grounds.

The "Strathroy" property has a total area of approximately 1,628 hectares. The sub-division will excise approximately 56 hectares (3.4% of the total).

The numbers of sheep and cattle on property as a whole as at 1 July in the last three years are shown below:

Total stock numbers	1/7/2001	1/7/02	1/7/03
Sheep	5052	4894	4792
Cattle	207	186	206
Total Dry Sheep Equivalents (DSE)*	9078	8752	8888

* Dry Sheep Equivalents is a method of comparing the feed requirements of all livestock relative to a 45 kilogram Merino wether. Thus, on 1/7/01 the property was carrying the equivalent of 9,078 Merino wethers.

The proposed subdivision will reduce the carrying capacity of the property by 200-250 DSE's. The impact on the farming business as a whole will be insignificant.

6. Salinity

6.1 Salinity in the Land System

The proposed subdivision is located within Land System 384131 (Land Systems of Tasmania, Region 4. GJ Pinkard, 1980). Moderate surface salinity has been found in this Land System.

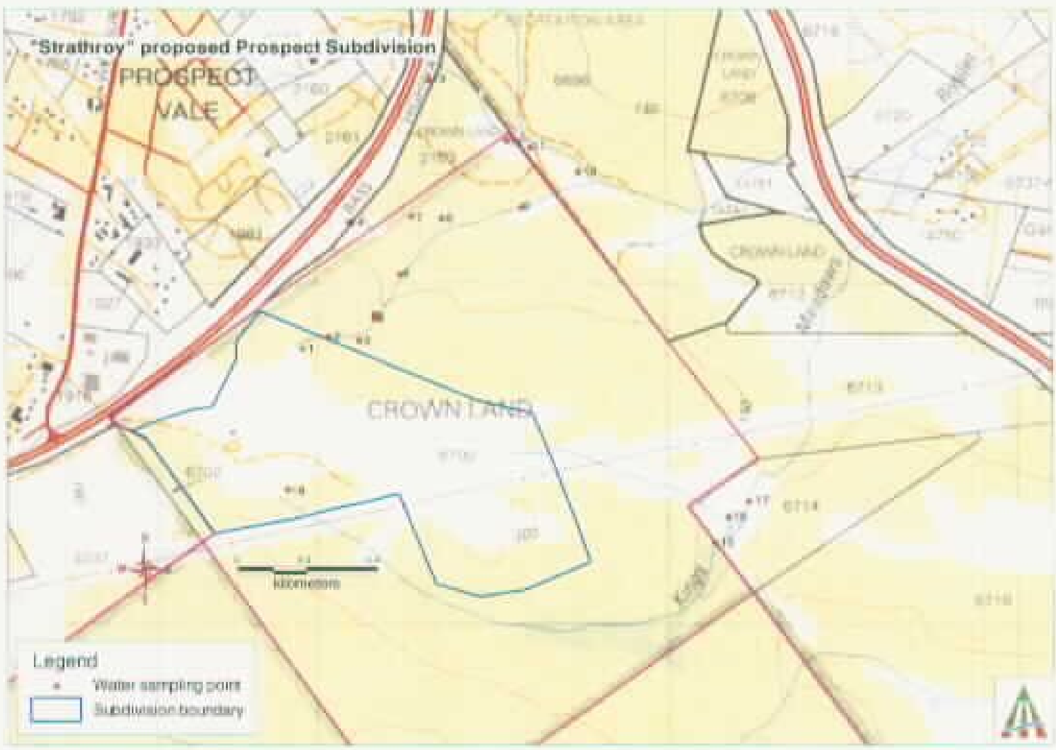
6.2 Surface expressions of soil salinity

Some Sea Barley Grass (*Hordeum marinum*) was noted one of the drainage lines. The grass indicates a relatively low level of soil salinity; as soil salinity increases other salt tolerant plat species predominate before surface scalds (bare areas) appear. No scalds or bare areas indicating higher levels of soil salinity were found.

6.3 Salinity of surface water samples

Surface water salinity levels were measured in drainage lines and dams downstream of the proposed subdivision on 21 November 2003. The sampling locations are shown in Figure 3, and the results in the following table.

Figure 3. Location of sites for testing surface water salinity, 21/11/03.



Salinity testing of surface water samples.

Prospect sites for surface water salinity, snapshot 21 November 2003					
Waypoint	dS/m #	Comments	Salinity Class	Level	Comment
1	0.95	Still water in hole	3	High	Concerns if used for irrigation
2	0.75	Running water	2	Medium	Some limitations for irrigation
3	0.04	Tributary / still water in hole	1	Low	
4	8.85	Constructed water hole	5	Extremely High	Not suitable for irrigation
5	0.03	Running water below water hole	1	Low	
6	0.03	Running water	1	Low	
7	0.03	Head of marsh / barely running	1	Low	
8	0.03	Head of marsh / barely running	1	Low	
9	0.04	Running water in marsh	1	Low	
10	0.06	Swampy / powerlines	1	Low	
11	0.03	Powerlines / rd / KMR	1	Low	
14	0.03	Trib / highway run-off	1	Low	
15	1.60	Dam on trib	3	High	Not suitable for irrigation
16	2.50	Upstream of dam on trib	4	Very High	Not suitable for irrigation
17	8.15	Downstream of dam on trib	5	Extremely High	Not suitable for irrigation
18	4.50	Rubbish pit at head of trib	4	Very High	Not suitable for irrigation

Electrical conductivity of the water sample, deci-Siemens per metre.

