

BSES



0010691

# **IDENTIFICATION OF ACID SULFATE SOILS USING A FIELD PEROXIDE pH TEST**

by

**Aaron Kaurila**

**Year 12**

**Gilroy Santa Maria College  
Ingham**

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## 1.0 INTRODUCTION

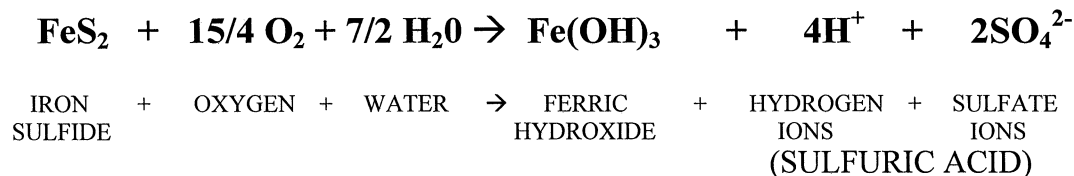
This science project was conducted as part of Year 12 Chemistry to provide an assessment of the presence of acid sulfate soils on an Ingham property. The results will determine the extent of acid sulfate soil existence on the land with regard to potential acid sulfate soils (PASS) and actual acid sulfate soils (ASS). This information will enable advice to be provided regarding the impact of future soil disturbance of the target site. Consequently, this will allow the owner to make decisions concerning management of the land and in this case, assess the feasibility of altering the depth of a drain on the property. The project was undertaken with the assistance of the landholder from whose property samples were taken and with facilities generously provided by the Herbert Sugar Experiment Station.

## 2.0 BACKGROUND

Recently, there has been a heightened awareness of the need for landowners to understand the dangers that acid sulfate soils pose to farm productivity and environmental ecosystems. This has been followed by pressure on the owners to actively manage soils that are affected by acid sulfate or have the potential to be affected by acid sulfate.

Many thousands of years ago, Australia's coastline was covered in seawater. In anaerobic conditions and in the presence of organic matter, aquatic bacteria used iron oxides in sediments and sulphates in the ocean to form iron pyrites (iron sulfide,  $\text{FeS}_2$ ). As the oceans retracted, they left fertile alluvial soils that were utilised for agricultural purposes. Iron sulfide compounds buried beneath the water table or in a waterlogged condition have remained stable and caused no significant damage as they could not react under the severely reduced conditions.

In recent times, a marked increase in the amount of drainage has lowered the water table. Cultivation and levelling have disturbed the iron sulfides. When the sulfide is exposed to air, it reacts with oxygen as is shown in the following formula, to form ferric hydroxide (rust) and sulfuric acid that lowers the pH of farmland, drains, wetlands, creeks and estuaries, reducing land productivity and resulting in severe environmental damage.



Disturbance and lowered pH also triggers the release of heavy metals such as soluble aluminium from clay minerals which causes just as much destruction and is particularly toxic to fish. When the pH of contaminated water is reduced to just 5.5, it has the potential to kill fish, restrict plant growth, corrode metal and damage concrete structures. Acid sulfate soils generally occur in lands no more than five metres above AHD (Australian Height Datum - sea level).

Indications that a disturbed soil has acid sulfate potential include:

- inhibited vegetation growth,

- jarosite (pale yellow deposits) along cracks in the soil and the presence of iron stains
- water with a pH of less than 5,
- unusual water colour (either bright blue-green or very clear),
- the absence of fish life in drains.

As human development continues to encroach upon lands that have the potential to be affected by acid sulfate, identification and subsequent management of the land in question is and will continue to be vital for the sustainability of agriculture and natural ecosystems.

### 3.0 MATERIALS

Tape  
 Dutch auger  
 50 polyethylene bags (clipseal)  
 Buckets  
 Esky  
 Refrigerator  
 Laser beacon (LB-1)  
 Mabo rod (STANLEY)  
 pH meter (MC-80) with IJ probe  
 Buffer Solutions (pH 4 and pH 6.88)  
 30% Hydrogen Peroxide adjusted to pH 4.5-5.5  
 Labelled styrofoam cups  
 Wash bottle of distilled water  
 Plastic probe  
 Tissues  
 Protective equipment including gloves, laboratory coat and face mask

### 4.0 METHOD

Soil at the field site was classified by Wilson and Baker (1990) in the Toobanna soil mapping unit which includes the common great soil groups (Stace *et al.*, 1968) of soloth, solodic and solodized solonetz soils. These soils are characterised by dark grey-brown loam or fine sandy clay loam at 10cm-30cm and mottled yellow-brown to brown medium heavy clay at 30cm-80cm. Site plans are presented in Appendices A, B and C, representing orthophoto view, soil classification and land use suitability of the sample site respectively. The latter two views show 1 metre contour lines.

#### 4.1 Field soil collection

1. Label all bags to display site number and sample depth e.g. 1-10 for bag holding sample from first site taken from a depth of 0-10cm.



Fig 1: Measuring drain height with a mabo rod. The transmitter is set up in the background.

2. Choose suitable test sites at 40m intervals and mark with tape. Appendix D contains a site plan showing the sample points.
3. Erect laser beacon on raised land with unobstructed view of all marked points.
4. At site one, turn on mabo rod and raise rod (with receiver side facing toward laser) until device begins to sound. Record height.
5. Use auger to collect five soil samples to 50cm depth in 10cm increments. Clean auger of soil residue following each successive collection.
6. Place each sample in appropriately labelled plastic bag and place bags in esky with ice to keep sample stable.
7. Repeat steps 4, 5 and 6 for sites two through to ten. Seal all bags properly, removing trapped air and store in refrigerator until required for laboratory soil testing.



