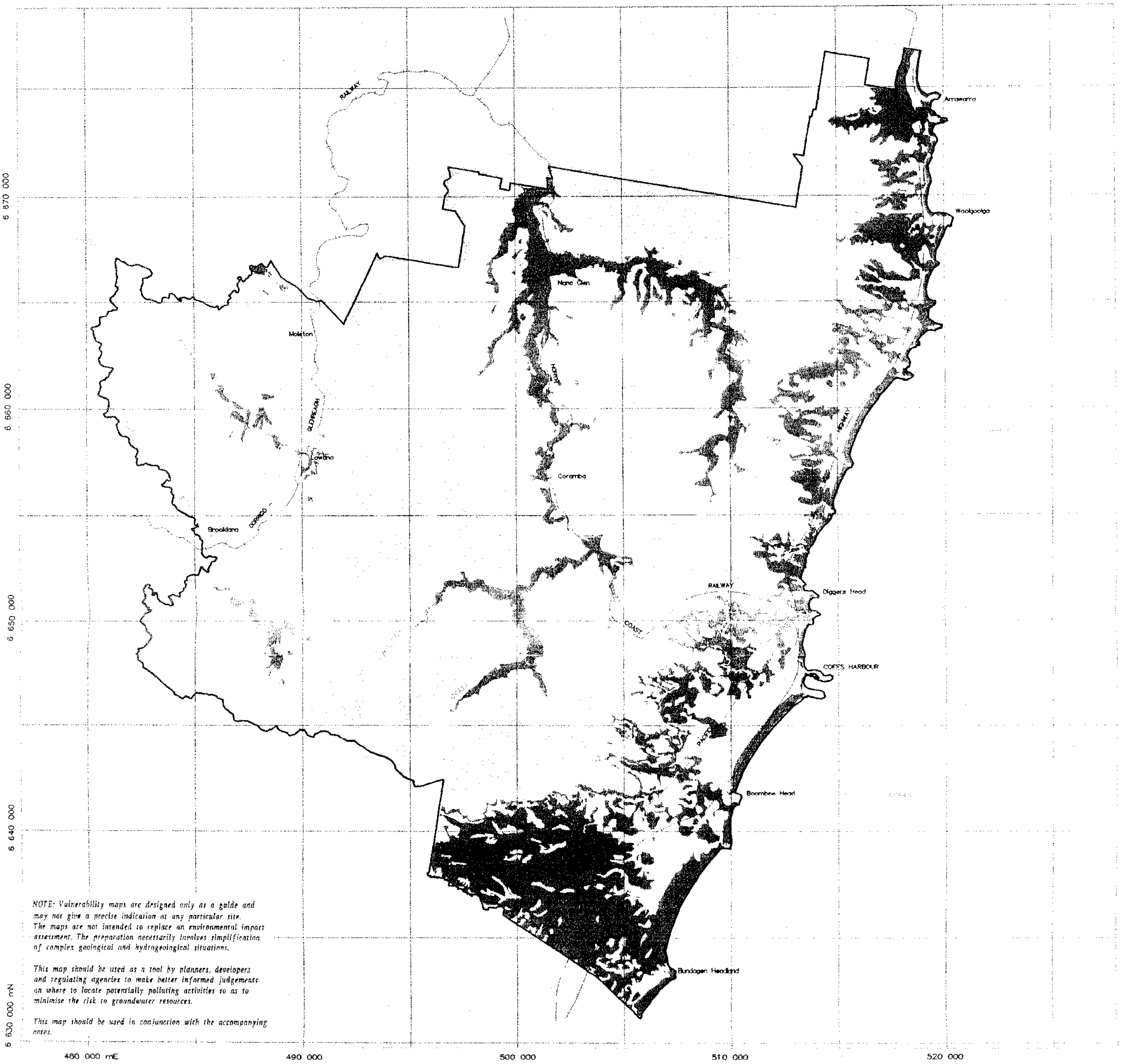
LAND & WATER CONSERVATION
PREPARED BY THE RESOURCE INFORMATION SECTION GRAFTON.

GROUNDWATER VULNERABILITY

COFFS HARBOUR LOCAL GOVERNMENT AREA



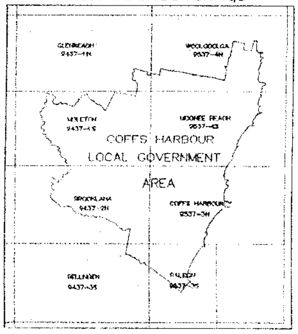
NOTE: Vulnerability maps are designed only as a guide and may not give a precise indication at any particular site. The maps are not intended to replace an environmental impact assessment. The preparation necessarily involves simplification of complex geological and hydrogeological situations.

This map should be used as a tool by planners, developers and regulating agencies to make better informed judgements on where to locate potentially polluting activities so as to minimise the risk to groundwater resources.

This map should be used in conjunction with the accompanying notes.

Grid lines shown at 5000 metre intervals from False Origin of AMG Zone 56.

1:25000 MAP COVERAGE



Vulnerability Rating	Aquifer Conditions	Level of Assessment Required
LOW	"Low" vulnerability groundwater areas in general contain a considerable depth to the water table and low aquifer potential.	The work should include a desk study to identify the concerns and potential risk to groundwater or the environment.
MODERATELY LOW	This class includes much of the hilly or steep country associated with the meta-sediments located around the more remote areas and low rainfall areas. These areas generally have low to moderate soil permeability with depth to water often greater than 15 metres providing conditions suitable for some attenuation of any contaminant prior to it reaching the water table.	A potential risk is indicated by the vulnerability map requiring site investigation. The extent of work should involve a site investigation, including soil and water sampling and testing, definition of flow systems and reporting in addition to a desk study.
MODERATE	"Moderate" vulnerable groundwater refers to areas associated generally with the meta-sediment terrain with moderate slopes and a depth to water table greater than 10 metres. These areas have a moderate recharge component and the aquifer is of marginal quality.	The work should investigate and make recommendations on the need for an ongoing monitoring program, details on the protection design factors, (natural attenuation, physical barriers, etc) in addition to the previous levels of investigation.
MODERATELY HIGH	This class includes the unconfined shallow alluvium along the coast and along the major rivers and their tributaries where the slope and depth to water table is minimal.	The work should include a desk study, detailed site investigation, and implementation of an on-going monitoring program. In addition, the protection design system, incorporating natural attenuation, hydraulic and physical barriers etc needs to be demonstrated to be effective.
HIGH	"High" vulnerability ranked groundwater resources usually contain fresh quality groundwater, are both unconfined aquifers that are highly permeable and have a shallow depth to water table. Aquifers contained within the aeolian beach and sand dunes are typically found in this class. Aquifers within this class require a high level of protection.	The work should include a desk study, site investigations, ongoing monitoring plus a demonstrated remedial action plan for clean-up which analyses the effectiveness of the remediation plan. The financial capacity of the responsible party to enact the plan should also be evaluated. In the event that the risk to groundwater is unacceptable an activity may be banned by the responsible authority.