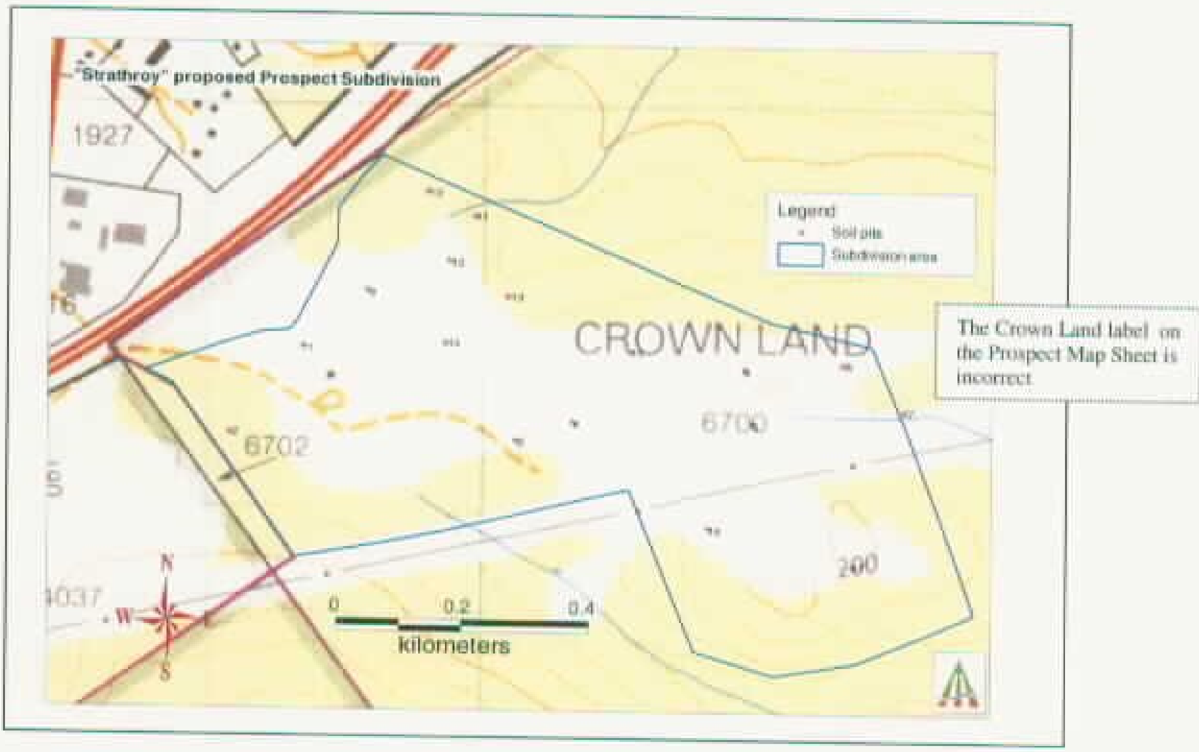
Salinity was elevated to Very High or Extremely High levels at or near dams at four sites downstream of the subdivision area, and was highest in dams where the salinity could have been concentrated by salt inflows and evaporation over a period of years.

These results simply indicate that there is a source of salt in the catchment. This is consistent with WaterWatch observations that the streamflows in Kings Meadows Rivulet often have high levels of salinity.

6.4 Salinity of subsoil clay samples

A number of test pits were excavated in November 2003 to investigate subsoil drainage conditions for the suitability of septic tank soakage and effluent management. Samples of clay from the base of 17 pits were analysed for salinity (electrical conductivity of a 1:5 soil:water suspension). The locations of the pits are shown in Figure 4.

Figure 4. Location of soil pits, November 2003.



Salinity of subsoil samples from the test pits.

Pit	Sample depth (cm)	Conductivity, dS/m $EC_{1:5}$	EC_{se} *	Salinity Class
1	100	0.03	0.39	Low
2	140	.065	0.85	Low
3	70	.04	0.52	Low
4	150	.055	0.72	Low
5	140	.04	0.52	Low
6	150	.32	4.16	Moderate
7	150	.27	3.51	Moderate
8	150	.08	1.04	Low
9	130	.07	0.91	Low
10	130	.035	0.45	Low
11	110	.075	0.98	Low
12	100	0.11	1.43	Low
13	120	0.52	6.76	High
14	130	0.16	2.08	Moderate
15	110	.075	0.98	Low
16	90	0.13	1.69	Low
17	60	.045	0.59	Low

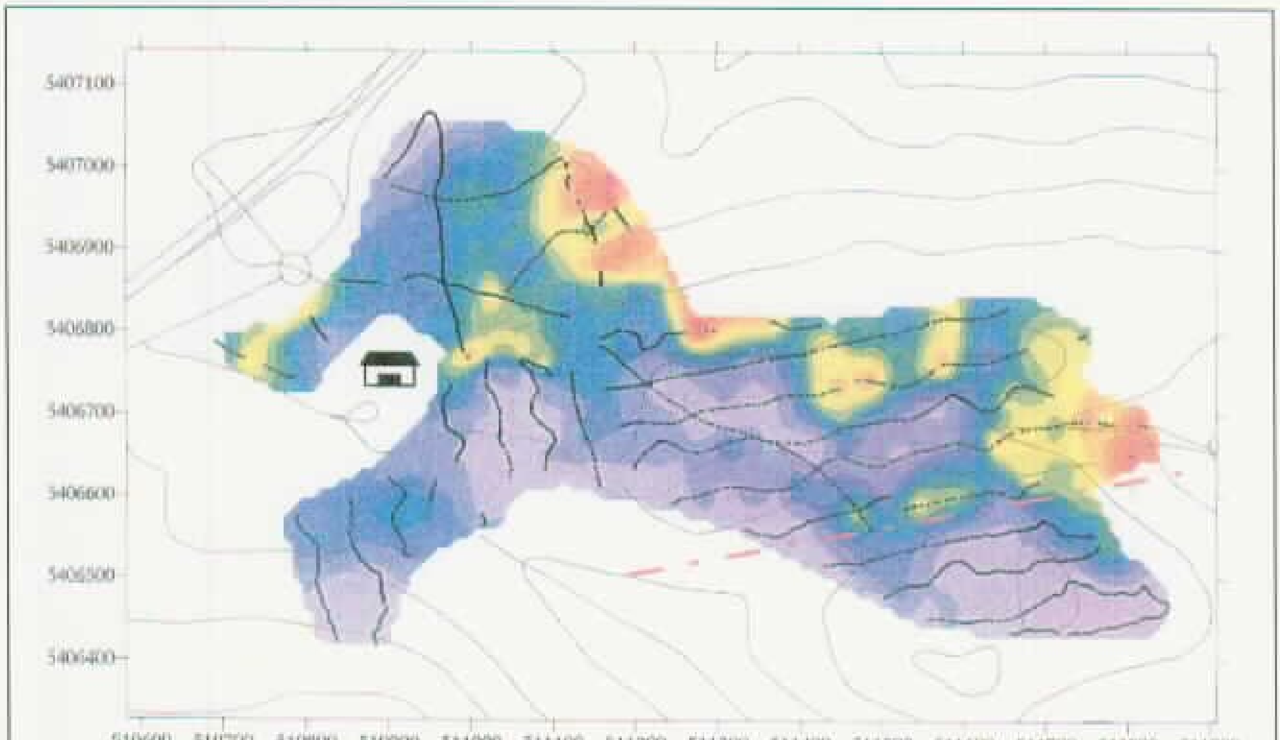
* Calculated Electrical Conductivity of a Saturation Extract (using a soil texture factor of 13). NSW Salt Action salinity limits, Low 0-2, Moderate 2-6, High 6-15, Extreme >15 dS/m.