Fig.2: Collecting soil samples from drain with dutch auger.



Fig.3: Soil sampling from upper section of the drain.



Fig.4: Taking soil samples from beside culvert two.

#### 4.2 Laboratory soil testing

Due to the time available for this project, only samples 1, 3, 5, 7, 9 and 10 were analysed. Sixty analyses were performed using the field peroxide pH test. These samples came from the six sites listed above with five depths per site and each analysis done in duplicate.

**SAFETY PRECAUTION:**

**HYDROGEN PEROXIDE IS A STRONG OXIDANT AND SHOULD BE HANDLED CAREFULLY WITH APPROPRIATE EYE AND SKIN PROTECTION. LABORATORY COAT, PROTECTIVE MASK, SURGICAL GLOVES AND COVERED SHOES SHOULD BE WORN WHILE DOING THE EXPERIMENT.**

1. Remove container of 30% hydrogen peroxide ( $H_2O_2$ ) and soil samples from refrigerator and allow to become warm. Adjust pH of peroxide to 4.5-5.5 with a few drops of 0.1M NaOH.
2. Assemble labelled styrofoam cups, distilled water, pH meter and tissues on a stainless steel bench and turn on the extractor fan to prevent build up of sulfur dioxide gas evolved during reaction.
3. Calibrate pH meter using pH 4 and 6.88 buffer solutions.
4. Remove a small amount of soil from bag marked '1-10'. Record soil colour.

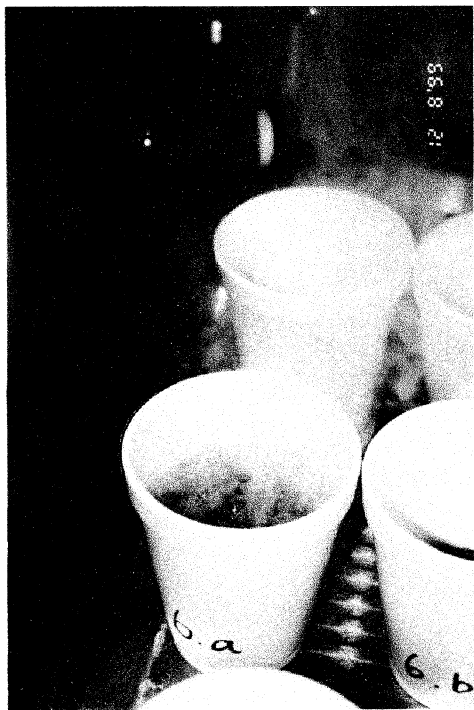


Fig.5: Measuring pre-oxidised pH of soil sample.

5. Insert tip of pH meter probe into saturated soil and record pH reading ( $pH_F$ ). If soil is tough or dry, add small amount of distilled water and make a hole with the probe.

6. Place a teaspoon of soil in a cup, adding sufficient hydrogen peroxide to cover sample. Crush soil with plastic probe, then clean probe with distilled water.

7. Repeat steps four to six for the duplicate sample.



Figs.6 and 7 (left and above): Violent reaction of hydrogen peroxide with soil sample from site 10, 0-10cm depth. Note steam and increasing reaction from left to right. This reaction classed as a 5, required addition of distilled water to prevent overflow of the sample.

8. Repeat steps 4 to 7 using soil from bags labelled '1-20' through to '10-50'.
9. Observe violence of reaction in each cup and record on a scale 0-5.  
(0 = nil, 1 = very slight, 2 = slight, 3 = moderate, 4 = strong, 5 = violent).
10. If reaction is violent and in danger of overflowing cup, add distilled water from wash bottle to prevent loss of sample.

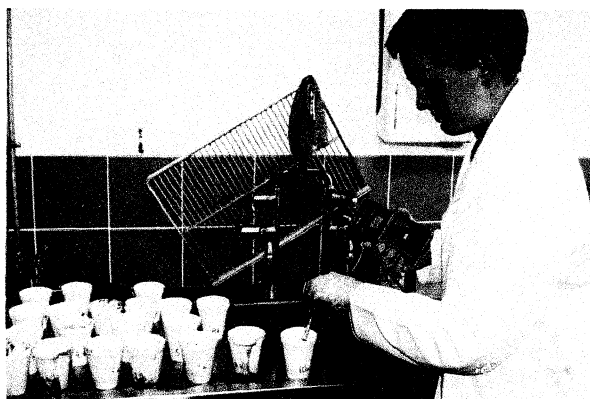


Fig. 8: Measuring oxidised pH of soil sample with the pH meter after reaction is complete.

11. Once reaction has subsided add additional hydrogen peroxide, a few millilitres at a time, until reaction is complete.

12. Insert pH meter probe into each cup recording oxidised pH readings ( $pH_{FOX}$ )

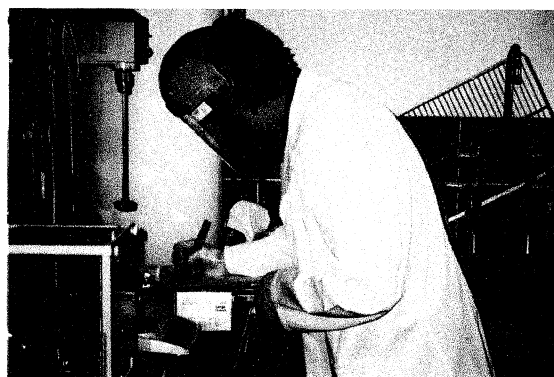


Fig. 9: Recording data from the laboratory experiment results.

