MESA A-WARRAMBOO ROBE RIVER

LANDSCAPE AND GEODIVERSITY ASSESSMENT STUDY

Prepared for

Robe River Iron Associates

Prepared by

JOHN CLEARY PLANNING

2005

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Contents

		Page
Part One - Introduction		***1***
1.1	Study Background	1
1.2	Study Area Description	1
1.3	Relevant Studies/Reports	4
1.4	Study Process and Scope	4
1.5	Definitions	7
1.6	Report Structure	8
Part Two – Geodiversity Values		***9***
2.1	Intrinsic Values	9
2.2	Ecological Values	24
2.3	Scientific Values	25
Part Three – Landscape Values		***27***
3.1	Landscape Character Classification and Description	28
3.2	Landscape Significance	31
3.3	Community Use	37
3.4	Views and other sensory Characteristics	38
3.5	Wilderness Quality	39
3.6	Recreation and Tourism Values	40
Part Four - Planning Framework Objectives		***41***
Part Five – Impact Assessment		***45***
5.1	Development Elements and Physical Changes	45
5.2	Areas Potentially Visually Affected	45
5.3	Visibility and Appearance	49
5.4	Impacts on Values	59
5.5	Cumulative Effect	6
Parts Six - Evaluation		***69***
Parts Seven - Recommendation and Modifications		***71***
Parts Eight - Conclusion		***73***

Appendices

1.	***Types of Values***	***74***
2.	***Data Sources for the Assessment of Landscape Values***	***75***
3.	***Sensitivity Level Criteria***	***76***
4.	***View Data Variables***	***78***

Bibliography ***78***

Tables

1.	Feature types found at Mesa A.	11
2.	Criteria for natural aesthetic significance.	32
3.	Sensitivity levels of use areas.	38
4.	Project geodiversity and landscape significance objectives.	42
5.	Project landscape character objectives.	43
6.	Project view objectives.	44
7.	Project access objectives.	44
8.	Project wilderness quality objectives.	44
9.	Typical effect over distance zones.	47-48
10.	Impacts on values.	61-67

Figures

1.	Management process for landscape values.	5
2.	Plan view of the notional layout of the project.	45

Maps

1.	Study Area, Site and Landform Relief.	3
2.	Landscape Character Units.	30
3.	Significant Features.	36

Plates

1-36	Robe River Mesa Characteristics.	15-23
37-38	Examples of landscape character.	29
39-40	Examples of significant features.	35
41-52	Simulated views of the project.	51-58

Part One - Introduction

1.1 Study Background

This report documents the landscape and geodiversity assessment and related evaluation of the proposed Mesa A-Warramboo mine proposal located approximately 43km west of Pannawonica, adjacent to the North West Coastal Highway. The proposal includes:

- two mine pits, (one at Mesa A, one at Warramboo), to be partly backfilled by the end of operations;
- a haul road and light truck roads between the two pits and road or rail link to Mesa J;
- a crusher/loader plant area;
- waste rock dumps;
- top soil dumps;
- bunds to protect adjacent areas;
- re-alignment/raising of the North West Coastal Highway to allow an underpass for the Mesa A – Warramboo haul road;
- possible diversion of the creek at Warramboo; and
- fencing adjacent to the highway.

The assessment focuses on the impacts that these changes could have on landscape and geodiversity values, appropriate conservation of these values in the area, and treatments to reduce the impacts. It particularly focuses on the level of representation of geodiversity values and the landscape characteristics that are of most value to human experience and enjoyment. The study, and this report, includes:

- an assessment of landscape and geodiversity values of the area;
- objectives and standards that apply to these values;
- an assessment of the area affected by the development, its visibility and appearance from locations within this area, and how values are affected;
- an assessment of the impact that the development will have on the landscape and geodiversity values of the area;
- an evaluation of the development based on the assessed impact and its compliance with objectives and standards;
- recommendations, including modifications, that will help minimise impacts on values and improve compliance.

Underlying this study is the recognition that landscape and geodiversity values need to be appropriately conserved and that landscape values are a vital component of people's enjoyment of the area.