These soil analyses indicate several areas with Moderate to High concentrations of salt in the subsoil (generally at depths of 1-2 metres) in the proposed subdivision area.

6.5 Electromagnetic (EM) survey for salinity

An EM survey was undertaken by Cambium Land and Water in December 2003 (see report in Appendix 1), using EM31 equipment that measures soil apparent conductivity to a depth of 4-5 metres. The EM readings are used to calculate the estimated Electrical Conductivity (EC) of a Saturation Extract (EC_{se}, a direct soil analysis of soil salinity), using statistical relationships established elsewhere. These EC_{se} records have been mapped to produce a salinity map. Figure 5 shows the raw EM readings from the EM31 instrument, and indicates relatively high readings (in red colour) on the northern boundary of the surveyed area.

Figure 5. Salinity map from EM31 survey.



The raw EM31 data has been converted to an estimated EC_{se} value for the soil profile for the full depth of the EM measurement, approximately 5 metres, with the results shown in Figure 6.

Figure 6. Interpreted EC_{se} map from EM31 measurements

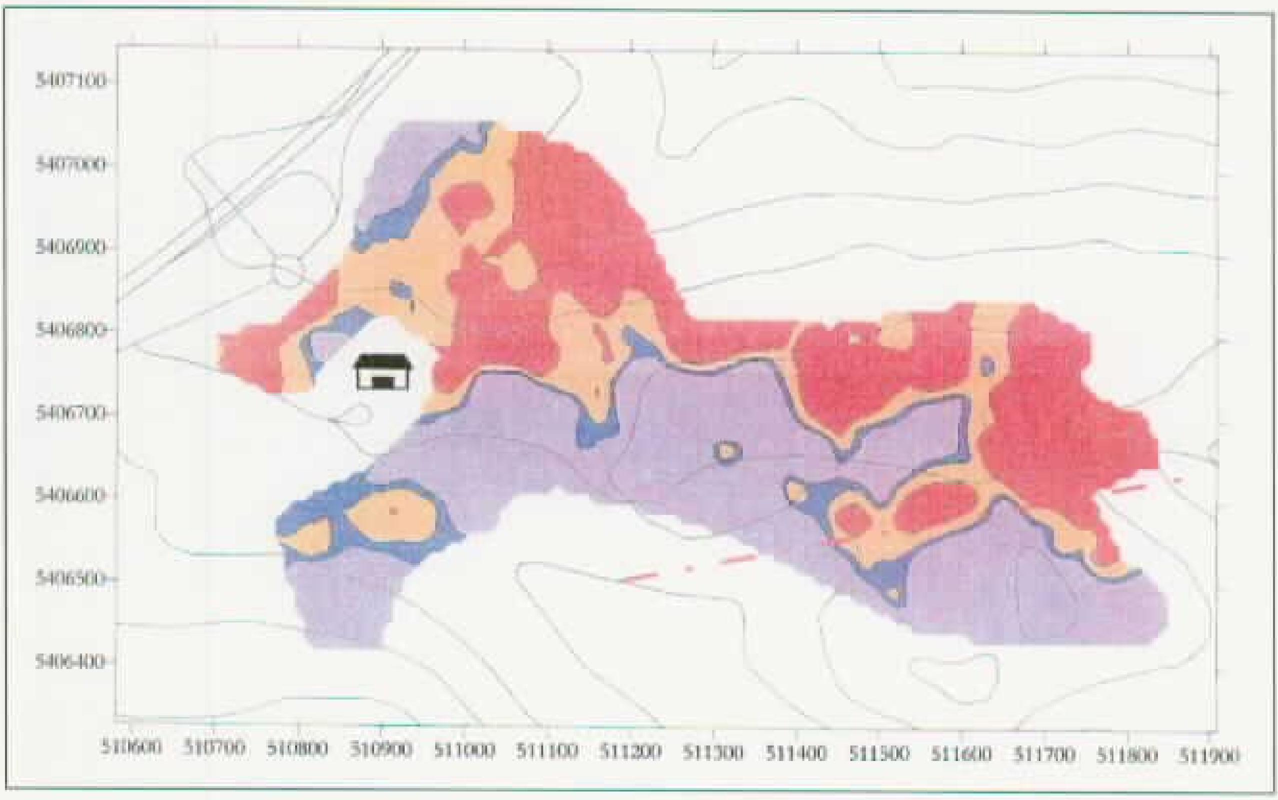


Figure 6 shows high to severe levels of salinity in a considerable proportion of the northern side of the proposed subdivision area. This conversion from raw data to interpreted salinity EC levels is not precise, and in this instance based on work by the DPIWE. To provide field verification of the salinity risks, soil samples of the lower layers of the soil profile were taken by drilling 20 bores to 5-8 metres maximum depth, or to refusal where the drilling rig was unable to penetrate rock (drilling 10 Feb. 2004 and 12 March 2004).

6.6 Drilling of boreholes

Four boreholes were drilled with a 100mm auger on 10[th] February, 2004. Soil samples were collected at approximately 1 metre intervals for salinity analysis ($EC_{1:5}$). The location of the boreholes is indicated in Figure 7, and results of the EC analyses on the soil samples are in the following table. A conversion factor or 13 has been applied to calculate EC_{se} from $EC_{1:5}$.

Figure 7. Locations of all bore sites and the soil $EC_{1:5}$ analyses of samples from the base of each bore.

Soil $EC_{1:5}$ analyses for bores G1-G4.