#### 4.3 Classification system

Three factors were used to classify soil samples to determine the extent of acid sulfate presence in the drain:

- Strength of reaction with hydrogen peroxide
- Degree of pH drop on oxidation ( $pH_F - pH_{FOX}$ )
- Actual  $pH_{FOX}$  value

The system, presented in Table I below, was used to classify soils:

**Table I. Acid sulfate classification system using the field peroxide pH test.**

Classification	Reaction	pH drop	$pH_{FOX}$
A. Potential acid sulfate (Agricultural sig.)	May be moderate to violent (3-5)	>2	<3
B. Potential acid sulfate (Environmental sig.)	May be moderate to violent (3-5)	1 - 2	<3
C. Actual acid sulfate	May be nil to slight (0-2)	<1	$pH_F < 3.5$ and $pH_{FOX} < 3$
D. Less positive	Moderate to violent (3-5)	0-2	3-4
E. Undetermined	Moderate to violent (3-5)	<1	4-5
F. Not acid sulfate	Nil to slight (0-2)	<1	>4

#### 5.0 RESULTS

Complete results are listed in appendix E, while average results are presented below.



### 5.1 Average results for soil sites

The mean results for each of the six sampling sites analysed are presented below in Table II.

**Table II. Average results of field peroxide pH test for sampling sites.**

Site	Reaction (scale 1-5)	pH <sub>F</sub>	pH <sub>FOX</sub>	pH Drop	Classification (see Table I)
1 top	2.00	3.36	2.04	1.34	B
3	3.36	3.40	2.17	1.22	B
5	1.60	3.41	1.39	2.02	A
7	1.45	3.42	1.81	1.61	B
9	3.80	4.16	2.35	1.77	B
10 bottom	3.90	3.22	2.17	1.05	B

### 5.2 Average results for soil depth

The mean results for each of the five soil depths were calculated and are illustrated below in Table III.

**Table III. Average results of field peroxide pH test for sampling depths**

Depth (cm)	Reaction (scale 1-5)	pH <sub>F</sub>	pH <sub>FOX</sub>	pH drop	Classification (see Table I)
0-10	3.88	3.61	2.26	1.35	B
10-20	3.08	3.93	1.98	1.96	B
20-30	3.29	3.53	2.22	1.30	B
30-40	2.25	3.29	1.89	1.40	B
40-50	0.96	3.10	1.62	1.48	B

### 5.3 Classification of tested soils

Each soil sample has been classified into the categories listed in Table I and this information is displayed in Table IV below using colour coding to clearly identify the position of acid sulfate soils.

**Table IV. Classification of soil profile on the basis of field peroxide pH test results**

Site Depth (cm)	1 top	3	5	7	9	10 bottom
0-10	A	C	B	A	B	C
10-20	A	A	A	A	B	B
20-30	C	B	A	B	B	C
30-40	C	B	A	B	B	C
40-50	B	B	B	B	B	B

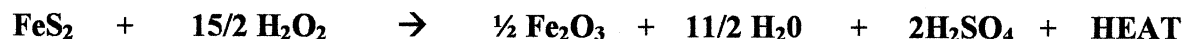
#### Key

A = Potential acid sulfate (Actual cultural significance)	B = Potential acid sulfate (Environmental significance)	C = Actual acid sulfate
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## 6.0 DISCUSSION

A field peroxide pH test was used to rapidly screen soils for acid sulfate potential. A saturated pH of field soil ( $\text{pH}_F$ ) was determined, then hydrogen peroxide added. If pyrite was present, the following reaction proceeded:

### RAPID FIELD TEST REACTION



In some cases, the reaction was quite violent, resulting in the generation of large amounts of heat and steam. Once the reaction was complete, the field oxidised pH ( $\text{pH}_{\text{FOX}}$ ) was measured. From this information, the drop in pH between pre-oxidised pH and oxidised pH (the difference between  $\text{pH}_{\text{FOX}}$  and  $\text{pH}_F$ ) was calculated. The Department of Natural Resources denotes a drop of one unit as of environmental concern, while from an agricultural perspective, a drop of two units can be considered to be an indication that potential exists for crop damage.

The results confirmed that all of the samples tested were either potential or actual acid sulfate soils. The distribution of acid sulfate potential in the soil is notoriously variable and this fact is made obvious in Table IV. In this case soil with severe potential for damage seemed to occur more in the centre and upper portion of the drain, generally within 20cm of the surface. There was evidence both at the upper and lower sections of the drain of soils already having been oxidised to actual acid sulfate soil. The site is classified by the Department of Natural Resources as suitable for agriculture with moderate limitations (Appendix C). However, on the basis of this report it would be recommended that the drain area be classified as unsuitable land with marginal limitations.

The height of the drain above sea level (Appendix D and Fig. 10) reveal that the end of the drain is only 3cm lower than the start of the drain and that an area between sites 7 and 9 is at least 3cm lower than the culvert and 1cm lower than the end of the drain.

