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## Optimal prediction of coastal acid sulfate soil severity using geographic information systems

Marcus John Morgan  
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# **Optimal Prediction of Coastal Acid Sulfate Soil Severity using Geographic Information Systems**

A thesis submitted in fulfilment of the requirements for the award of the degree

**MASTER OF ENGINEERING (HONOURS)**

**From**

**UNIVERSITY OF WOLLONGONG**

**By**

**MARCUS JOHN MORGAN**

B.Sci (Environmental), B.Comm (Economics)

FACULTY OF ENGINEERING  
2006

## **CERTIFICATION**

I, Marcus J. Morgan declare that this thesis, submitted in fulfilment of the requirements for the award of Master of Engineering (Honours), in the Faculty of Engineering, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

A handwritten signature in blue ink, reading "Marcus J. Morgan". The signature is fluid and cursive, with a large loop at the end of the last name.

Marcus J. Morgan

24 March 2006

## Table of Contents

<b>Certification.....</b>	<b>ii</b>
<b>List of Figures.....</b>	<b>iii</b>
<b>List of Tables.....</b>	<b>iv</b>
<b>List of Plates.....</b>	<b>v</b>
<b>Abbreviations.....</b>	<b>vi</b>
<b>Abstract.....</b>	<b>vii</b>
<b>Acknowledgements.....</b>	<b>viii</b>
<b>Dedication.....</b>	<b>ix</b>
<b>Chapter 1 Introduction.....</b>	<b>1</b>
1.1 Introduction to Coastal Acid Sulfate Soils.....	1
1.2 Objectives.....	2
1.3 Thesis Structure.....	3
<b>Chapter 2 Coastal Acid Sulfate Soils.....</b>	<b>4</b>
2.1 Introduction.....	4
2.1.1 Thionic Fluvisol.....	4
2.1.2 Distribution.....	5
2.1.3 Spatial Distribution in Australia.....	6
2.2 Formation – Geomorphology.....	9
2.2.1 Shoalhaven River: A Barrier Estuary.....	9
2.2.2 Influence of Floodplain Drainage on Landform.....	14
2.2.2 Iron Sulphide.....	15
2.2.3 Pyrite Oxidation.....	16
2.2.4 Pyrite Oxidation influenced by Bacteria (Biological Oxidation)....	19
2.3 Affects on Soil Parameters.....	20
2.3.1 Soil pH.....	20
2.3.2 Total (Titratable) Actual Acidity.....	23
2.3.3 Cation Exchange Capacity.....	24
2.3.4 Exchangeable Aluminium (Aluminium Saturation).....	25
2.3.5 Chloride: Sulfate Ratio.....	26
2.3.6 Electrical Conductivity and Salinity.....	27
2.3.6.1 Electrical Conductivity in Soils.....	27
2.3.6.2 Soil Salinity.....	30
2.3.6.3 Measuring Electrical Conductivity for Water Quality .....	30
2.3.6.4 Electromagnetic (EM) Surveys in determining EC.....	32
2.3.7 Jarosite Level.....	33
2.3.8 Analysis of Variables.....	35
2.4 Environmental Management Using Digital Terrain Models.....	35
2.5 Acid Sulfate Soil Management Options – Broughton Creek.....	36
2.5.1 Shoalhaven River Acid Drainage Working Group.....	36
2.6 Management Applications in New South Wales, Australia.....	37
2.6.1 Two-Way Floodgates.....	37
2.6.2 V-notched Weirs.....	39
2.6.3 Self-Regulating Tilting Weirs.....	39
2.6.4 Deep Subsurface Lime Injections.....	40
2.6.5 Subsurface Liming Buffer Strips.....	41
2.7 Planning Remediation Strategies.....	41
<b>Chapter 3 Methodology.....</b>	<b>43</b>