Depth (m)	G 1	G 2	G 3	G 4
1.0	$EC_{1:5}$ 0.03 dS/m EC_{se} 0.39	0.035/0.45	0.05/0.65	0.09/1.17
2.0	0.45/5.85	0.3/3.9	0.4/5.2	0.055/0.72
4.0	0.38/4.94	0.75/9.75	0.89/11.57	0.44/5.72
6.0	0.24/3.12	0.28/3.64	0.67/8.71	4.5m, 0.53/6.89
8.0	0.29/3.77	8.5m, 0.19/2.47	Refusal at 6.5m	Refused at 4.5m
	Water at ~5.5m; Tested 4.4 dS/m	Water at ~8.0m, not tested	Hole dry	Water at 4.5 m
Water measured on 12/2/04	Depth, 3.4m EC, 5.0 dS/m	3.8m 2.6 dS/m	Dry	1.7m 7.1 dS/m

These four bore holes were all sited low in the landscape and in areas of high EM values and thus elevated soil salinity levels are not surprising. Bores 1 shows moderate levels of salinity, while bores 2, 3 and 4 show high levels at depth. High salinity levels at depths of 4-6 metres are not a major concern, as the salt is so deep that expression on the surface is unlikely.

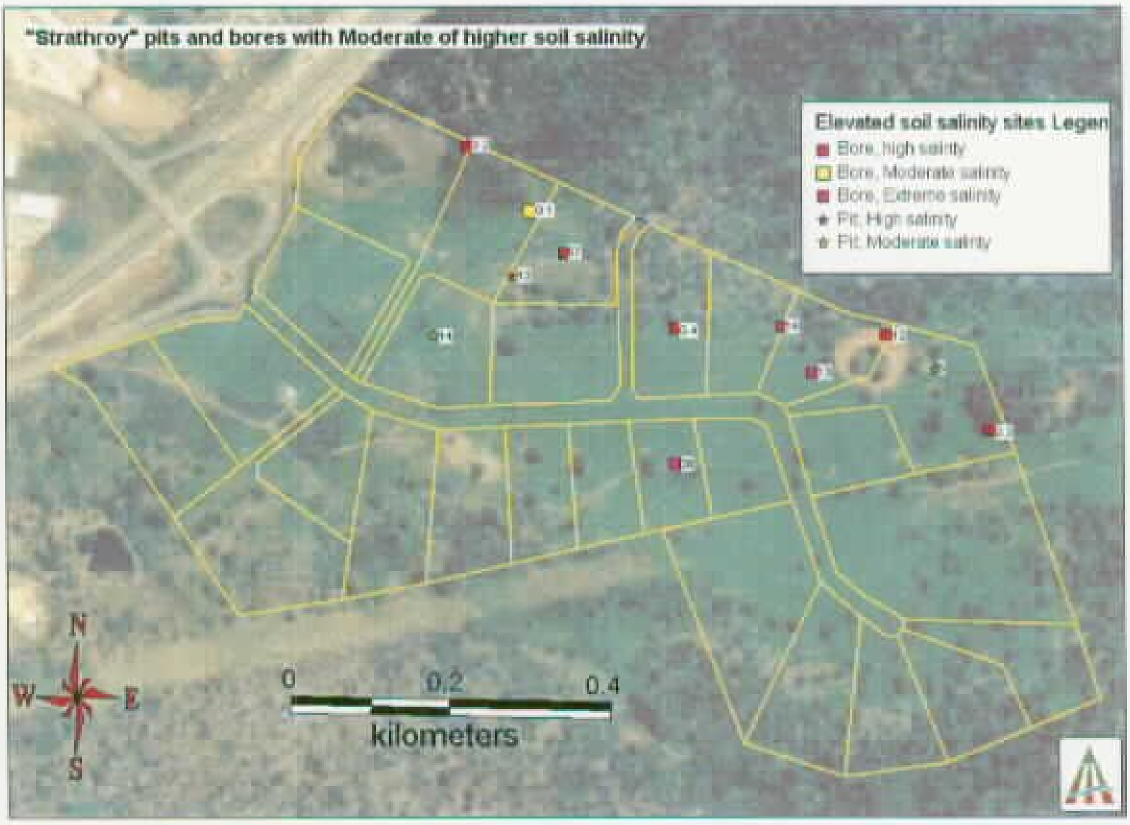
A further 16 bores were drilled on 12th March, to 5 metres or refusal, to provide a more detailed assessment of the depth and salinity of groundwater, and the salinity of the lower material in the soil profiles. Samples from the base of each bore were analysed for salinity, with results in the following table.

Bore ID	Comments	Depth of lowest soil sample and texture	Conversion factor ($EC_{1:5}$ to EC_{se})	Sample salinity $EC_{1:5}$ dS/m/EC_{se}
1	Damp at 1.5m, refusal at 4.75m	4.75m, medium clay	13	0.12/1.56
2		5.0m, clayey sand	16	0.081.28
3	Refusal at 0.5m	Not sampled		
4	Wet sandy clay at 3m, no free water	5.0m, medium clay	13	0.055/0.72
5		5.0m, sandy clay	14	0.15/2.1
6		5.0m, medium clay	13	0.055/0.72
7		5.0m, medium clay	13	1.05/13.65
8		5.0m, medium clay	13	1.2/15.6
9	Refusal at 2.2m	2.2m, sandy clay	14	0.08/1.12
10	Refusal at 0.5m	No sample		
11	Refusal at 0.4m	No sample		
12	Very hard at 5.0m	5.0m, clayey sand	16	0.44/7.04
13	Very wet at 5.0m	5.0m, light clay	13	1.2/15.6
14	Refusal at 4.5m	4.5m, clayey sand	16	0.38/6.08
15	Refusal at 3.5m	3.5m, sandy clay	14	0.09/1.26
16	Refusal at 1.4m	1.4m, clayey sand	16	0.045/0.72

Bores 7, 12 and 14 show high levels at depth, while bores 8 and 13 show extreme levels of salinity at the base of the bore.

The location of all sites (test pits and bores) with Moderate or higher levels of soil salinity are shown in Figure 8.

Figure 8. All Moderate or higher soil salinity bores and pits.



These locations are broadly consistent with the EM31 results. It is noted that the EM survey showed higher readings under the High Voltage Transend transmission lime, and the operator considered the readings in that area may be an artifact of the power line.

It is recognised that there was limited drilling or excavation of pits on the areas where there are rock outcrops. However, development of salinity or the presence of shallow groundwater in these more elevated areas is unlikely.