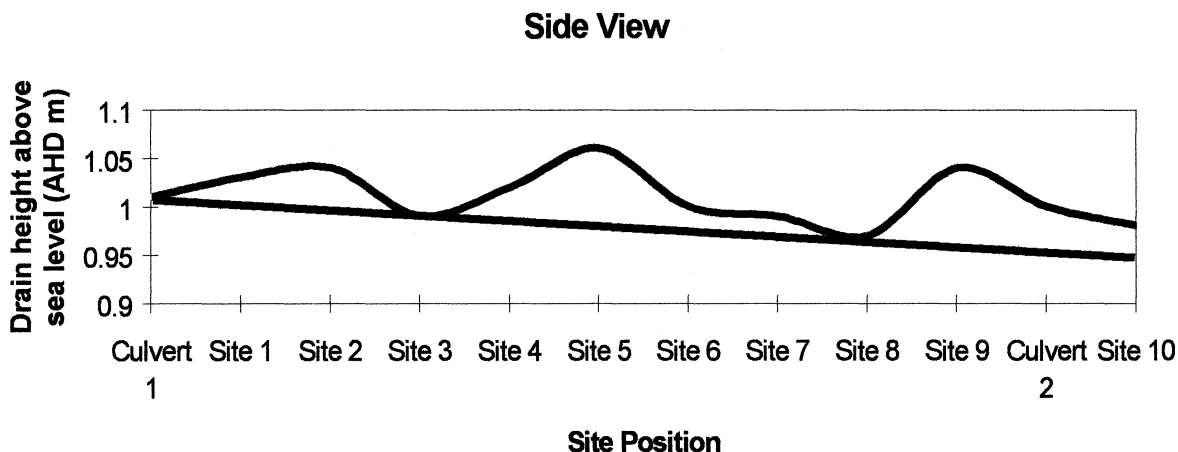


Fig. 10: Side view of drain

This means that if the drain were to be constructed in such a way to allow uninterrupted flow (see the line in Fig 10), the drain must be dug 5cm, 8cm and 7cm deeper at sites 2, 5 and 9

respectively. Soil from site 2 was not tested, but on the basis of data from adjacent sites 1 and 3 (Table IV), there is a high possibility that if the drain is lowered, potential acid sulfate soil of agricultural concern will be exposed. Sites 5 and 9 were tested and it can be deduced from Table IV that if sufficient depth of soil were removed from each, acid sulfate soil of agricultural significance would most probably be uncovered at site 5 and soils of environmental concern would be exposed at site 9. Also the second culvert at the bottom of the drain would require replacing.

The colour of the soil at the test site changed from dark brown/black at the surface of the soil (i.e. to a depth of 20 to 30cm) to a lighter brown with shades of grey and traces of mottling at a depth of approximately 20cm to 50cm (Appendix E). Soil colour and strength of the peroxide reaction appear related, with an average of 3.88 at 10cm for the darker soil and an average of 0.96 at 50cm for the lighter soil (Table III). Both  $\text{pH}_F$  and  $\text{pH}_{\text{FOX}}$  illustrate a general decline in pH value from 10cm to 50cm depth (Table III). These two factors (soil colour and pH value) could indicate that there is a high level of organic matter at the surface of the drain, but that the actual acid sulfate soils are located at a greater depth in the soil.

Many steps were taken to reduce error in this experiment. A minor source of error was present in field soil collection, where the auger was wiped only by hand between sampling. This may have increased variability slightly, but should not have resulted in unreliable results. Sealing and refrigeration of the polyethylene sample bags were also an important aspect of error minimisation. If oxygen had been allowed to enter the stored sample at room temperature, the soil may have partially oxidised before laboratory testing. This would have been more of a problem with sub-surface soils that had not already been in contact with the atmosphere. The procedures used to store the sample in an airtight bag at low temperature would have kept the sample stable.

The temperature of the hydrogen peroxide influenced the rate of reaction. The violence of reactions may not have reached their peak prior to the end of the experiment had the sample and the peroxide not been warmed before mixing. The strength of the peroxide reaction with soil is a useful indicator for classification of acid sulfate potential, although organic matter and other soil constituents such as manganese oxide can result in a reaction. This was obviously the case when the dark-coloured surface soils that are high in organic matter produced large reactions but little or negative pH changes. A sample such as 3-10 indicated a negative pH difference even though the violence of the reaction was 5 (Appendix E). Discrepancies in judging the violence of the reaction could have occurred, as this was not a quantitative but a qualitative result.

Testing of the pH of the soil samples was crucial to the outcome of the experiment. Readings from the pH meter varied with the amount and type of soil touching the probe tip. If the probe was moved during testing, the pH usually declined, extending the time taken to obtain a stable pH reading. Care was taken during this experiment to ensure correct soil-probe contact to produce rapid and reliable pH measurements. Sufficient cleaning of the probe during this experiment would have meant that the results reported here were representative of the soils being tested.

If soil pH becomes lower than 4, oxidation of sulfides has probably already occurred, indicating an actual acid sulfate soil. The average oxidised pH of the test soil is in fact less than 2 and the pre-oxidised soil is approximately pH 3.5. Such high levels of acidity is likely to cause environmental damage to surrounding waterways with water run-off.

## 7.0 CONCLUSION

The results obtained from the experiment appear to indicate that the drain contains actual and potential acid sulfate soils. Consequently, it would be advised that the property owner does not alter the drain by disturbing the soil without remedial measures such as the addition of lime at the correct rates. There may also be a case to apply lime to the drain surface to treat existing potential and actual acid sulfate soils found in the top 10 cm. It should be noted that the field peroxide test is only an indicative test and definitely not quantitative. It is also difficult to interpret field test results on high organic or peat soils and coffee rock. If drainage works are intended at this site, a quantitative laboratory analysis of the soils should be undertaken.