LEGEND
- Road
- Railway
- River or creek
- Water body
- No classification

0 2 4 6 8km

Scale 1:100000

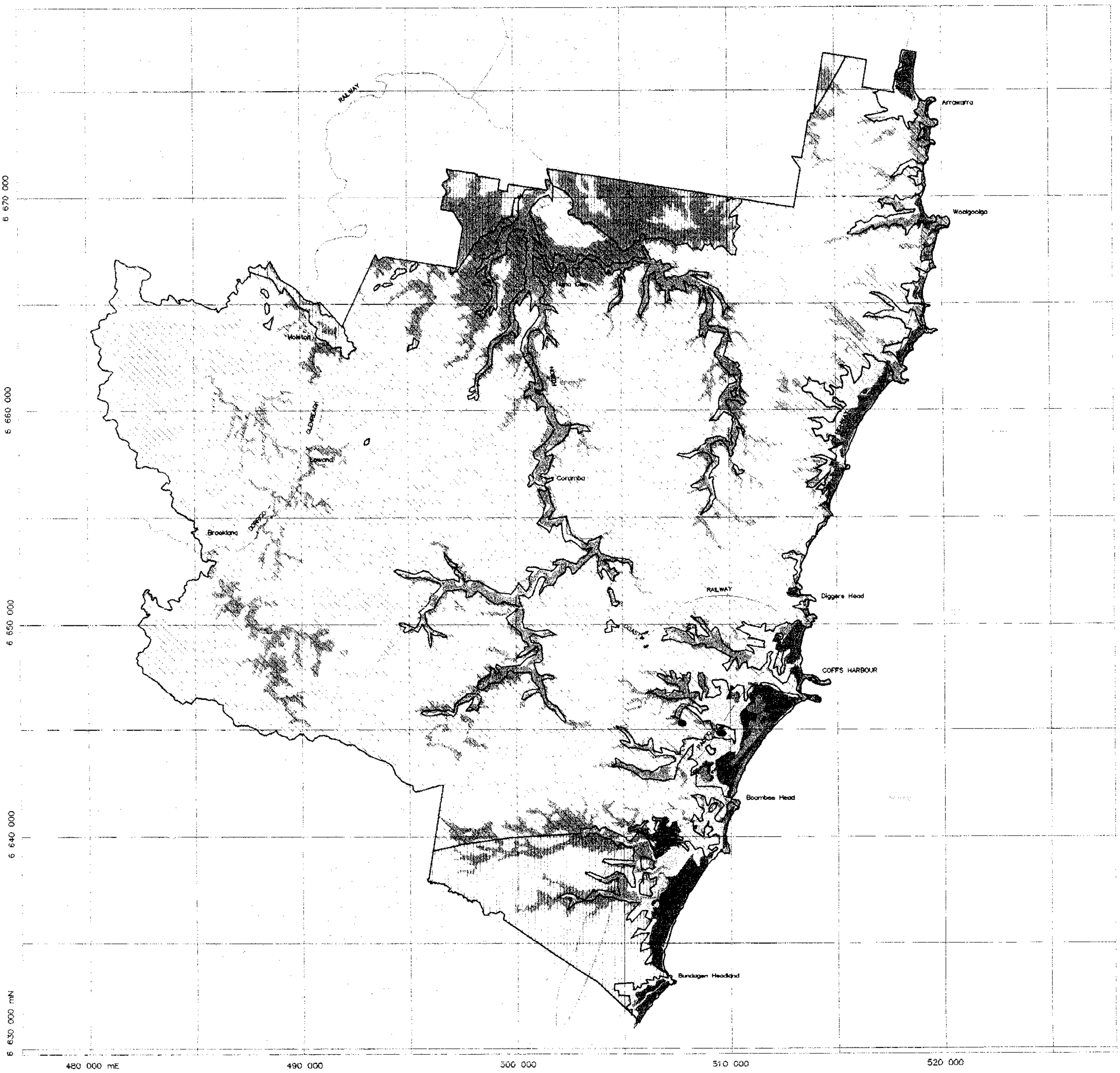
September 1997

A0 GF053PV

LAND & WATER CONSERVATION
PREPARED BY THE RESOURCE INFORMATION SECTION GRAFTON.

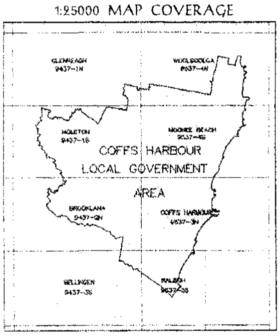
GROUNDWATER AVAILBILITY

COFFS HARBOUR LOCAL GOVERNMENT AREA



Grid lines shown at 5000 metre intervals from False Origin of AMG Zone 56.

1:25000 MAP COVERAGE



TDS	CLASSIFICATION	YIELD
1501 – 5000 mg/L	brackish	0.1 – 1.5 L/s
500 – 1000 mg/L	marginal	0.1 – 1.5 L/s
500 – 1500 mg/L	marginal	0.3 – 1.5 L/s
<500 mg/L	fresh	0.3 – 1.5 L/s
<500 mg/L	fresh	1.5 L/s

GEOLOGY

- Unconsolidated Sediments
- Porous Rocks
- Metasediments – Fractured Rock

LEGEND

- Road
- Railway
- River or creek
- Water body
- No classification

0 2 4 6 8km

Scale 1:100000

September 1997

A0 GF053Ga

Figures 3 and 4 show two possible scenarios for potential contamination of adjacent surface water bodies via faulty septic tanks.