3.1	GIS Defined.....	43
3.2	History of GIS.....	44
3.3	ArcGIS.....	44
3.4	GIS in Soil Science.....	44
3.5	Case Studies.....	45
	3.5.1 CANSIS.....	46
	3.5.2 NASIS: National Soil Information System.....	46
	3.5.2.1 State Soil Geographic (STATSGO) Database.....	47
	3.5.2.2 Soil Survey Geographic (SSURGO) Database.....	48
	3.5.2.3 Soil Data Mart.....	49
	3.5.3 European Soil Information System (EUSIS).....	50
	3.5.4 SOTER: SOil and TERRain Database.....	51
	3.5.5 Australian Soil Resources Information System.....	51
	3.5.6 Soil and Land Information System (SALIS).....	52
	3.5.7 Analysis of Databases.....	53
3.6	Visual Data Reference.....	53
3.7	Airborne Laser Scanning (ALS).....	54
	3.7.1 History of ALS.....	54
	3.7.2 ALS Process.....	55
	3.7.3 ALS Accuracy.....	58
	3.7.4 Case Study: ALS Application to Coastal Acid Sulfate Soil.....	58
	3.7.5 Application ALS data to Soil Data.....	62
3.8	Acid Sulfate Soil Risk Maps.....	62
	3.8.1 Initial Mapping of ASS in coastal NSW.....	62
	3.8.2 Risk Map Soil Sampling.....	63
	3.8.2.1 Soil Sampling Techniques.....	64
	3.8.2.2 Risk Map Produced.....	64
3.9	Soil Data.....	67
	3.9.1 Locating Existing Soil Data.....	67
	3.9.2 Organising Soil Data in a GIS.....	70
	3.9.3 Data Coordinate Systems.....	70
	3.9.4 UTM Projections used in Broughton Creek Data.....	71
	3.9.5 The Geodetic Datum.....	71
	3.9.6 Vertical Datum – Australian Height Datum (AHD).....	73
<b>CH 4: Preliminary Data Analysis.....</b>		<b>74</b>
	4.1 Screening Data.....	74
	4.2 Univariate Descriptive Statistics.....	75
	4.2.1 Data Standardisation.....	77
	4.2.2 Coefficient of Variation.....	79
	4.3 Missing Data Analysis.....	82
	4.4 Variable Independence.....	82
	4.5 Assessment for Normality.....	82
	4.5.1 Individual Variable Analysis.....	85
	4.5.2 Skewness, Kurtosis and Probability Plots.....	86
	4.5.3 Data Transformations.....	86
	4.5.4 Justification for Transformation.....	88
	4.6 Outlier Identification.....	89
	4.6.1 Univariate and Multivariate outliers.....	92
	4.7 Nonlinearity and Heteroscedasticity.....	94
	4.8 Multicollinearity and Singularity.....	95

4.8.1 Other Variable Transformations.....	97
4.8.2 Data Summary.....	101
4.9 Spatial autocorrelation.....	101
4.10 Spatial Visualisation of Data.....	102
<b>Chapter 5: Spatial Statistical Analysis.....</b>	<b>105</b>
5.1 Local versus Global Statistical Analysis.....	105
5.2 Multiple correlation and regression.....	107
5.2.1 Multivariate Linear Regression Models.....	108
5.2.2 b-Coefficients.....	110
5.2.3 ANOVA – Analysis of Variance.....	111
5.2.4 Limits to Multiple Correlation and Regression Analysis.....	112
5.3 Geographically-Weighted Regression (GWR).....	112
5.4 Spatial Interpolation.....	115
5.4.1 Deterministic Interpolation Techniques.....	115
5.4.1.1 GPI – Global Polynomial Interpolation.....	115
5.4.1.2 IDW – Inverse Distance Weighting.....	116
5.4.1.3 LPI – Local Polynomial Interpolation.....	117
5.4.1.4 RBF – Radial Basis Functions.....	118
5.4.2 Geostatistical Interpolation Techniques.....	119
5.4.2.1 Kriging and Cokriging.....	120
5.4.2.2 Theory of Ordinary Kriging.....	121
5.5 Cross-validation and validation.....	129
<b>Chapter 6: Coastal Acid Sulfate Soil Severity Models.....</b>	<b>132</b>
6.1 Model 1: Ordinary Kriging in Parameter Estimation.....	132
6.1.1 Exploratory Spatial Data Analysis.....	132
6.1.2 Semi Variance Generation.....	133
6.1.3 Covariance.....	134
6.1.4 Model Generation.....	135
6.1.4.1 Exchangeable Aluminium (3-D Model).....	135
6.1.4.2 Total Actual Acidity (3-D Model).....	138
6.1.4.3 Electrical Conductivity (3-D Model).....	143
6.1.4.4 Error Generation.....	146
6.1.4.5 Weights.....	147
6.1.4.6 Ordinary Kriging Severity Map.....	149
6.2 Model 2: Inverse Distance Weighting in Parameter Estimation (Local).....	152
6.2.1 Exchangeable Aluminium (3-D Model).....	152
6.2.2 Total Actual Acidity (3-D Model).....	152
6.2.3 Electrical Conductivity (3-D Model).....	153
6.2.4 Error Generation.....	153
6.2.5 IDW Severity Map.....	154
6.3 Model 3: Universal Kriging in Parameter Estimation (Local).....	155
6.3.1 Exchangeable Aluminium (3-D Model).....	156
6.3.2 Total Actual Acidity (3-D Model).....	156
6.3.3 Electrical Conductivity (3-D Model).....	156
6.3.4 Error Generation.....	157
6.4 Universal Kriging Severity Map.....	157
6.5 Model evaluation.....	159
6.5.1 Comparison of three generated models.....	159
6.5.2 Comparison to DLWC/DNR Risk Maps.....	162
<b>Chapter 7 Application of Coastal Acid Sulfate Soil Risk Model.....</b>	<b>164</b>