## 8.0 ACKNOWLEDGEMENTS

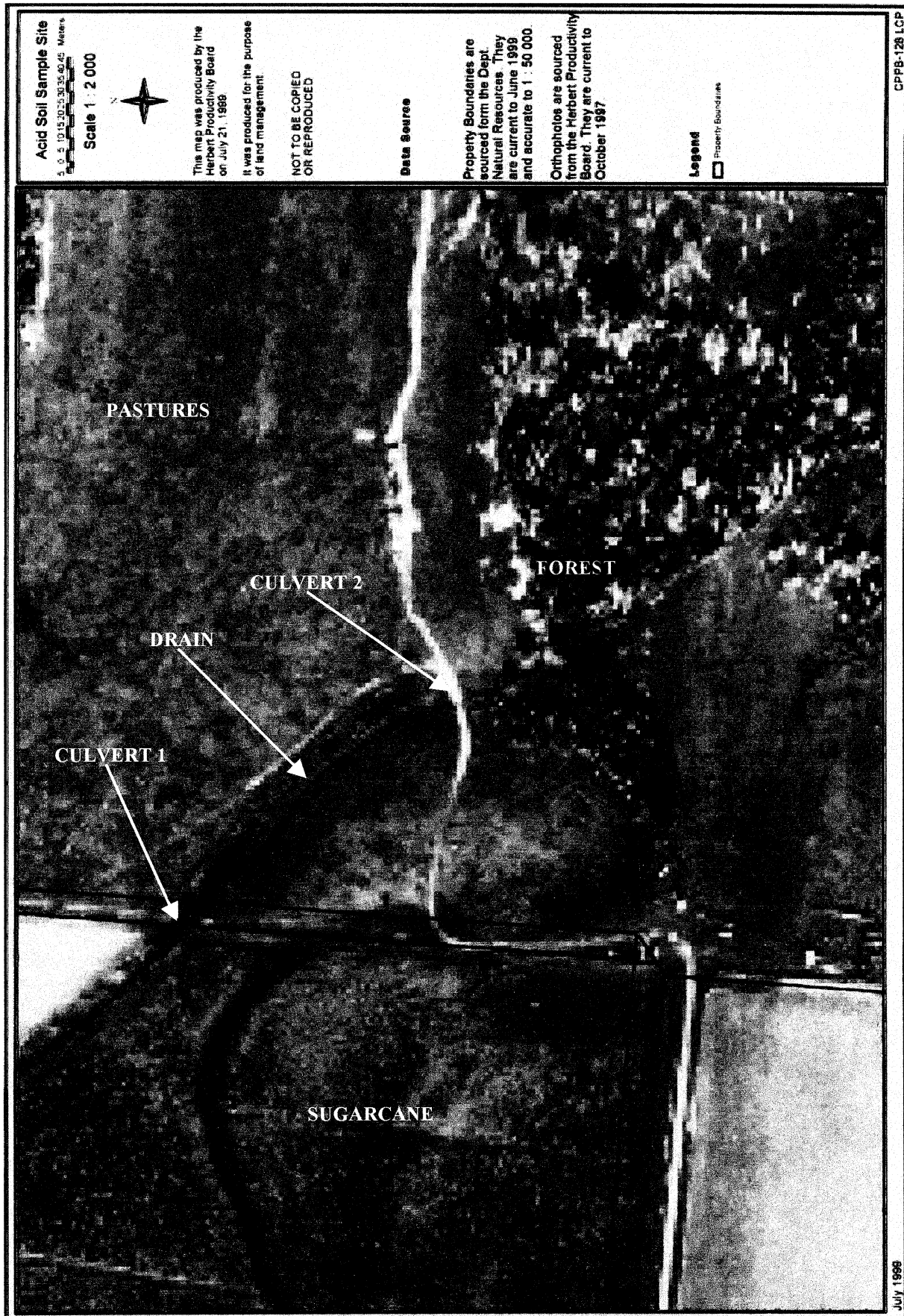
I would like to thank the Ingham branch of the BSES and in particular Mr John Reghenzani for his supervision and time and Mr Glen Park for his assistance. The provision of orthophoto, soils and land suitability maps by the Herbert Cane Protection and Productivity Board is gratefully acknowledged.

Gratitude is expressed to Gilroy Santa Maria College for providing the opportunity to undertake this independent research assignment. Also I would like to acknowledge the owner of the property from where the soil samples were taken for his cooperation.