This study has been undertaken to enable the proponent to understand and therefore minimise the impact of the proposal on landscape and geodiversity values. It forms part of a suite of environmental assessment studies undertaken as part of the preparation of the Public Environmental Review report for the project.

1.2 Study Area Description

The proposed mine is situated in the Shire of Ashburton. It is located approximately 70 kilometres east from Onslow and approximately 43km west of

Pannawonica, adjacent to the North West Coastal Highway (See Map 1). The mine areas total approximately 1000 hectares, located in a mining lease on pastoral land.

The site lies within the Ashburton Plain Landscape Character Type (CALM 1994), close to the Gascoyne Ranges and Hamersley Ranges Landscape Character Types, and is within the Pilbara Bioregion (Thackway R. & Creswell I.D. 1995). The Ashburton Plain Landscape Character Type has extensive sand plain with low rocky hills in the east, including near the area of the mine.

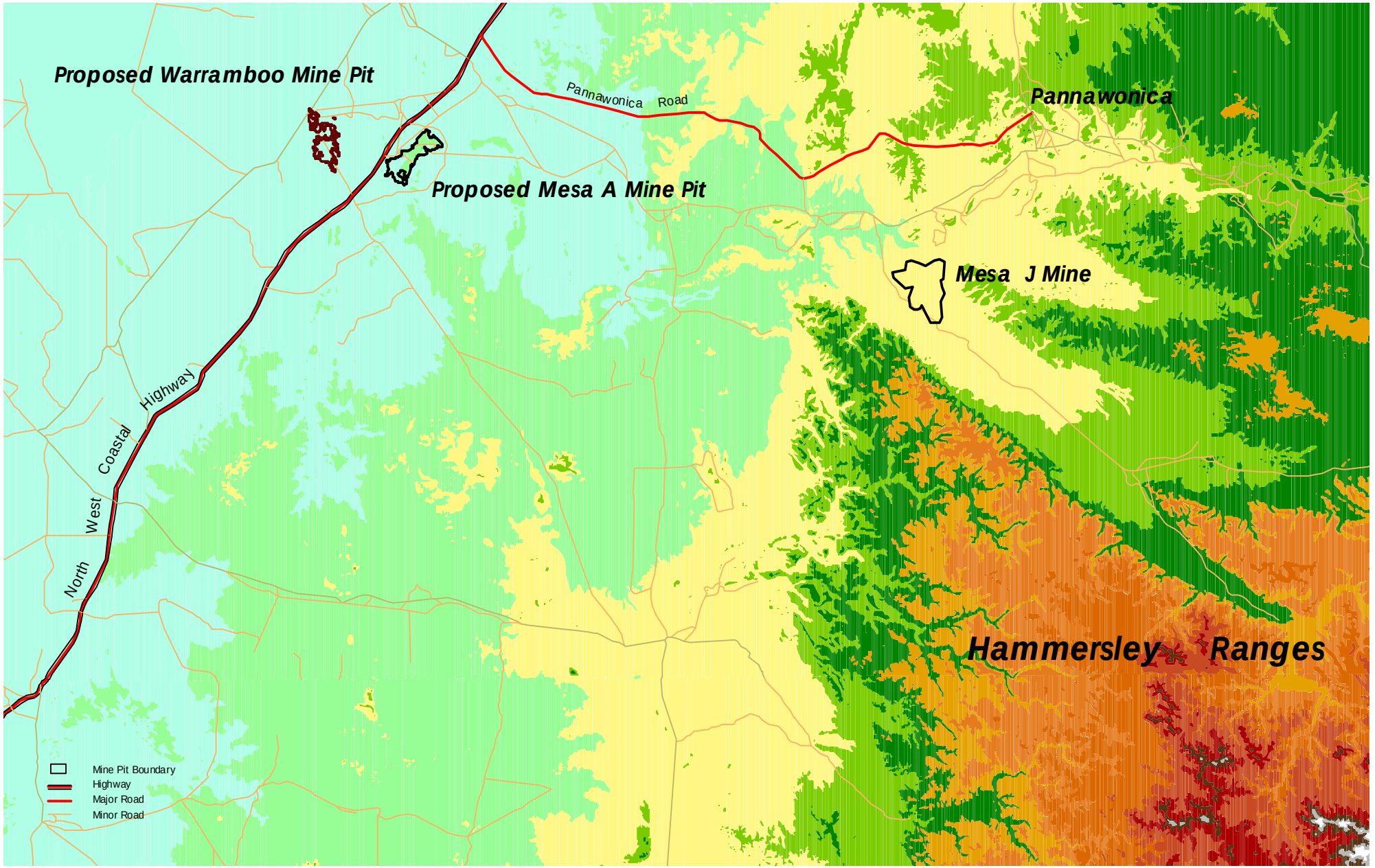
The proposed mine is at the western extremity of a series of pisolite, mesa formations associated with the Robe River. These mesas punctuate a landform of plains and low angle talus slopes that generally fall away to the Ashburton Plain in the west. Further inland, to the east-south-east, the land rises substantially in elevation, into the Hamersley Ranges, where more robust formations create more rugged and highly dissected landforms, including prominent highpoints, ridges and cliffs (See Map 2).