7.1 Using CASS Severity Maps.....	164
7.2 Validity of Severity Models.....	166
7.3 Applying Severity Models to Natural Resource Management.....	166
7.4 Best Practice Management for Coastal Acid Sulfate Soil Identification in a Catchment.....	167
7.5 Coastal Acid Sulfate Soil Legislation.....	169
7.5.1 Environmental Planning and Assessments Act 1979.....	170
<b>CH 8: Conclusion.....</b>	<b>171</b>
8.1 Problems with Locating Data.....	171
8.1.1 Lack of Central Repository.....	171
8.1.2 Incomplete Information.....	172
8.2 Recommendations.....	172
8.2.1 Online Interactive Tool.....	172
8.2.2 Hydrological Modelling.....	173
8.3 Disclaimer Limitations.....	173
<b>References.....</b>	<b>174</b>
 <b>Appendices</b>	
<b>A1: Formats of GIS Data.....</b>	<b>A1</b>
<b>A2: Geographical Coordinate Systems.....</b>	<b>A4</b>
<b>A3: Projected Coordinate Systems.....</b>	<b>A6</b>
<b>A5: Coordinate System References.....</b>	<b>A11</b>
<b>A6: Model Output.....</b>	<b>A14</b>

## List of Figures

Figure 2.1 Landforms of the Shoalhaven river deltaic-estuarine plains.....	11
Figure 2.2 Stratigraphic profiles E and F, Shoalhaven River deltaic-estuarine plains.....	12
Figure 2.3 Typical Coastal Estuary.....	13
Figure 2.4 Natural Setting - low frequency, low magnitude, short duration acidity.....	14
Figure 2.5 Post Drainage - High frequency, high magnitude, persistent acidity....	15
Figure 2.6 Redox potential v pH (stability) of compounds in a typical CASS.....	18
Figure 2.7 Relationship between pH and $[Al^{3+}]$ , and $[Fe^{3+}]$ .....	21
Figure 2.8 The pH log scale and examples of solutions found at each level.....	23
Figure 2.9 Chloride/sulfate ratios vs. log salinity for seawater.....	27
Figure 2.10 Electrical Conductivity of a soil and associated composition.....	28
Figure 2.11 The Veris Sensor EC Cart.....	29
Figure 2.12 Electrical Conductivity at Broughton Creek Upstream and Downstream Datalogger.....	31
Figure 2.13. Electromagnetic Survey measuring Conductivity.....	33
Figure 2.14: Upstream and Downstream: pH v Rainfall.....	38
Figure 3.1: Structure of how NASIS organizes data to be used for other applications.....	47
Figure 3.2 Hierarchical Structure of Land Resources.....	48
Figure 3.3 Aerial Photograph of Broughton Creek Floodplain: Elevation $\leq 4m$ .....	56
Figure 3.4 Three-Dimensional Flooding Simulation of Broughton Creek Drains...	57
Figure 3.5 Digital Terrain Model of Broughton Creek Floodplain.....	60
Figure 3.6 Flood Mitigation Drain Elevation Intervals on 0.2m scale.....	61
Figure 3.7 CASS Risk Map – Broughton Creek Floodplain.....	66
Figure 3.8 Spheroid shape as referenced to the earth.....	72
Figure 3.9: Geocentric Datum (WGS84) - Geodetic Reference System 1980 & Geodetic Datum (AMG66) – Australian National Spheroid.....	73
Figure 4.1 Normal Distribution of intervals in project data set.....	78
Figure 4.2 Pearson Correlation pH and log (TAA).....	81
Figure 4.3 Pearson Correlation pH and log (ExAl%/CEC).....	81
Figure 4.4 Distribution of variables (TAA, EC, pH) used in the project.....	83
Figure 4.5 Distribution of variables (ExAl%, Cl:SO4) used in the project.....	84