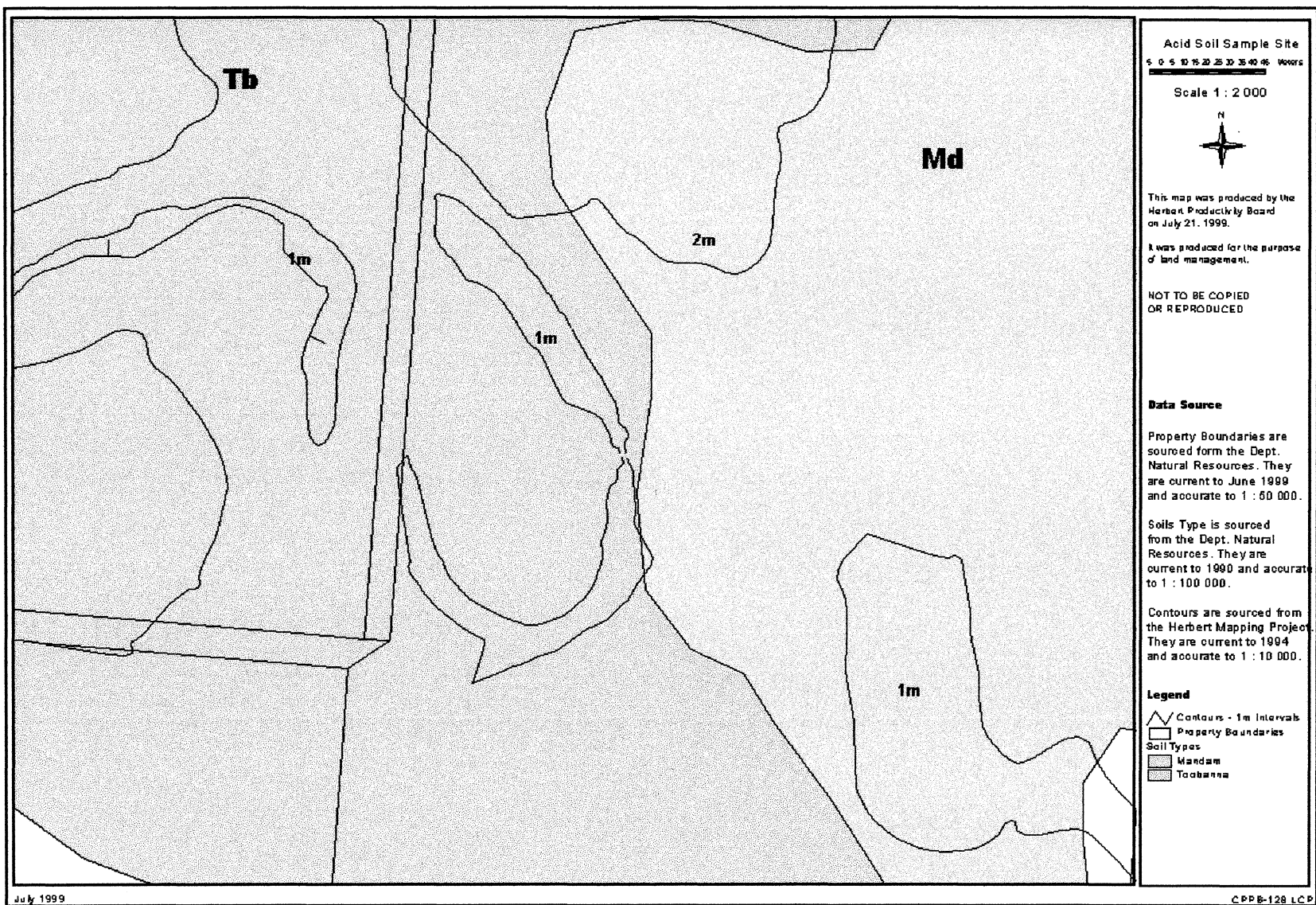
## 9.0 REFERENCES

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- Wilson, P.R. and Baker, D.E. (1990) Soils and Agricultural Land Suitability of The Wet Tropical Coast of North Queensland: Ingham Area. (Queensland Department of Primary Industries: Brisbane)