Vegetation consists of hummock and other mixed grasses with sparse shrub and small tree overstorey. Dense scrub occurs in some of the gullies and the river course has prominent riverine trees, including red gum, coolibah, and paperbark.

The area is used for pastoral activities although these activities are often not evident to people using the area. The region is very sparsely populated, with occasional homesteads and outstations, mining operations, roadhouses and towns such as Pannawonica and Onslow.

The North West Coastal Highway is the main travel route though the region. Main link roads extend from it to Onslow and Pannawonica. Other roads are generally unformed pastoral access roads.

Panoramic, high distance views over the surrounding country are generally available throughout the study area, due to the open nature of the landforms and sparse vegetation. Views become confined close to, and between, mesa formations, in gullies and near the riverine vegetation. Further insight relating to the study area is provided in the description of values, photographs and maps later in this report.



Map 1 - Study Area, Site, Landform Relief

MESA A-WARRAMBOO ROBE RIVER *Landscape & Geodiversity Assessment Study*

NORTH

0 5 10 Km

1:350,000

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1.3 Relevant Studies and Reports

Proposed Mesa J Development, Report and Recommendations*. EPA Bulletin 574, Assessment 590*

This includes useful background information, applied to a similar proposal in the area.

Reading the Remote, Landscape Character Types of Western Australia *(CALM 1994)*

This provides a description of the Landscape Character Types in Western Australia. Frames of reference are provided for assessing scenic quality within these settings.

1:250,000 Geological Series and Explanatory Notes, Geological Survey of Western Australia

These provide mapping and description of the geological formations in the region.

Geology and Iron Deposits of the Hamersley Range Area*, W.A. Bulletin 117, Geological Survey of Western Australia*

These provide further mapping and description of the geological formations in the region.

Heritage Lists

These contain various categories of listing (eg. Registered, Indicative) for places that are considered to have heritage significance.

1.4 Study Process and Scope

The study process follows a similar pattern to other environmental assessments and includes:

- An assessment of values, focussing on the mesa formations of the Robe River area and surrounding region, with particular reference to Mesa A.
- A review of environmental framework requirements (eg. policies).
- An impact assessment, which details the effect of the proposed operations on the values. In relation to visual landscape values, this includes 3D modelling of mine options, allowing the visibility and appearance to be determined (as seen from key locations) and the visual impact to be assessed.
- An evaluation, which provides an indication of the level of acceptability of the options.
- Recommendations, including preferred mine option(s) and guidelines that specify treatments that will help ensure the development minimises impacts on values, creates an acceptable outcome, and provide a measure for the assumptions made in the assessment.
- A conclusion.

This process is illustrated in Figure 1 below.