Figure 4.6 Various types of data distributions (Wulder, 2002).....	85
Figure 4.7 Possible Data Transformations to meet Normality Assumption.....	86
Figure 4.8: Log-Transferred Distribution of TAA.....	87
Figure 4.9 Log-Transferred Distribution of EC, Cl:SO4 and logEXAl%.....	88
Figure 4.10 Distribution of pH.....	91
Figure 4.11 Box-Whisker Plot of pH.....	91
Figure 4.12 Homoscedasticity with both variables normally distributed (pH v logExAl, pH v logCl:SO4).....	92
Figure 4.13 Homoscedasticity with both variables normally distributed (pH v logTAA, pH v log EC).....	93
Figure 4.14 Homoscedasticity.....	94
Figure 4.15 Heteroscedasticity.....	94

Figure 4.16 Prediction of logTAA using Equation 4.3.....	97
Figure 4.17 Prediction of ExAl/CEC using Equation 4.4.....	98
Figure 4.18 Prediction of log (ExAl/CEC) using Equation 4.4.....	99
Figure 4.19 Residuals (Error) of ExAl/CEC using Equation 4.4.....	100
Figure 4.20 Map of soil sampling locations in Broughton Creek.....	103
Figure 5.1 A RBF network (Gaussian bell function) with one output.....	118
Figure 5.2 Ordinary Kriging of Exchangeable Aluminium for Layer 1 (0.00 – 0.05m AHD).....	125
Figure 5.3 Exchangeable Aluminium - Interval 2 on Catchment DEM (x100 exaggeration).....	126
Figure 5.4 Semivariogram of Exchangeable Aluminium for Layer 1.....	127
Figure 5.5 Cross Validation: Predicted v Measured logExAl for Layer 1 (0.00 – 0.05m AHD).....	129
Figure 5.6 Cross Validation of the Training Set – Interval 1 (ExAl).....	130
Figure 5.7 Validating the Validation Set – Interval 1 (ExAl).....	131
Figure 6.1 Semi Variance generation of Interval 5, ExAl Prediction Using Ordinary Kriging.....	133
Figure 6.2 Covariance generation of Interval 5, ExAl Prediction Using Ordinary Kriging.....	134
Figure 6.3 Exchangeable Aluminium Soil Profile – Stretched Raster.....	136
Figure 6.4 Exchangeable Aluminium Soil Profile – Classified Raster.....	137
Figure 6.5 Measured v Predicted Exchangeable Aluminium (Interval 5).....	138
Figure 6.6 Measured v Predicted Total Actual Acidity (Interval 5).....	140
Figure 6.7 Total Actual Acidity Soil Profile – Stretched Raster.....	141
Figure 6.8 Total Actual Acidity Soil Profile – Classified Raster.....	142
Figure 6.9 Electrical Conductivity Soil Profile – Stretched Raster.....	144
Figure 6.10 Electrical Conductivity Soil Profile – Classified Raster.....	145
Figure 6.11 Ordinary Kriging Optimal Lags – RMSS Error.....	146
Figure 6.12 Ordinary Kriging Optimal Lags – RMS v AS Error.....	148
Figure 6.13 Process of Generating Severity Maps in ArcGIS.....	149
Figure 6.14 Ordinary Kriging Severity Map.....	151
Figure 6.15 Inverse Distance Weighting Severity Map.....	154
Figure 6.16 Universal Kriging Detrending – Local Search.....	155
Figure 6.17 Universal Kriging Severity Map.....	158
Figure 6.18 Severity Map Model Comparisons.....	160
Figure 6.19 Severity Map Errors for all Models.....	161
Figure 6.20 Comparison of CASSOK Severity Map and DLWC/DNR Risk Map.....	163
Figure 7.1 CASS Risk Map Schematic.....	165
Figure 7.2 Outline of the process of Implementing Acid Sulfate Soil Management Strategies.....	168