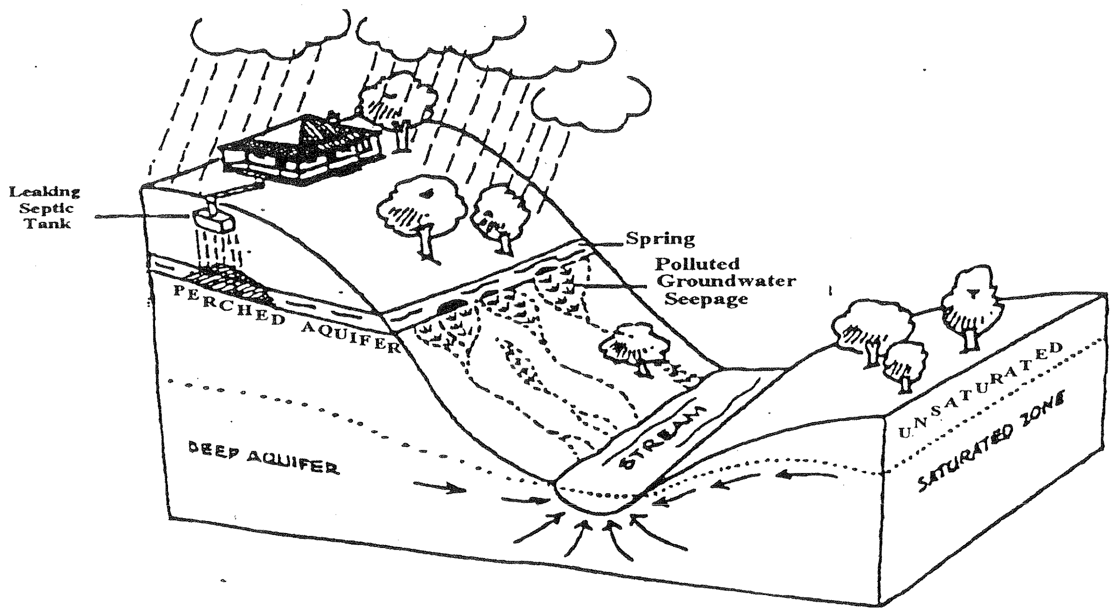


FIGURE 3. CONTAMINATION OF A SHALLOW PERCHED AQUIFER VIA A FAULTY SEPTIC TANK ON STEEP TERRAIN.

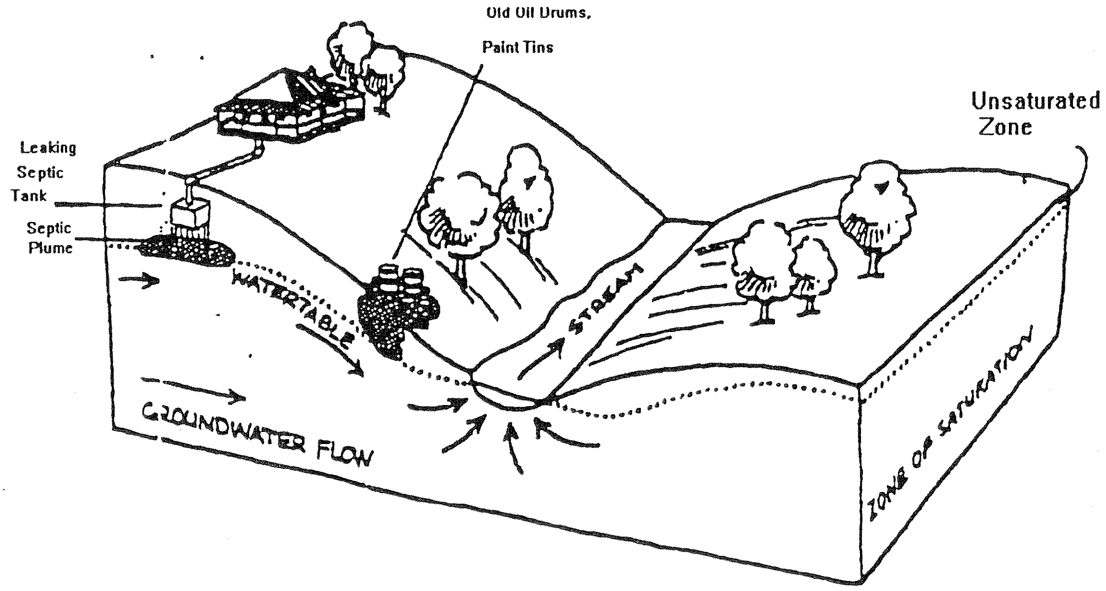


FIGURE 4. CONTAMINATION OF THE SHALLOW GROUNDWATER ENVIRONMENT VIA A FAULTY SEPTIC TANK.

There are ways in which the community can reduce the environmental impacts of certain industries such as waste disposal sites. Through the use of recycling and segregation of waste into different types, better management of an area can be achieved. Whilst generally a waste disposal site may be considered unacceptable for a particular site, the removal of the potential contaminants and the initiation of recycling can reduce the volumes of waste and surface area. The EPA are currently undertaking a report on Waste Minimisation & Management Regulation with the vision that waste disposed per capita will be reduced by 60% by the year 2000 (compared to 1990). The draft guidelines adopt a new waste system which classifies landfills into inert waste, solid waste & hazardous waste landfills.

Other initiatives include the concept of "designer" irrigation to provide a "best match" between the hydraulic properties of the land, the water requirements of the crop being grown, and optimal management and irrigation methods. This would prevent negligent wastage of water and the transfer of unnecessary contaminants into the groundwater, however the funds required to carry out the studies & the establishment cost are high.

5.2 Dlwc Groundwater Vulnerability Mapping

The methodology for groundwater vulnerability maps was developed by the DLWC Centre for Natural Resources, Hydrogeology Unit and has been adapted here to incorporate recently available local soils information. A groundwater vulnerability map has been prepared by the DLWC which shows the vulnerability classifications of the various aquifers (Figure 5). Previous vulnerability mapping projects for the North Coast Region and in other parts of the State carried out by the DLWC involved the overlay and index method, based on a modified DRASTIC technique developed by the United States Environment Protection Authority (EPA). The technique selected is usually based on levels of data, the scale of the area and the intended end use of the vulnerability assessment.

For the Coffs Harbour LGA, the DRASTIC technique was used. The technique involves the compilation of a number component maps comprising depth to water table, recharge potential, aquifer media, vadose zone media, soil media and topography that are overlain and combined to produce a single output map. Two of the input maps used in the analysis (Net Recharge and Vadose Zone) are each made from a composite of four other maps. Explanatory notes which describe how the map was developed is provided in Appendix 1.

5.3. *Aquifer Vulnerability Classification In The Coffs Harbour LGA Area*

"*High*" vulnerability ranked groundwater resources usually contain fresh quality groundwater, are both unconfined aquifers that are highly permeable and have a shallow depth to water table. Aquifers contained within the aeolian beach and sand dunes are typically found in this class. Characteristics deemed to be highly vulnerable include a water table less than 5 metres, combined with shallow soil depth and a high recharge component. Areas in the river alluvial belts also have a high groundwater vulnerability due to the shallow slopes, permeable soils and shallow water table. Aquifers within this class require a high level of protection.