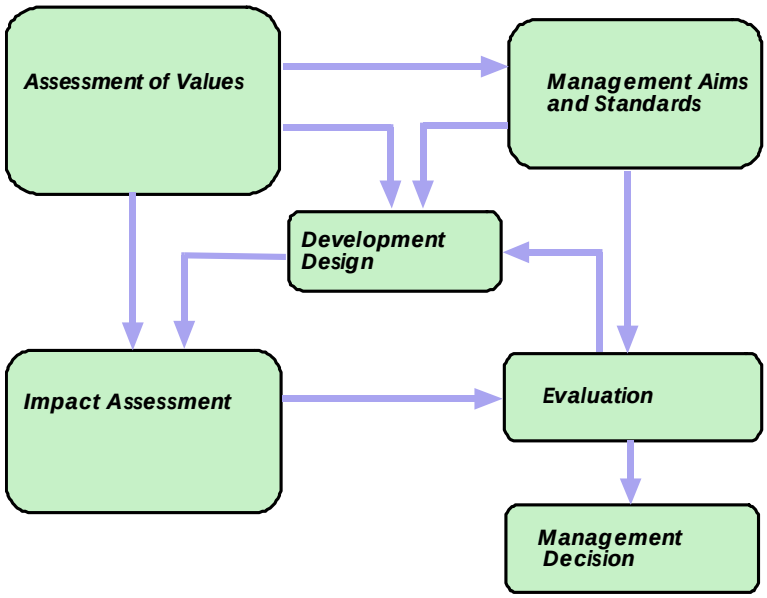


Figure 1 – Assessment process for landscape and geodiversity values.

The first component, the assessment of values, is the most complex part of the assessment. It combines well-established landscape assessment concepts and techniques with the concepts and criteria of geodiversity assessment. Briefly, these values are grouped as follows:

Geodiversity

- *Intrinsic Values* (value without human-related rating);
- *Ecological Values* (value as part of ecosystems);
- *Scientific Values* (value in demonstrating particular aspects of geological and geomorphic process);

Landscape

- Human Related Values (value stemming from the interaction of people with places), covering:
  - *Landscape Character*;
  - *Landscape Significance* ;
    - *Aesthetic*;
    - *Social*;.
    - *Historic*;
  - *Views*;
  - *Access*;
  - *Wilderness Quality*; and
  - *Recreation and Tourism Value*.

These values and related criteria and assessment are discussed further in Part 2.

KEY QUESTIONS

The assessment process for this study can also be expressed jointly in terms of the following key questions:

Assessment of values

- What are the extents of characteristics and features of the area?;
- What role do the characteristics or features play in local ecosystems?
- Which characteristics or features best demonstrate particular aspects of geological and geomorphic process?;
- How do people perceive the environment, which characteristics of the environment do they value most, and which do they value most for landscape reasons?;
- How can these variables be best represented for planning purposes?;

Management aims and objectives

- What are the management and planning framework aims, objectives and standards that apply to the study area?;

Impact assessment

- What types of physical changes are likely to occur as a result of the development?;
- What areas will be visually affected by the proposal and what will be the visibility and appearance of the development from these areas?;
- What will be the impact on existing landscape and geodiversity values?;
- What will be the effect on recreation and tourism values?;
- What will be the cumulative effect?;
- What will be the effect on neighbours?;

Evaluation

- Given the impact of the development on values, will management objectives be met?;
- What is current community sentiment in relation to the type of development proposed?;

Recommendations, design modifications and guidelines

- What planning and design principles will minimise the impact of the proposed development given the characteristics of both the area and the proposal?;
- If management objectives are not met, what modifications can be made to the development to achieve better compliance?;
- What treatments will minimise the effect on neighbours?;

Conclusion

- What is the final evaluation of the development given the assessment work completed and after possible modifications and recommendations are made?.

1.5 Definitions

A number of terms are commonly used in discussion of the topics covered by this report. Definitions used in this report for some of these terms are provided below.

3D Modelling is a technique, usually performed on a computer, where landform and objects are accurately and mathematically defined in three-dimensional space. This allows the reconstruction of views of these landforms and objects from any location using a rendering process that applies textures to 3D forms to make them appear realistic.

Aesthetics refers to personal appreciation and enjoyment of things (eg. objects, places, and processes). It can include beauty, functional and non-functional aspects of things, and does not necessarily include visual qualities (see Appendix 1 for illustrated typology).

Area Visually Affected is all the seen area generated from points that represent the extent of the 3D form of the development.

Cross Sections depict an object or area with part of the object or area cut away to highlight the profile or shape at the plane that defines the cut.

Evaluation is the process where assessment results are examined and used to make decisions about alternative futures, usually based on given standards.

Geodiversity refers to the range of geological, geomorphological, and soil features, systems and processes that exist (in an area).