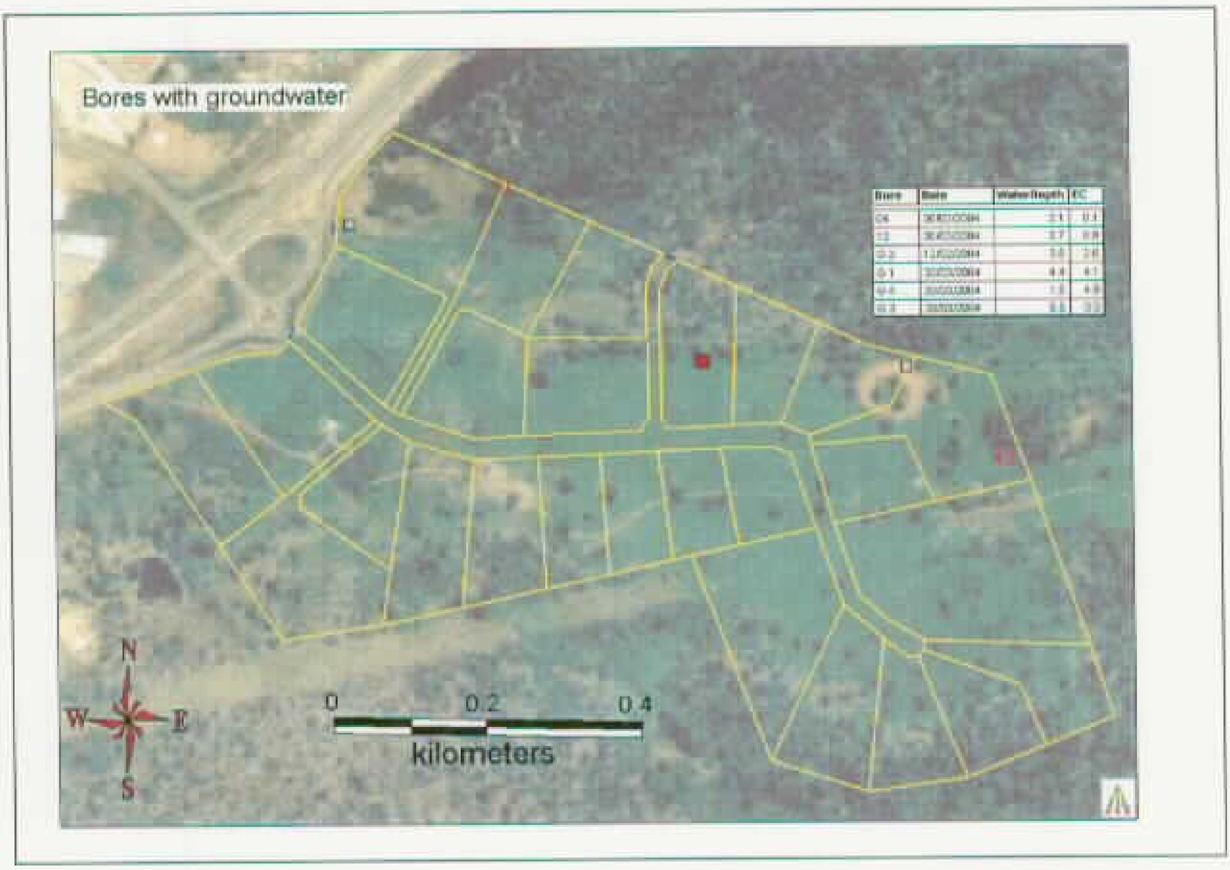
6.7 Groundwater depths and salinity

Groundwater depth and salinity was recorded in all bores on 30th March, 2004, with results as follows.

Bore ID	Depth of bore	Water depth, m	EC dS/m
1	5m	Dry	
2	5m	Dry	
3	0.5m, abandoned		
4	5m	2.1m	0.14
5	5m	Dry	
6	5m	Dry	
7	5m	Dry	
8	5m	Dry	
9	2.2m	Dry	
10	0.5m, abandoned		
11	0.4m, abandoned		
12	5m	3.7m	0.8 dS/m
13	5m	Dry	
14	4.5m	Dry	
15	3.5m	Dry	
16	1.4m, abandoned		
G1	8m	12 Feb, 3.4m 30 Mar, 4.42m	5.0 dS/m 4.1 dS/m
G2	8m	12 Feb, 3.8m 30 Mar, dry at 3m	2.6 dS/m Collapsed
G3	5.5m	12 Feb, dry 30 Mar, 5.5m	 No sample
G4	8m	12 Feb, 1.7m 30 Mar, 1.6m	7.1 dS/m 4.9 dS/m

Six of the 16 bores drilled deeper than 2 metres developed free water (see Figure 9), and of these only 1 had a static water level shallower than 2 metres (bore G4). The water in this bore had high salinity (4.9 dS/m), and three bores had water with salinity greater than 2 dS/m.

Figure 9. Bores with groundwater, with water depth and EC (dS/m).



All the bores with free water are located along the northern perimeter of the proposed subdivision area, although there was less drilling in the higher rocky areas of the site. Water was not encountered during drilling until a depth of approximately 4.5 metres (the depth of refusal) in bore G4, suggesting that the groundwater is confined to a narrow layer immediately above the rock.

6.8 Summary of the salinity hazard

There are significant amounts of salt in the soil and groundwater in the area, as indicated by the analyses of surface water, soils and groundwater. The salinity levels of the groundwater are lower than those found elsewhere in the Prospect area; the report by Phil Dyson[1] concerning the Country Club Resort Golf Course found salinity levels from 5 to 12 dS/m.

The Dyson investigations concluded "beyond any doubt that salinity is the region is the result of shallow saline groundwater", with a watertable "most probably" " within 1-1.5 metres of the soil surface." It is important to note that the Golf Course is located on a flat alluvial floodplain, and surface expression of salinity was apparent as bare areas throughout the course.

[1] Phil Dyson & Associates P/L. "Investigation into urban salinity and groundwater issues within the Prospect Vale area". 17 November 2003.

The proposed subdivision area includes a rocky area with Dolerite outcrops and undulating land with well defined drainage lines.

The presence of highly saline groundwater in the northern part of the site was established by drilling, but this water was deeper than three metres at 4 of the 6 sites where water was found. The water was highly saline and shallower than 2 metres at only one site (bore G4), and this water appears to originate from about 4.5 metres.