"*Moderately High*" vulnerability aquifers for the CHLGA area would include the unconfined shallow alluvium along the coast and along the major rivers and its tributaries where the slope and depth to water table is minimal and a high groundwater recharge component exist.

"*Moderate*" vulnerable groundwater refers to areas associated generally with the meta-sediment terrain with moderate slopes and a depth to water table greater than 10 metres. These areas have a moderate recharge component.

"*Moderately-Low*" vulnerability for groundwater covers a considerable proportion of the map and would include much of the hilly or steep country associated with the meta-sediments located around the more remote areas. These areas generally have moderate soil permeability with depth to water often greater than 15 metres providing the conditions suitable for some attenuation of the contaminant prior to it reaching the water table.

"*Low*" vulnerability groundwater areas in general contain a considerable depth to the water table and low aquifer potential. There are a number of extensive areas classed as low vulnerability on the meta-sediments and Clarence - Moreton porous sedimentary rocks.

5.3.1 Level of Assessment Required

Groundwater vulnerability maps do not directly consider the chemical nature of the pollutant in assessing vulnerability, they are concerned only with the hydrogeological setting which makes the groundwater susceptible to contamination from a surface source.

When a development application is being prepared or considered it is important that the impact of the development on both surface and groundwater resources is assessed. It is important to know who uses these resources (beneficial use) and also the current water quality. Certain developments should not be allowed within highly vulnerable areas. Where such activities are proposed, significant engineering measures would be necessary to minimise the risks of pollution.

The following Table, modified after AWRC, Draft Guidelines for Groundwater Protection, 1992, is a guide to the amount of groundwater assessment required for a development that requires consent in either of the five aquifer vulnerability classes.

Vulnerability Classification	Groundwater Assessment Requirements
Low	Groundwater Contamination Assessment Report A desk study is required to identify the concerns and potential risk to groundwater or the environment and the need for any further action to be presented in the development application. A standard format hydrogeological report would most likely result, including definition of the flow systems, known geology, soil information for the site and a professional statement as to the likely impact on the groundwater resources.
Moderately Low	Site Investigation A potential risk is indicated by the vulnerability map requiring site investigation. The extent of work should involve a site investigation, including soil and water sampling and testing, definition of flow systems and reporting in addition to a desk study.
Moderate	Detailed Site Investigation and Monitoring Moderately vulnerable areas, or where the previous levels of investigation indicate a demonstrated risk to groundwater then a detailed groundwater site investigation is required. The work should investigate and make recommendations on the need for an ongoing monitoring program, details on the protection design factors, (natural attenuation, physical barriers, etc) in addition to the previous levels of investigation.
Moderately High	Demonstrated Groundwater Protection System The risk to groundwater is demonstrated by the vulnerability map, as an area in which contamination to the groundwater systems should not be tolerated. The work should include a desk study, detailed site investigation, and implementation of an on-going monitoring program. In addition the protection design system incorporating natural attenuation, hydraulic barriers, physical barriers etc needs to be demonstrated to be effective. The proposal will need to include a feasibility plan for a clean-up in addition to a detailed monitoring and ongoing assessment program.
High	Demonstrated Remedial Action Plan/Prohibition This classification identifies the area as having a potential risk so great as to warrant a demonstrated remedial action plan. The work should include a desk study, site investigations, ongoing monitoring plus a demonstrated remedial action plan for clean-up which analyses the effectiveness of the remediation approach in achieving designated water quality criteria. The financial capacity of the responsible party to enact the plan should also be evaluated. In the event that the risk to groundwater is unacceptable an activity may be banned by the responsible authority.

6 ACKNOWLEDGMENTS

I gratefully acknowledge the assistance of various officers of the DLWC with special thanks to Lynne Cains from the Grafton Resource Information Unit. Thank you to Glen Atkinson for his peer review as well as the technical assistance and valued discussion provided when producing the groundwater maps. I express much gratitude to Stuart Murray for producing the detailed soil derivative maps at such short notice and Rick Bennell from Coffs Harbour Council. Other DLWC staff that contributed include Jeremy Black and Sue Rea.

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APPENDIX 1

DLWC Methodology
for
Groundwater Vulnerability
Mapping

The basis of the vulnerability mapping is the US EPA DRASTIC model.

Drastic

There are two major portions of the US EPA groundwater vulnerability mapping technique DRASTIC.

1) Designation of mappable units into hydrogeologic settings
2) Relative ranking of hydrogeologic parameters - DRASTIC

HYDROGEOLOGIC SETTINGS

A composite description of all the major geologic and hydrogeologic factors which affect and control groundwater movement, into and though and out of an area. Similar hydrogeologic parameters therefore produce similar vulnerability.

The USA is divided into Groundwater Regions (15) within which hydrogeologic settings were developed for each region.

Each hydrogeologic setting describes topography, soil type, bedrock type, estimate of rainfall and net recharge, depth to water table (DTWT), aquifer yield, relative permeability and any particular features associated with setting ie. over pumping => saline intrusion.

DRASTIC is an acronym for the most important mappable features controlling groundwater pollution.

D	Depth to water
R	(Net) Recharge
A	Aquifer media
S	Soil media
T	Topography (slope)
I	Impact of Vadose Zone Media
C	Conductivity (Hydraulic) of Aquifer.

To assess groundwater pollution potential within hydrogeologic settings numerical ranking is used on the DRASTIC features. There are 3 significant parts

1) Weights
2) Ranges
3) Ratings

Weights

Each DRASTIC feature is assigned a weight relative to each other in order of importance from 1-5. Most significant 5, least 1.

"Weights were determined by a committee in the US and should not be changed" (US EPA Drastic Manual).

DRASTIC by its namesake attempts to identify those features important in determining vulnerability of groundwater resources. However each study area will need to be assessed as to the importance of each specific feature for its area. Topography is obviously more important in a mountainous area than in the flat plains country. Also some features will be taken into consideration in the production of other features, eg topography will influence the production of a DTWT map in a fractured rock terrain where area between data points will need to be interpolated and may not be required in the final analysis

Assigned Weights for DRASTIC Features

Feature	Weight
Depth to water	5
Net Recharge	4
Aquifer media	3
Soil media	2
Topography	1
Impact of Vadose Zone Media	5
Hydraulic Conductivity of Aquifer	3

Ranges

For each DRASTIC feature/factor ranges or significant media types have been devised based on its impact of pollution potential. In the US EPA manual these ranges were generated for a wide variety of settings found in the US and were meant to cover most hydrogeologic settings. These settings often do not translate to hydrogeologic settings found in NSW. The ranges offered by the US EPA manual for some features can be used directly, for example slope classification, others can be used as a guide only and will require customising for each specific study area.