## List of Tables

Table 2.1 Estimation of acid sulphate soil distribution by region.....	7
Table 2.2 The Acid Test Criteria, with Expert Criteria <sup>^</sup> from Broughton Creek (NSW, Australia).....	8
Table 2.3 ASRIS Soil pH Classification.....	21
Table 2.4 Dent & Dawson (1996) weights for Soil Ph.....	22
Table 2.5 Exchangeable Aluminium as Percentage of Cation Exchange Capacity.....	25
Table 2.6 Values of Soil Salinity and Classes.....	30
 Table 3.1: Landform Codes used on the Acid Sulfate Soil Risk Maps.....	 63
Table 3.2: Grouped elevation increments for data standardization.....	69
 Table 4.1 Summary Statistics of All Variables.....	 76
Table 4.2 Summary Statistics of Log Variables.....	77
Table 4.3 Number of sample points per Soil Layer.....	78
Table 4.4 Pearson Bivariate Correlation Coefficients of Raw Data.....	80
Table 4.5 Pearson Bivariate Correlation Coefficients of Log-Transformed Data.....	80
Table 4.6 Simple Regression equations between pH and Important variables.....	80
Table 4.7 Critical z scores (normal) for certain levels of confidence.....	90
Table 4.8 VIF values between variables used in the project.....	96
Table 4.9 Variables to be used in multivariate analysis.....	101
 Table 5.1 Comparisons of Local versus Global Statistical Approaches.....	 106
Table 5.2 Theoretical relationship between variables.....	110
Table 5.3 Summary of the output of Kriging and CoKriging Methods.....	120
Table 5.4 Error readings for a good geostatistical model.....	128
Table 5.5 Prediction Error Values for Interval 1 (0.00-0.05m) Exchangeable Aluminium.....	129
 Table 6.1 Weights used in the project to generate Risk Maps.....	 147

## List Of Plates

Plate 2.1 Red spot disease (Epizootic Ulcerative Syndrome) in silver perch.....	26
Plate 2.2 Oxidised Potential CASS, causing intermediate Jarosite Product.....	34
Plate 2.3 Self-regulating titling weir installed at drain P6D8, located on the western side of Broughton Creek.....	40

## Abbreviations

ACASS	Actual Coastal Acid Sulfate Soil
AGD	Australia Geodetic Datum
AHD	Australian Height Datum
Al	Aluminium
ALS	Airborne Laser Scan
AMG	Australian Map Grid
ANOVA	Analysis Of Variance
ANS	Australian National Spheroid
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Australian Resource Management Council of Australian and New Zealand
ASRIS	Australian Soil Resource Information System
Cl:SO <sub>4</sub>	Chloride:Sulfate
CANSIS	Canadian Soil Information System
CASS	Coastal Acid Sulfate Soils
CASSOK	Coastal Acid Sulfate Soils Ordinary Kriging Model
CEC	Cation Exchange Capacity
CIS	Commonwealth of Independent States
CLT	Central Limit Theorem
DEM	Digital Elevation Model
DTM	Digital Terrain Model
EAA	European Environment Agency
EC	Electrical Conductivity
EM	Electromagnetic Survey
ESB	European Soil Bureau
EGII	European Geographic Inform Infrastructure
ESRI	Environmental Systems Research Institute
EU	European Union
EUSIS	European Union Soil Information System
ExAl	Exchangeable Aluminium
Fe	Iron
GCS	Geographic Coordination System
GDA	Geocentric Datum Australia
GIS	Geographic Information Systems
GPI	Global Polynomial Interpolation
GPS	Global Positioning System
GWR	Geographically Weighted Regression
FAO	Food and Agriculture Organization
IDW	Inverse Distance Weighting
ISG	Integrated Survey Grid
KCl	Potassium Chloride
LIDAR	Light Detection And Ranging
LPI	Local Polynomial Interpolation
LRR	Land Resource Region
LRRC	Land Resources Research Centre
LRU	Land Resource Unit
MGA	Map Grid Australia
MLRA	Major Land Resource Area