The water levels were recorded in March, when levels are likely to be at their lowest. However, the level of risk is considered to be lower than for the Golf Course due to the topography of the site (undulating with defined surface drainage), and the water table being at a much greater depth below the soil surface. Water table levels should be measured during the coming winter to determine whether there is a significant rise.

A range of publications describing urban salinity have been prepared for areas of Mainland Australia where the salinity risks are more apparent than on this site. However, a precautionary approach to the salinity risk is appropriate, and this approach is embodied in the following recommendations:

- Monitor groundwater levels and salinity at intervals of 2 months from May to December this year.
- Encourage homebuilders to build on the more elevated land on each title.
- Use the building techniques described in the publication "Building in a saline environment", NSW Department of Infrastructure, Planning and Natural resources, 2003. A copy of this publication is included with this report.

Photographs

Photograph 1. Gently undulating land, Land Capability 4.

Photograph 2. Land with large boulders, Land Capability 6.

Photograph 3. Land that has been cultivated for a fodder crop, with some surface cobbles. Land Capability 4.

Photograph 4. Typical soil profile, with subsoil clay at 35 cm, drainage imperfect.
Land Capability 4.

Appendix 1.

EM survey report by Cambium land and Water management.

'STRATHROY'

SOIL CONDUCTIVITY SURVEY USING AUTOMATED ELECTROMAGNETIC INDUCTION TECHNIQUES (THE EM31)

DECEMBER 2003

Cambium Land and Water
ABN: 87 097 228 512

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Disclaimer and Document Control

This report is compiled on the basis of the available amount of information and time permitted to investigate its components. In areas where information was not readily available, assumptions may have been made to aid the client. These assumptions are identified within the body of the report.

This report is for the exclusive use of the client and cannot be used for any other purpose without prior permission from *Cambium Land and Water*. The report is valid only in its entire form.

Survey Date	15 Dec 2003
Report Completion	24 Dec 2003
Created by	Neil Meadows

1. Introduction

Electromagnetic induction (EMI) instruments are tools that can be used to map and characterise the spatial variability of soil qualities related to soil electrical conductivity. Incorporated with Global Positioning Systems (GPS), EMI instruments have been used extensively in mainland Australia and overseas as a tool to:

- Confirm and quantify the extent of salt problems (McFarlane and George, 1992)
- Determine soil chemical and textural properties (Rhodes et. al. 1990, Bennett et. al. 1999, Hill 2001)
- Monitor the effectiveness of salinity remediation treatments including revegetation and engineering (George et. al. 1999)
- Develop regional and farm plans (George and Bennet, 1999)
- Model the salinity content of soil layers (Reid and Howlett, 2001)

Electromagnetics involves the creation of a fluxing magnetic field with a transmitting coil that penetrates into the ground. The magnetic field produced by an EMI instrument induces an electrical current in any conducting material in the soil that in turn creates a secondary magnetic field. The receiver coil measures the induced secondary magnetic field and the ratio of the secondary to primary field is in linear proportion to the apparent electrical conductivity (ECa) of soil in the field and is indicated by readout on the instrument.

Following careful soil sample site selection and soil chemical and textural analysis a statistical relationship between various soil factors (including soil salinity) and soil electrical conductivity can be determined. By applying these relationships to the conductivity data collected in a survey, maps of certain soil characteristics can be produced with a known degree of statistical accuracy.

The EMI meter (the Geonics EM31) used in this survey was mounted off the side of an all terrain vehicle at approximately 100 cm of the ground. Used in this way soil conductivity data was captured in the top 4 m or so of the soil strata.

1.1 Project Aims

The aims of the project were to:

1. Assess bulk soil apparent electrical conductivity.
2. Apply generally accepted soil salinity classes across the survey site that *may* correspond to levels of apparent conductivity.

2. Methods

Soil apparent conductivity was captured using a Geonics EM31 meter in the vertical dipolar mode of operation. Geographic locations were captured and stored using a Trimble differential Global Positioning System with TSC1 data recorder. Transects of the survey area were completed at approximately every 50 m, and data recorded every 1 second.

The captured raw apparent conductivity data was corrected to more accurately represent true soil apparent conductivity as outlined in Reid and Howlett (2001). The corrected conductivity data was spatially processed using Golden Software Surfer 7 software and spatial interpretation was completed using block kriging with a universal linear semi-variogram model.

Levels of salinity were assigned to the apparent conductivity contour map following classes outlined in Finnigan (1995) and shown below in Table 1.

Table 1 Commonly used salinity classes associated with apparent conductivity levels.

Salinity Class	Non-corrected soil conductivity levels[a]	Corrected soil conductivity levels[b]
Not Saline	< 100 mS/m	< 200 mS/m
Low-moderate	100 – 150 mS/m	200 – 300 mS/m
High	150 – 200 mS/m	300 – 500 mS/m
Severe	> 200 mS/m	> 500 mS/m

[a] – in Finnigan (1995)
[b] – adapted from Reid and Howlet (2001) for an automated EM31 survey at 100 cm height above ground level.

2.1 Assumptions

The main factors likely to affect soil electrical conductivity in this survey were soil texture and salinity. Without a targeted drilling and soil chemistry analysis program, it is impossible to assess the relationships between these variables and the captured soil apparent conductivity data with any statistical robustness. As such, for this survey, it is assumed that soil apparent conductivity directly correlates with soil salinity. However, previous surveys around Tasmania using the same EMI technology has shown that actual soil salinity assessed to a depth of 3.5 m typically describes between 55 – 90% of the EM31 signal (Meadows 2001, 2002).

3. Results & Discussion

2,128 individual soil conductivity measurements were captured over an area of 36.7 hectares. Figure 1 shows a spatial projection of the corrected bulk soil apparent conductivity.

Figure 2 shows a representation of the same conductivity map and the topography of the survey site. Electromagnetic interference was observed along the transects close to the overhead powerlines. As such, the readings in this area may not be a true representation of the apparent conductivity of the soil. There is clearly an association between the occurrences of high conductivity levels with topographic lows. These areas may correspond to unconsolidated sediments of Tertiary age.