The following graphs and tables are those as defined by the US EPA manual.

Ratings

In the US EPA the range for each DRASTIC feature has been assigned a rating which varies between 1 and 10. D,R,S,T and C have been assigned one value per range. A and I have been given variable ratings to allow specific knowledge of site to be incorporated.

The ratings for each DRASTIC feature in the CHLGA exercise will be assigned a value between 0 -10. The rating enables the ranking of the ranges found in each DRASTIC feature map. These ratings provide for a relative assessment between ranges in each feature.

The DRASTIC Index is determined.

Pollution Potential = DrDw + RrRw + ArAw + SrSw + TrTw + IrIw + CrCw

where r = rating
w = weight

The computed DRASTIC index identifies areas which are more likely to be susceptible to groundwater contamination relative to one another. **The higher the DRASTIC index the greater the groundwater pollution potential.** DRASTIC is a relative evaluation tool and not designed to provide absolute answers. It offers planners and developers a categorisation of areas based on the level of site investigation required or expected for an area when considering the impact of potential development on the groundwater resources.

Feature Definition

Depth To Water

This is an important feature as it determines the depth of material through which a contaminant must travel before reaching the aquifer. In general attenuation capacity increases with depth to water increases, because deeper water levels imply longer travel times. The presence of low permeability layers which confine aquifers will also limit the travel of contaminants into an aquifer. Where an aquifer is confined Depth to Water should be redefined as the depth to the top of the aquifer. For semi-confined a decision must be made as to whether it is more appropriate to consider the aquifer as unconfined or confined.

Depth to Water feature for CHLGA was calculated by combining actual DTWT data with geology and topography. The groundwater is defined as a having three discrete aquifer system, which recharge locally. Initially a groundwater contour map was constructed using groundwater data where available and hydrogeologic principles where no data was available. A Depth to Water map was then constructed from the groundwater contour map and hydrogeologic principles with 5 metre intervals.

Recharge

Net Recharge represents the amount of water per unit area of land which penetrates the ground surface and reaches the water table. This recharge water is available to transport a contaminant vertically to the watertable and horizontally within the aquifer. In addition it controls the volume of water available for dispersion and dilution of the contaminant in the vadose and saturated zones. In general the greater the recharge the greater the potential for groundwater pollution.

DRASTIC modelling by the US EPA attempts to provide a value for Net Recharge for an area based on:

Net Recharge = Annual Precipitation - Surface Runoff - Evaporation - Transpiration

For the CHLGA study area an alternative is being proposed which will derive a recharge potential for a zone relative to another zone within the study area. It is believed that this will more closely approximate recharge potential within the study area than applying a Net Recharge value for the area. The factors incorporated into this approach which are believed to be important for recharge include; Infiltration Proportion of Geology (Aquifer) Type, Rainfall, , and Soil Permeability.

Aquifer Media

Aquifer medium governs the route and path length, (flow system), within the aquifer. The path length is important in determining the time available for attenuation processes such as sorption, reactivity, and dispersion to occur. The aquifer medium also influences the amount of effective surface area of materials with which the contaminant may come in contact within the aquifer. The route which a contaminant will take can be strongly influenced by fracturing or by an interconnected series of solution openings which may provide pathways for easier flow.

The US EPA defines aquifer media by descriptive names based on geological units or settings. A similar approach was taken for the CHLGA, where the aquifer was defined by its geology.

Soil Media.

The US EPA considers the soil to be the upper weathered surface of the earth which averages a depth of 2 metres or less from the ground surface. Soil has a significant impact on the amount of recharge which can infiltrate into the ground and hence on the ability of a contaminant to enter into the ground and hence on the ability of a contaminant to move vertically into the vadose zone. The presence of fine-textured materials such as silts and clays can decrease relative soil permeability's and restrict contaminant migration. Moreover where the soil zone is fairly thick, the attenuation processes of filtration, biodegradation, sorption, and volatilisation may be quite significant. The US EPA describes the soil media in terms of its textural classification and ranks it in order of pollution potential.

The soil mapping for the CHLGA area was organised by Glenn Atkinson (DLWC Soil Surveyor). Field mapping was at a 1:25 000 scale with the final maps produced at a 1:100 000 scale. The final soil map incorporated into the CHLGA vulnerability map was a combination of soil thickness, soil permeability and cation/anion exchange of both the topsoil and subsoil.

Topography

The US EPA refers to topography as the slope and slope variability of the land surface. Topography helps control the likelihood that a pollutant will run off or remain on the surface, in one area long enough to infiltrate. Slopes which provide a greater opportunity for contaminants to infiltrate will be associated with a higher ground-water pollution potential. Topography influences soil development and therefore has an effect on contaminant attenuation. For the CHLGA digitised terrain data was provided by the Land Information Centre (LIC). From the terrain data, the GIS then calculated slope percentage which could be used for ranking and rating purposes.

Impact of the Vadose Zone

The vadose zone refers to the zone above the water table which is unsaturated or discontinuously saturated. The type of vadose zone media determines the attenuation characteristics of the material below the typical soil horizon and above the water table. The media also controls the path length and routing, thus affecting the time available for attenuation and the quantity of material encountered. The routing is strongly influenced by any fracturing present. The US EPA have designated vadose zone media by lithology descriptions from bore logs and ranked according to pollution potential.

An alternative was proposed for the CHLGA study area as there was insufficient borehole data available for characterising the vadose zone over the entire study area. Those factors which are believed to influence contaminant movement or attenuation through the soil profile were incorporated into an equation and a map constructed for the resulting polygons which identified zones (polygons) relative to each other which would be relatively more susceptible to contaminants moving through a vadose zone than another area. The factors considered important in defining the vadose zone in the CHLGA include soil depth, vadose zone type, and depth to water. A more detailed breakdown of the factors employed and the resulting equation and rating is discussed in the range and rating tables devised for The CHLGA study area.

Hydraulic Conductivity

The US EPA define hydraulic conductivity as the ability of aquifer materials to transmit water, which in turn, controls the rate at which ground water will flow under a given hydraulic gradient. The rate at which the groundwater flows also controls the rate at which it enters the aquifer. Hydraulic conductivity is controlled by the amount and interconnection of void spaces within the aquifer which may occur as a consequence of intergranular porosity, fracturing and bedding planes. For purposes of this document, hydraulic conductivity is divided into ranges where high hydraulic conductivities are associated with higher pollution potential. Hydraulic conductivities are determined from aquifer pumping tests.

For the CHLGA, the details available on hydraulic conductivities for the differing geological units were scarce. As it was considered that this would not contribute in defining zones of vulnerability this feature was not included in the DRASTIC equation.