# APPENDIX A: Orthophoto of sample site.

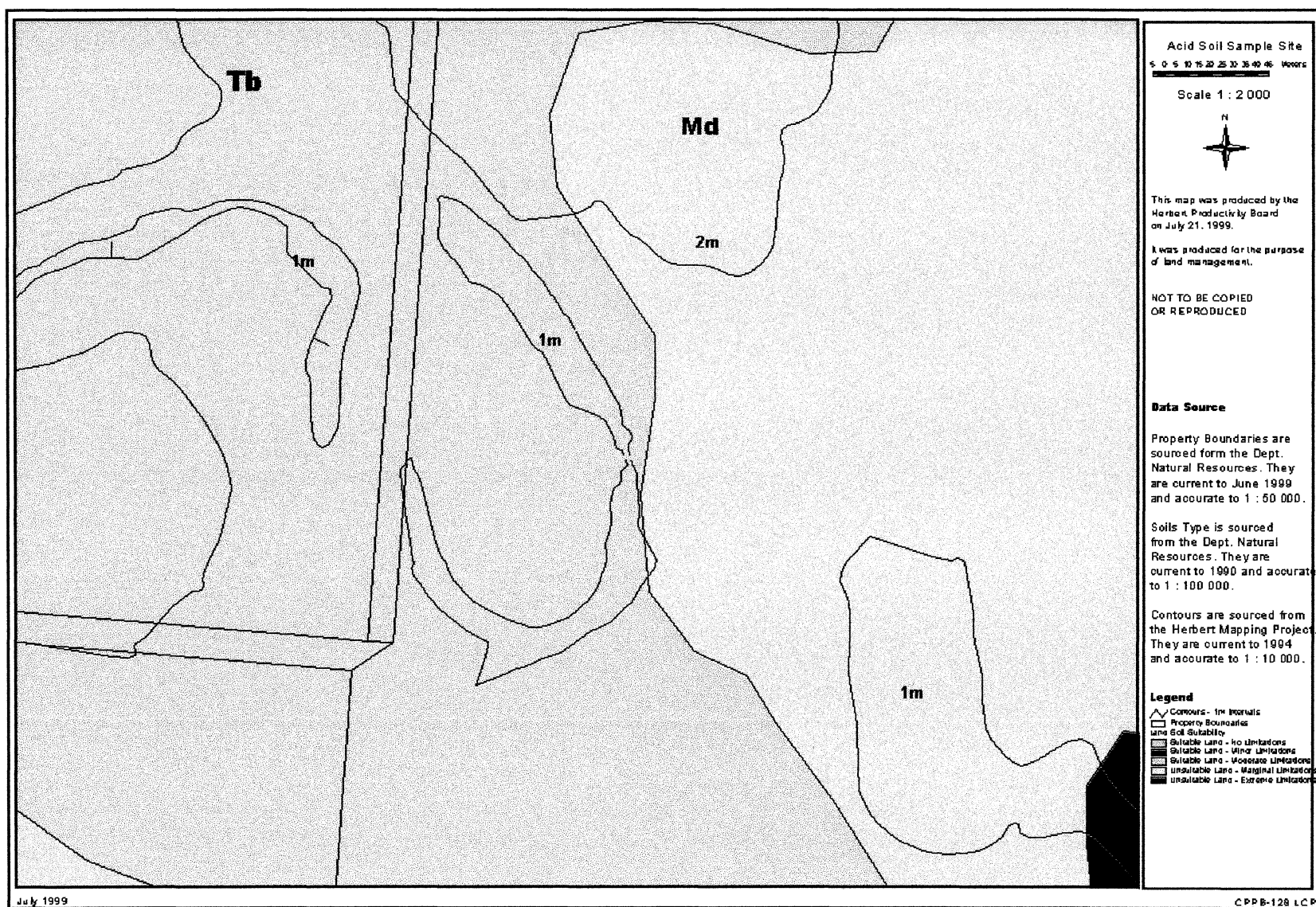


# APPENDIX B: Soil classification map of sample site.

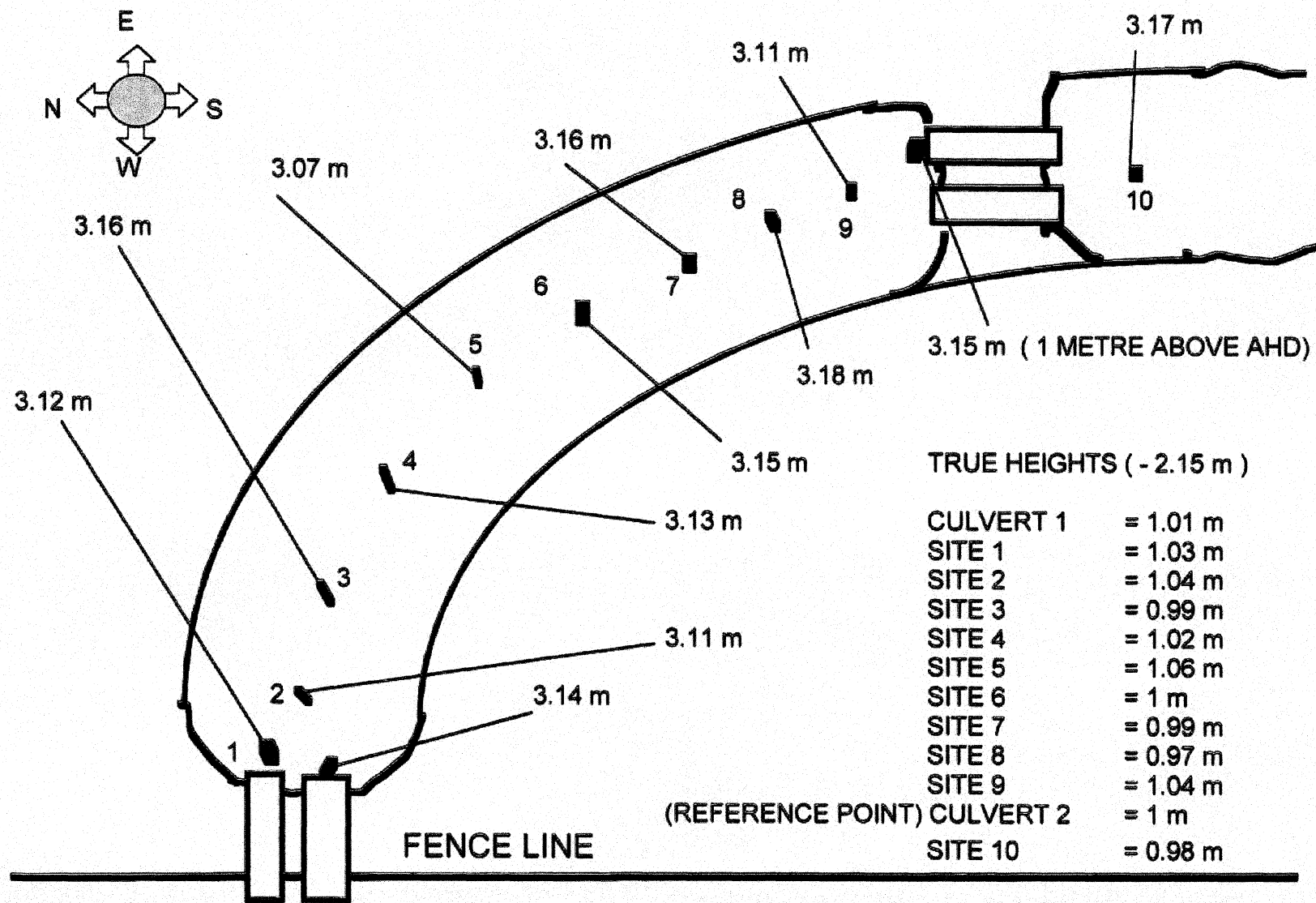




# APPENDIX C: Soil suitability map of sample site.




# APPENDIX D: Site sampling plan.






# APPENDIX E (a): Results spreadsheet.

Field Peroxide pH Test (pH <sub>FOX</sub> )								
Location	Mungalla						Date sampled	22/07/1999
Student Project by Aaron Kaurila							Date analysed	
Reaction violence 0 = nil, 1 = slight, 5 = severe								
Number	Site	Depth	Pre Oxid.pH	Oxid pH	pH Diff.	Reaction	Comments (colour)	
1	1	10	4.09	1.94	2.15	3	29/07/1999	
2	1	10	3.97	1.64	2.33	3		
			4.03	1.79	2.24	3	Dark brown	
3	1	20	3.90	1.39	2.51	3		
4	1	20	3.76	2.14	1.62	3		
			3.83	1.77	2.07	3	Dark brown	
5	1	30	3.24	2.46	0.78	2		
6	1	30	3.31	2.90	0.41	2		
			3.28	2.68	0.60	2	Dark brown	
7	1	40	2.87	1.97	0.90	1		
8	1	40	3.05	2.60	0.45	1		
			2.96	2.29	0.68	1	Dark brown - slightly mottled	
9	1	50	2.68	1.52	1.16	1		
10	1	50	2.70	1.74	0.96	1		
			2.69	1.63	1.06	1	Dark brown - very mottled	
11	3	10	2.75	2.86	-0.11	5	Dark brown/black 5/8/1999	
12	3	10	3.51	2.57	0.94	5		
			3.13	2.72	0.42	5		
13	3	20	4.13	1.55	2.58	1		
14	3	20	3.95	2.58	1.37	5		
			4.04	2.07	1.98	3	Black/brown	
15	3	30	3.78	2.97	0.81	5		
16	3	30	3.14	1.37	1.77	5		
			3.46	2.17	1.29	5	Brown/grey (mottled)	
17	3	40	3.12	1.90	1.22	2		
18	3	40	3.06	1.66	1.40	2		
			3.09	1.78	1.31	2		
19	3	50	3.04	2.09	0.95	2	Orange Grey/black	
20	3	50	3.42	2.13	1.29	2		
			3.23	2.11	1.12	2		
21	5	10	3.19	1.14	2.05	2	Dark/brown - mottled orange	
22	5	10	3.87	2.55	1.32	4	Dark brown	
			3.53	1.85	1.69	3		
23	5	20	3.37	1.06	2.31	2.5	Black	
24	5	20	3.39	1.21	2.18	1.5	Black	
			3.38	1.14	2.25	2		
25	5	30	3.50	1.32	2.18	1.5	Black	
26	5	30	3.50	1.54	1.96	1.5		
			3.50	1.43	2.07	1.5		
27	5	40	3.44	1.17	2.27	1	Dark brown	
28	5	40	3.45	1.23	2.22	0.5		