Figure 3 shows the spatial variability of salinity classes after applying the salinity descriptions outlined in Table 1. The EMI signals captured in the topographic lows may be indicative of soil that is classed 'highly' and 'severely' saline.

It is important for the reader to keep in mind that the levels of apparent conductivity associated with each salinity class is a commonly accepted 'rule-of-thumb' most often applied to quick, reconnaissance scale EMI surveys. Without a direct comparison of actual soil salinity within the range of EMI responses, it is difficult to comment on the statistical accuracy of this map.

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Proposed Prospect Subdivision
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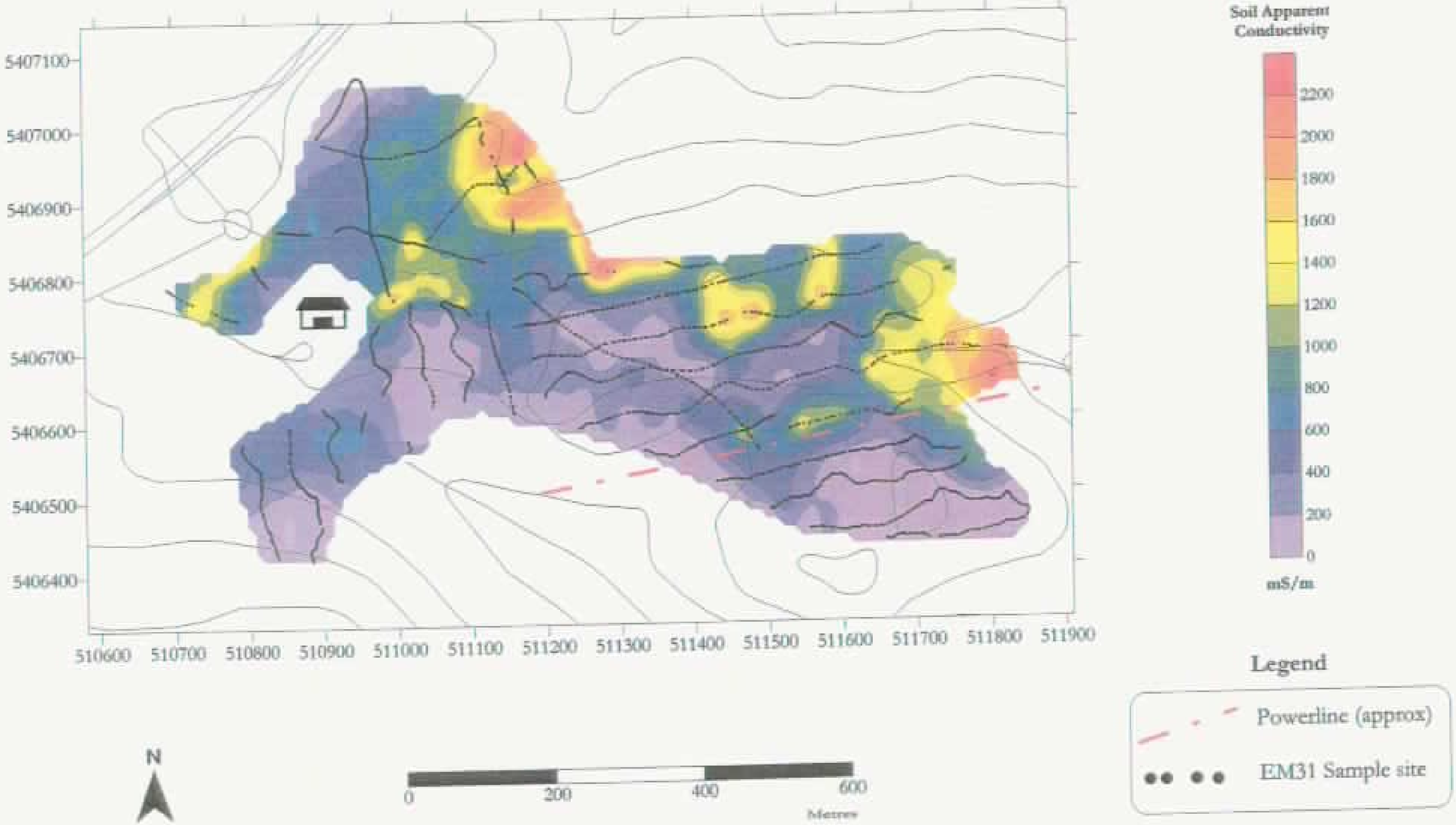

Figure 1 - Bulk soil apparent conductivity.

This map necessarily relies upon certain assumptions and predictions. Cambium Land and Water cannot guarantee its accuracy. Therefore no management decision should be based solely upon these data.