Range and Rating Tables For the CHLGA Study Area

Within the CHLGA study area the features which were deemed important in the development of a vulnerability map included: Depth to Water, Recharge, Aquifer media, Soil Media, Impact of Vadose Zone and Topography. The other features found within the DRASTIC framework such as the aquifer, soil permeability and aquifer media (geology) are incorporated as the factors when generating the Recharge, and Impact of Vadose Zone maps or they are not considered to demonstrate enough variation within the study area to provide a useful feature for assessing vulnerability for the study area.

Table 1 - Ranges and Ratings for Depth to Water

Depth to Water Table (m)

Range	Rating
<5	10
5 - 10	9
10 - 15	7
15 - 20	5
20 - 25	3
>25	1
Weight 5	

Table 2 - Ranges and Ratings for Topography

Topography as Slope %

Range	Rating
<2%	10
2 - 5%	8
5 -10%	5
10 - 30%	3
>30%	1
Weight 1	

Table 3 - Ranges and Ratings for Aquifer Media

Aquifer Media

Range (Geology Type)	Rating
Beach sand and dunes	10
Fluvial Alluvium	8
Sedimentary	5
CHB Metasediments	4
Estuarine Alluvium	3
Weight 3	

The derivation of the a) Recharge, b) Vadose Zone Impact, and c) Soils maps will now be discussed.

a) Recharge

This feature is generated as a map which is specific for the study area. It incorporates features into an equation which are believed to be important to the recharge component of the study area. The equation used calculates the ability of an area to act as a recharge zone relative to another area. The factors used to generate the Recharge map include: geology type (aquifer media), geological infiltration proportion, slope, soil permeability, and rainfall.

The equation is used to generate a **Recharge Value**. This Recharge Value is then grouped into a range of values which are given a rating for use in the final DRASTIC calculation.

Recharge Value = Slope % + Rainfall + Infiltration Proportion of Geological Type + Soil Permeability

Where:

Infiltration Proportion of Geological Type

Range	Factor
Beach sand and dunes	5
Fluvial Alluvium	4
Sedimentary	3
Metasediments	2
Estuarine Alluvium	2

Slope %

Range	Factor
<2%	5
2 - 5%	4
5 - 10%	3
10 - 30%	2
>30%	1

Rainfall (mm)

Range	Factor
>1600mm	4
1500 - 1600mm	3
1400 - 1500mm	2
<1400mm	1

Soil Permeability

Range	Factor
very low	1
low	2
medium	3
high	4
very high	5

The maximum Recharge Value is: 19
The minimum Recharge Value is: 5

The rating table for Recharge is shown in Table 4.

Table 4 - Ranges and Ratings for Recharge

Recharge

Range	Rating
17-19	10
14-16	9
11-13	5
8-10	3
5-7	1
Weight 4	

b) Impact of Vadose Zone

This feature attempts to classify that zone of soil and regolith (saprolite) found above the water table, known as the vadose zone, with regard to its ability to allow any potential contaminant to move through this zone towards the aquifer. This zone is known as the Vadose zone and incorporates Soil Depth, Vadose Zone Type, and DTWT.

An equation is used incorporating these factors, believed to be important to the vadose zone for the study area. The equation provides a **Vadose Zone Value** for a particular area defined by these factors and which is relative to another zone within the context of the study area. This **Vadose Zone Value** is then grouped into a range of values which are given a rating for use in the final DRASTIC calculation.

Impact of Vadose Zone = **Soil depth** + **Vadose Zone Type** + **DTWT**

Where:

Soil Depth information has been provided by Glenn Atkinson (Senior Soil Officer - Kempsey) as a derivative maps from Soil Landscapes 1:100 000 sheets.

Vadose Zone Type is based on the digitised ion exchange index maps.

Depth to water table has previously been calculated but is factored for its contribution to the vadose zone impact.

Soil Depth (m)

Range	Factor
very low	5
low	4
medium	3
high	2
very high	1

Vadose Zone Type (Ion Exchange Capacity >20cm depth)

Range	Factor
< 6 me/100g (very low)	5
6-12 me/100g (low)	4
12-25 me/100g (moderate)	3
25-40 me/100g (high)	2
> 40 me/100g (very high)	1

Vadose Zone Type (Ion Exchange Capacity <20cm depth)

Range	Factor
< 6 me/100g (very low)	5
6-12 me/100g (low)	4
12-25 me/100g (moderate)	3
25-40 me/100g (high)	2
> 40 me/100g (very high)	1

Depth To Water Table (m)

Range	Factor
<5	5
5 - 10	4
10- 15	3
15- 25	2
>25	1

The maximum **Vadose Zone Impact Value** is: 20
The minimum **Vadose Zone Impact Value** is 4

The ratings for **Vadose Zone Impact** are displayed in Table 5.

Table 5 - Ranges and Ratings for Vadose Zone Impact

Vadose Zone Impact	
Range	**Rating**
18-20	10
14-17	8
10-13	6
7-9	3
4-6	1
Weight 5	

c) Soils

The soils feature attempts to classify the unique soil of the study area with regard to its ability to allow any potential contaminant to move through this zone towards the aquifer.

The impact of the soil media within the CHLGA was based solely on the soil permeability.

The ranges and ratings for soils have been classified as outlined in Table 6.

Table 6 - Ranges and Ratings for Soils

Soil Permeability	
Range	**Rating**
very low	1
low	4
medium	7
high	9
very high	10
Weight 2	