NASIS	National Soil Information System
NRCS	Natural Resource Conservation Service
NSW	New South Wales
OK	Ordinary Kriging
PCASS	Potential Actual Coastal Acid Sulfate Soil
PCS	Projected Coordination System
pH	$\log_{10}(\text{H}^+)$
RBF	Radial Basis Function
REMS	Reclaimed Water Management System
RMSPE	Root Mean Square Prediction Error
RMSS	Root Mean Squared Standardised
RV	Representative Value
Spocas	Sulfate –
Scr	Sulfur-Chromium Reducible
SAI	Space Applications Institute
SALIS	Soil and Land Information System
SOTER	Soil and Terrain Database
SPADE	Soil Profile Attribute Data Environment
SRADWG	Shoalhaven River Acid Drainage Working Group
SRTW	Self Regulating Tilting Weir
SSIS	Spanish Soil Information System
SSSD	State Soil Survey Database
SSURGO	Soil Survey Geographic database
STATSGO	State Soil Geographic database
SQL	Structured Query Language
TAA	Total (Titratable) Actual Acidity
TF	Thiobacillus Ferroxidans
TPA	Titratable Peroxide Activity
UK	Universal Kriging
USDA	United States Department of Agriculture
UTM	Universal Transverse Mercator
VIF	Variance Inflation Factor

## Abstract

Coastal Acid Sulfate Soil (CASS) is a soil-water phenomenon that causes soil and water pollution resulting from the exposure, typically human-initiated, of pyrite to atmospheric and biotic oxygen. Structural deformation of capital works, combined with loss to flora and fauna (biodiversity) resulting from CASS has caused major concern to environmental managers, industries that rely directly on high quality water conditions for day-to-day operations, and landholders who experience characteristic scalding and other associated environmental problems on land adjacent to disturbed areas.

Areas of CASS in Australia have been identified by Department of Natural Resources (DNR) using a combination of expert knowledge, geomorphologic principles and Geographic Information Systems (GIS) known as Acid Sulfate Soil Risk Maps. These maps have been applied by local managers in planning and natural resource management to identify areas showing the highest probability of being severely affected by CASS.

In this project, with the DNR model as a starting point, the aim was to improve the way CASS severity is assessed. This included using five major soil-chemical parameters and/or relationships in a number of geostatistical models. The five parameters included were: Total Actual Acidity (TAA), pH, Chloride to Sulfate ratio ( $\text{Cl}^-:\text{SO}_4^{2-}$ ), Depth to actual CASS layer (Jarosite layer), and Exchangeable Aluminium per cent of total Cation Exchange Capacity. Other parameters such as depth to Potential CASS layer (Pyrite layer) and Sulfur per cent (S%), also have weight but not as significant as the other parameters and were subsequently removed from further detailed analysis.

Ordinary Kriging (OK) was identified as the most suitable geostatistical method to predict CASS severity using the aforementioned soil-chemical principles. The resulting 3-Dimensional model was compared to the 2-Dimensional DNR Risk Maps with similarities in both models validating both approaches in determining severity using different methods. The CASSOK model put a greater emphasis on soil parameters down the soil profile and how they relate to surface elevation across a finite study area (Broughton Creek floodplain, New South Wales).

Applying the new CASSOK model to broader areas of New South Wales will be dependent on available data to input into the model. Using the current DNR risk maps is a broad indication of an area, using CASSOK will give a greater indication of what can be expected 2m below the surface. The ability to create a method that can be applied across the entire state of New South Wales, and then to a national level will be an invaluable resource to land managers in future planning and risk management.

## **Acknowledgements**

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## **Dedication**

This is dedicated to all the research students that undergo serious difficulties in trying to complete a research document due to reasons out of their control, I understand your grief.