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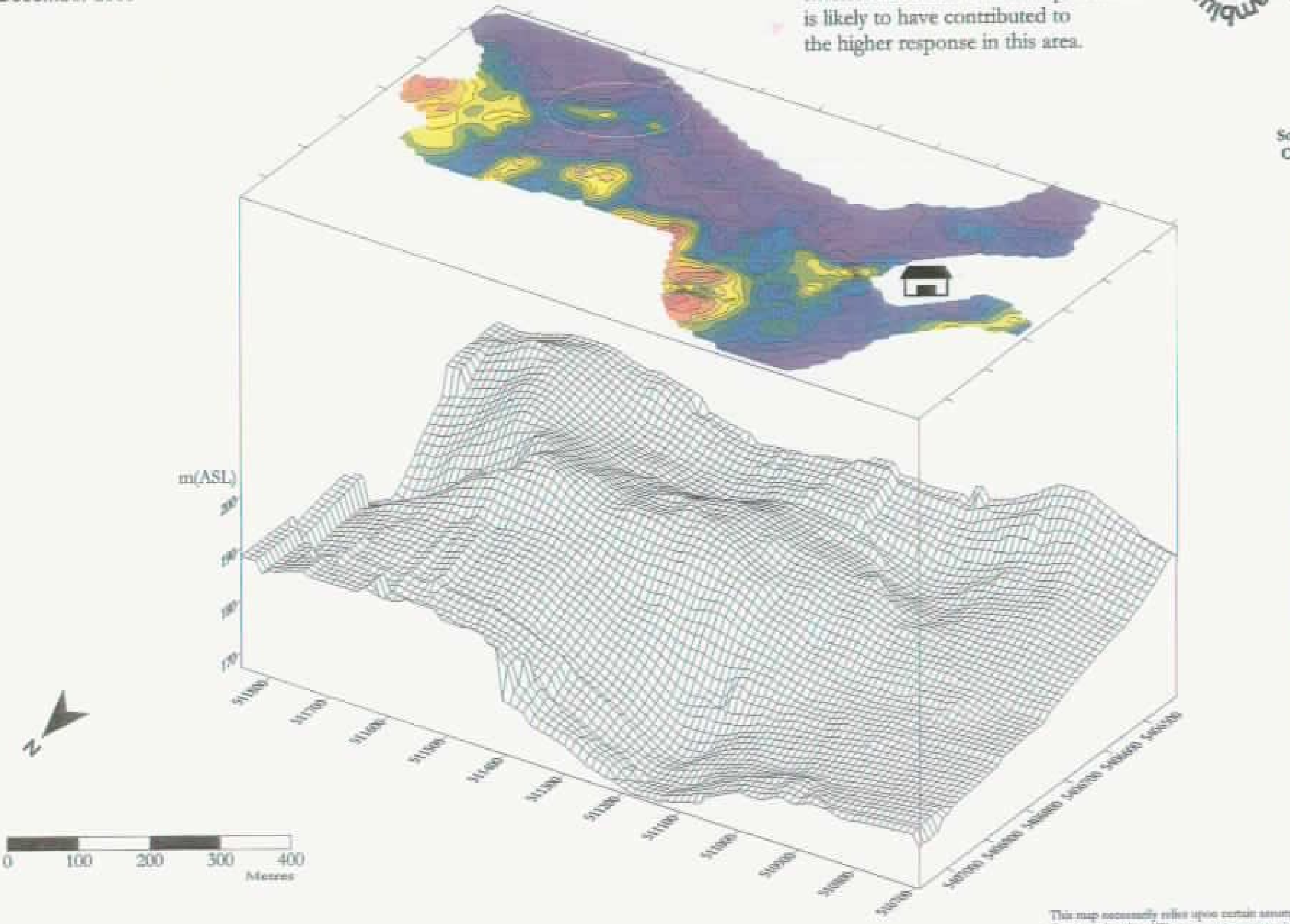

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Figure 2 - Bulk soil apparent conductivity projected over topography.

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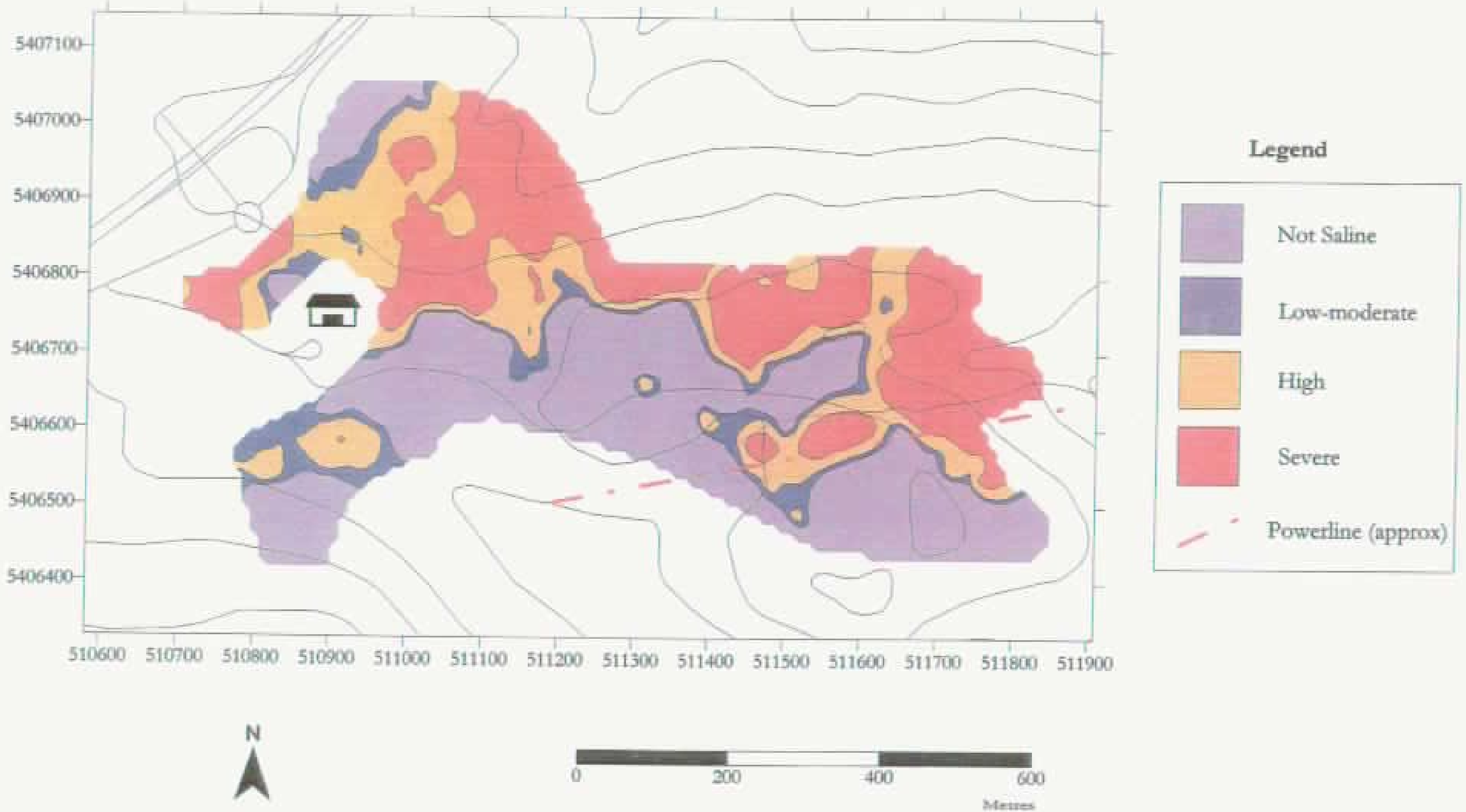

Figure 3 - Predicted bulk soil salinity classes.

This map necessarily relies upon certain assumptions and predictions.
Cambium Land and Water cannot guarantee its accuracy.
Therefore no management decision should be based solely upon these data.

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