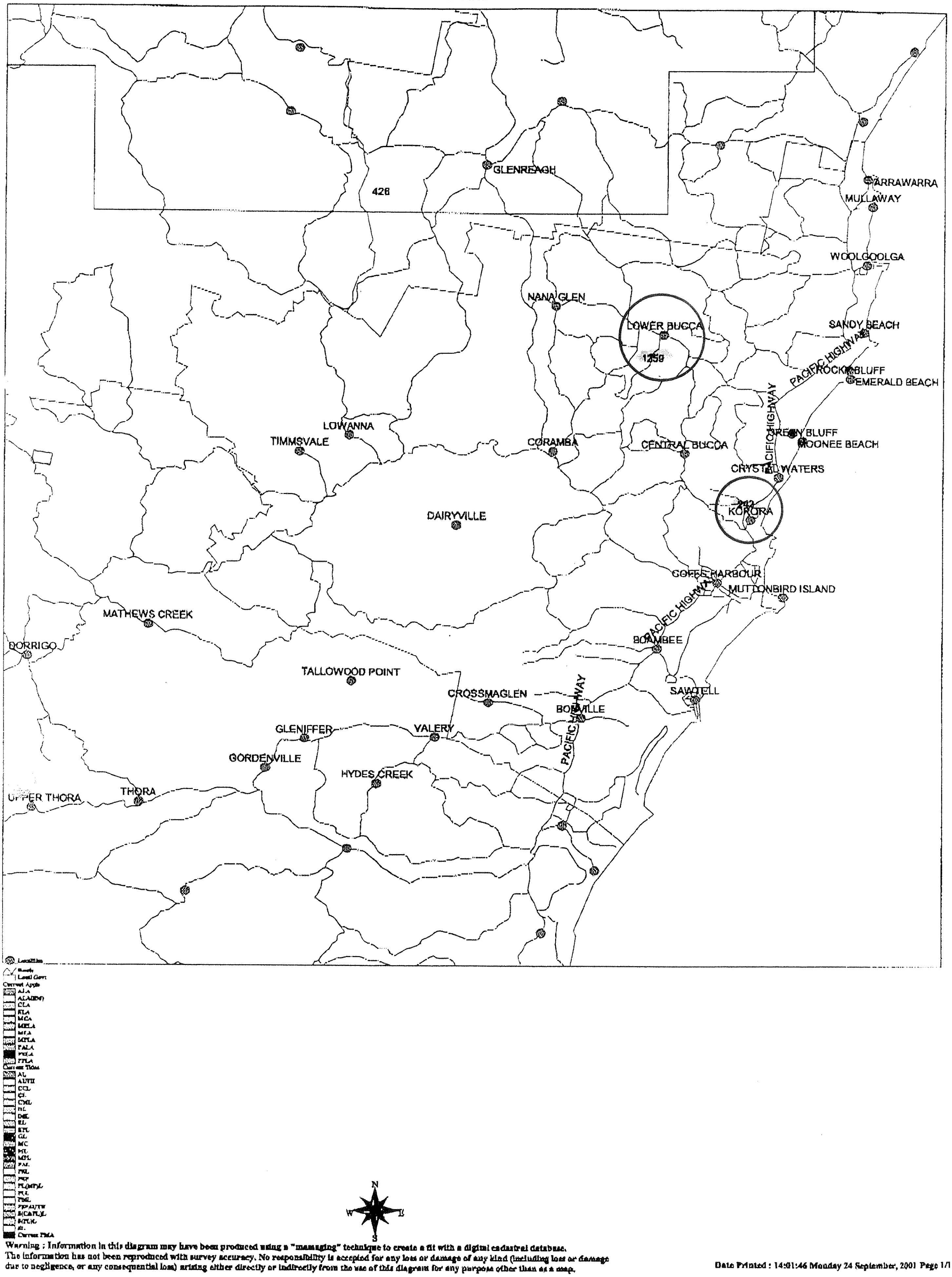
Appendix D

NSW Department of Mineral Resources: Titles Data

MINERAL RESOURCES

DEPARTMENT OF MINERAL RESOURCES NEW SOUTH WALES

GRAPHIC REPORT



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Date Printed : 14:01:46 Monday 24 September, 2001 Page 1/1