			3.45	1.20	2.25	0.75		
29	5	50	3.09	1.26	1.83	0.5	Dark brown	
30	5	50	3.25	1.41	1.84	1		
			3.17	1.34	1.84	0.75		

## APPENDIX E (b): Results spreadsheet (continued).

Field Peroxide pH Test (pH <sub>FOX</sub> )							
Location		Mungalla		Date sampled		22/07/1999	
		Student Project by Aaron Kaurila				Date analysed	
Reaction violence 0 = nil, 1 = slight, 5 = severe							
Number	Site	Depth	Pre Oxid.pH	Oxid pH	pH Diff.	Reaction	Comments (Jarosite,smell,colour)
31	7	10	3.73	1.55	2.18	2	Dark brown
32	7	10	3.43	1.58	1.85	2.5	
			3.58	1.57	2.02	2.25	
33	7	20	3.58	1.41	2.17	2	Dark brown
34	7	20	3.38	1.32	2.06	1	
			3.48	1.37	2.12	1.5	
35	7	30	3.42	2.38	1.04	2	Dark brown
36	7	30	3.30	2.24	1.06	2.5	
			3.36	2.31	1.05	2.25	
37	7	40	3.37	2.13	1.24	1	Dark brown/grey
38	7	40	3.32	1.52	1.80	0.5	Dark brown/grey
			3.35	1.83	1.52	0.75	
39	7	50	3.37	1.90	1.47	0.5	Orange /grey
40	7	50	3.25	2.00	1.25	0.5	Green/brown
			3.31	1.95	1.36	0.5	
41	9	10	4.46	3.00	1.46	5	Dark brown/black
42	9	10	4.96	3.20	1.76	5	
			4.71	3.10	1.61	5	
43	9	20	4.60	3.19	1.41	5	Dark brown/black
44	9	20	4.90	2.97	1.93	5	
			4.75	3.08	1.67	5	
45	9	30	4.15	1.39	2.76	3	Dark brown/black
46	9	30	4.05	2.92	1.13	5	
			4.10	2.16	1.95	4	
47	9	40	4.04	1.35	2.69	3	Dark brown/peach mottled
48	9	40	3.80	2.65	1.15	5	
			3.92	2.00	1.92	4	
49	9	50	3.30	1.57	1.73	1	Green/dark brown/black
50	9	50	3.33	1.68	1.65	1	
			3.32	1.63	1.69	1	
51	10	10	2.72	2.58	0.14	5	Dark brown/black
52	10	10	2.63	2.49	0.14	5	Speckled
			2.68	2.54	0.14	5	
53	10	20	4.15	2.33	1.82	3	Speckled
54	10	20	4.02	2.55	1.47	5	
			4.09	2.44	1.65	4	
55	10	30	3.45	2.46	0.99	5	Speckled
56	10	30	3.52	2.68	0.84	5	
			3.49	2.57	0.92	5	
57	10	40	3.00	2.20	0.80	5	Dark brown
58	10	40	2.98	2.30	0.68	5	Dark brown
			2.99	2.25	0.74	5	
59	10	50	2.87	0.99	1.88	0.5	Grey/orange/dark brown
60	10	50	2.83	1.11	1.72	0.5	Grey/orange/dark brown
			2.85	1.05	1.80	0.5	