MINERAL RESOURCES

DEPARTMENT OF MINERAL RESOURCES NEW SOUTH WALES

CURRENT TITLE ID :MC-243-1992

Localities

Parcels DCDB

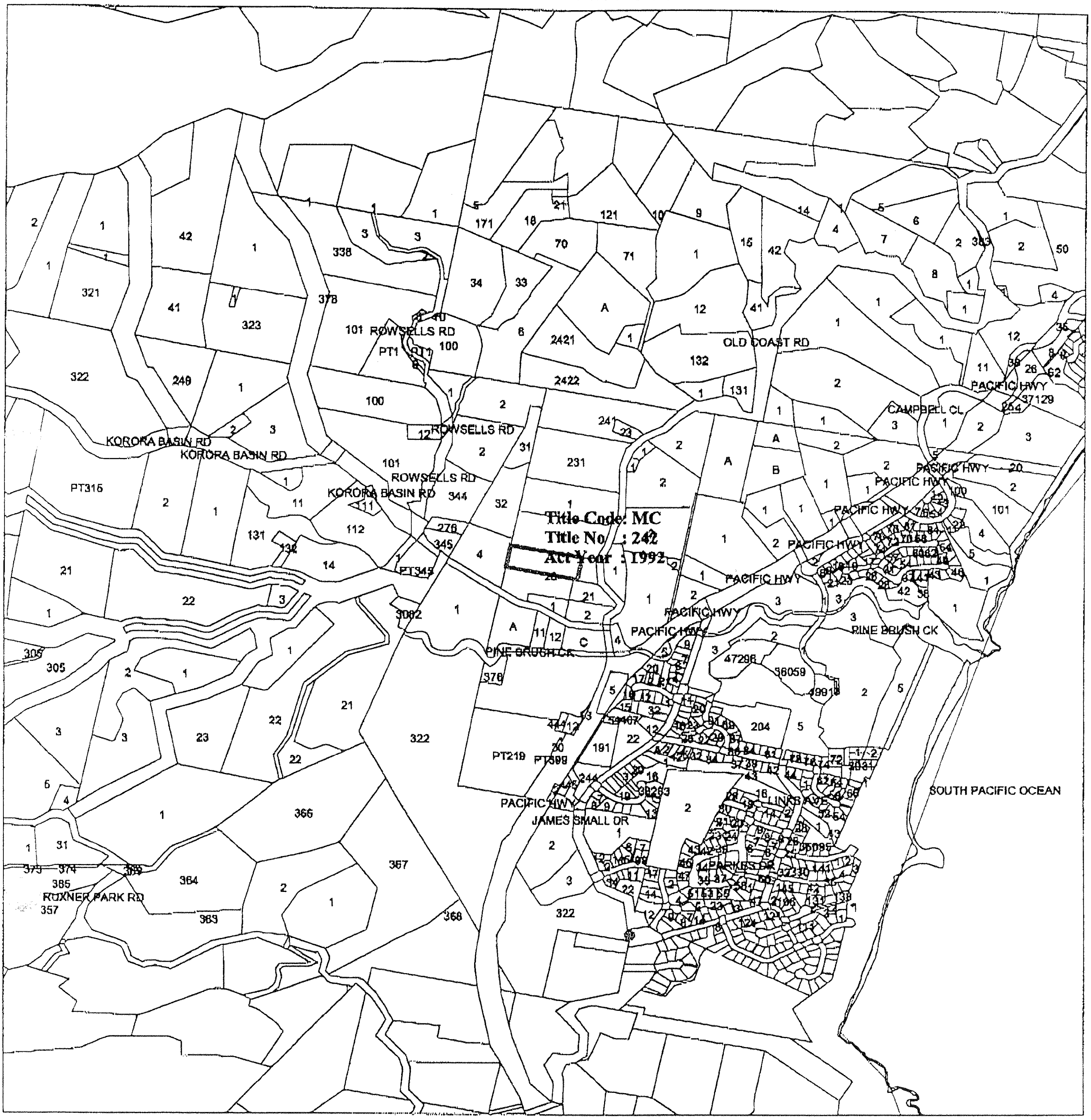
Local Govt

Title:	MC-243-1992
Holder(s):	EDWARDS, Edward Charles EDWARDS, Mark John
Mineral Group(s):	ANTIMONY,ARSENIC,BARYTES,BISMUTH,CADMIUM,CHROMITE,COBALT
Grant Date:	0:00:00 Friday 6 August, 1999
Determination Date:	nil
Determination Status:	
Area:	1.274 HECTARES
Location:	About 5km N of COFFS HARBOUR
Original Application:	MCA 55 CH 1992
Correct Position Flag:	Massaged to fit DCDB

MINERAL RESOURCES

DEPARTMENT OF MINERAL RESOURCES NEW SOUTH WALES

CURRENT TITLE ID :MC-242-1992



Localities

Parcels DCDB

Local Govt

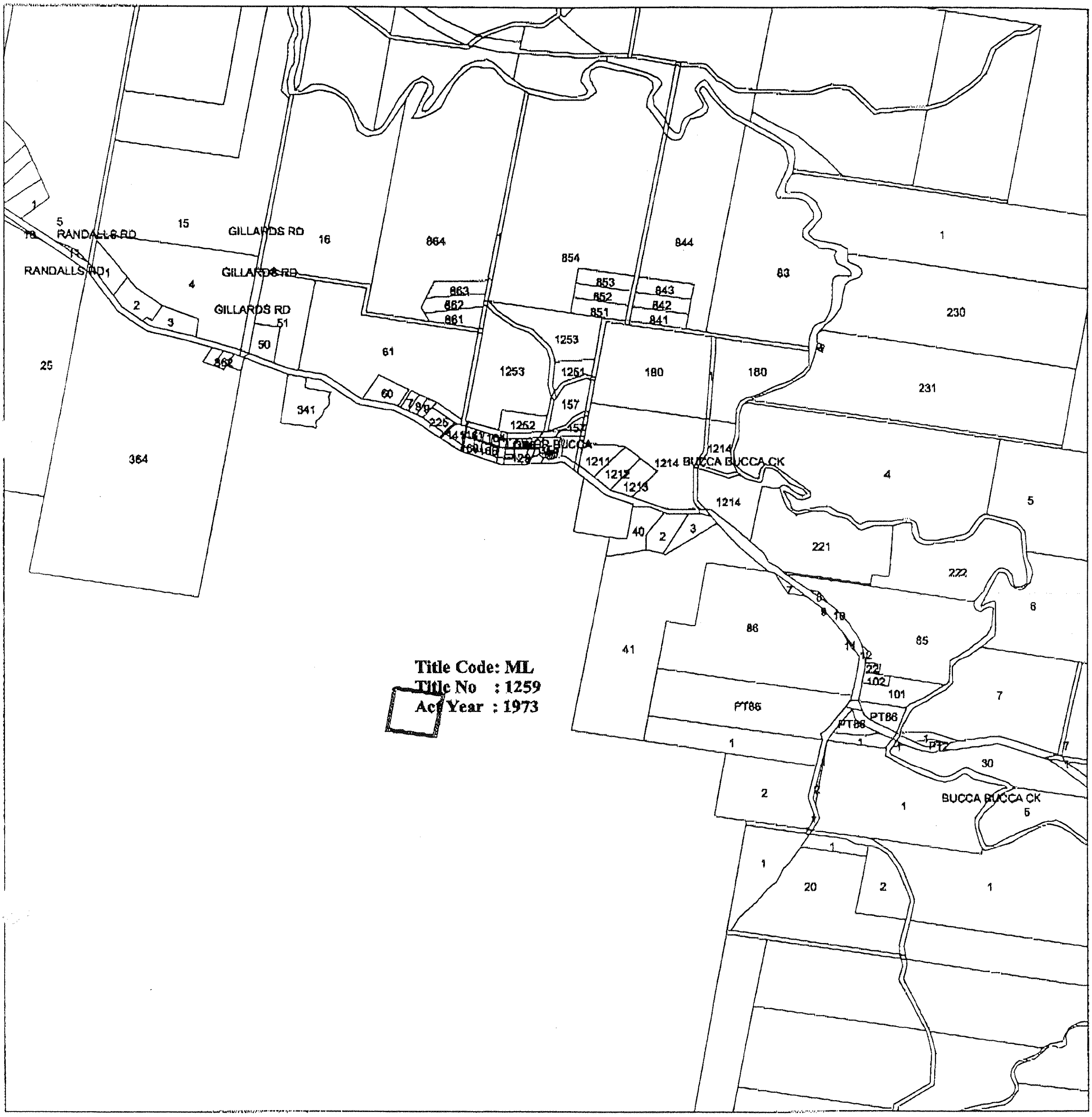
Title:	MC-242-1992
Holder(s):	EDWARDS, Edward Charles
	EDWARDS, Mark John
Mineral Group(s):	ANTIMONY,ARSENIC,BARYTES,BISMUTH,CADMIUM,CHROMITE,COBALT
Grant Date:	0:00:00 Friday 6 August, 1999
Determination Date:	nil
Determination Status:	
Area:	1.417 HECTARES
Location:	About 6km N of COFFS HARBOUR
Original Application:	MCA 54 CH 1992
Correct Position Flag:	Massaged to fit DCDB

Warning : Information in this diagram may have been produced using a "massaging" technique to create a fit with a digital cadastral database. The information has not been reproduced with survey accuracy. No responsibility is accepted for any loss or damage of any kind (including loss or damage due to negligence, or any consequential loss) arising either directly or indirectly from the use of this diagram for any purpose other than as a map.

MINERAL RESOURCES

DEPARTMENT OF MINERAL RESOURCES NEW SOUTH WALES

CURRENT TITLE ID :ML-1259-1973



Localities
Parcels DCDB
Local Govt

Title:	ML-1259-1973
Holder(s):	GRANT, Colin GRANT, Gillian Rose
Mineral Group(s):	GOLD
Grant Date:	0:00:00 Wednesday 27 May, 1992
Determination Date:	nil
Determination Status:	
Area:	4.84 HECTARES
Location:	About 16km NNW of COFFS HARBOUR
Original Application:	MLA 109 CH 1973
Correct Position Flag:	Massaged to fit DCDB