Intrinsic Value recognises that a thing that exists has value regardless of human notions of importance.

Landscape refers to a person's perception or image of an environment (ie. it is a human construct).

Landscape Assessment is a process of analysing and mapping environmental characteristics and, using known criteria, determining those that contribute most to the experience and enjoyment of people

Landscape Impact Assessment is a process of determining how changes to the environment will affect landscape values.

Landscape Value is the value people attach to a place based on their perception of that place. *Landscape Value* and *Visual Aesthetic Value* are often used synonymously (see Appendix 1 for illustrated typology).

Landscapes stem from perception. Through the process of perception people create their own 'landscapes', their interpretation of an environment (ie. 'their environment as they know it')(Meinig 1979, Zube et al 1982, Lowenthal 1978). There are two other main usages. The first refers to a scene (as in a landscape painting). The second refers to an area that has a common pattern of bio-physical features (as in a landscape ecology).

Perception is the process where environmental information is combined with a person's existing knowledge, emotional response and values.

Seen Area is a term used to describe the land surface that is potentially visible from a given point.

Sensory characteristics relate to the paths by which people receive environmental information (eg. vision, hearing, etc.).

Values are measures of the importance people attach to things and typically stem from perception.

Visual Absorption Capability describes or indexes an area's ability to visually absorb or sustain change based on variables such as landform, vegetation pattern and height, and existing land use.

Visual Aesthetic Value refers to the visual aspects of aesthetic value. *Aesthetic Value* refers to personal appreciation and enjoyment of things (eg. objects, places, and processes). It can include beauty, functional and non-functional aspects of things, and does not necessarily include visual qualities.

Visual characteristics relate to information received through the visual sensory path.

The terms *visual*, *aesthetics* and *landscape* are often used synonymously or combined, despite their different definitions. This study includes a *landscape* assessment that focuses on *visual characteristics* and *aesthetic values*.

1.6 Report Structure

This report is divided into 8 main parts:

- Part 1 is introductory and describes the context and nature of the study and report and briefly explains the study process.
- Part 2 covers the assessment of geodiversity values.
- Part 3 covers the assessment of landscape values.
- Part 4 defines management objectives and standards within the planning framework that relate to landscape and geodiversity values.
- Part 5 includes an assessment of the impact of the development on values.
- Part 6 includes an evaluation of the impact of the development based on the management objectives of the area
- Part 7 includes recommendations and design guidelines that will help minimise the impact of the development.
- Part 8 is the conclusion.

Part Two – Geodiversity Values

Values in this study have been identified by a systematic assessment procedure covering landscape and geodiversity values. Parts Two and Three of the report describes each step of the assessment process and summarises the results.

The assessment approach used for these values consists of three main components:

1. an understanding of theoretical or researched landscape and geodiversity values (see Section 2.1);
2. formulation of criteria that define the value types (see Section 2.3);
3. systematic assessment of the study area using the defined criteria (see Section 2.2 to 2.7).

This part of the report deals specifically with the assessment of geodiversity values. These values are grouped as follows:

- Intrinsic Values (value without rating, largely representation);
- Ecological Values (value as part of ecosystems);
- Scientific Values (value in demonstrating particular aspects of geological and geomorphic process);

The assessment of these geodiversity values is discussed in the following sections. While the classification of value types may suggest that there are discrete values embodied in landscape and geodiversity aspects of our environment, there is often considerable overlap between value types. The value types provide a useful basis for assessment that satisfies practical and theoretical requirements.

The scope of the assessment is limited to values that might be affected by the proposed mining activities at Mesa A. The assessment of some of these values requires assessment at a regional scale.

2.1 Intrinsic Values

2.1.1 BACKGROUND TO THE ASSESSMENT

Intrinsic Value recognises that a thing that exists has value regardless of human notions of importance. In relation to geodiversity, intrinsic value refers to the existence of a range of geological, geomorphological, and soil features, systems and processes (in an area).

It necessarily follows that we need to assess intrinsic value without applying typical human valuation processes. The assessment focuses on what exists, the range of features or characteristics, and the extent of these. This part of the process is largely inventory and classification.

The assessment also needs to address the requirements of management and conservation. Intrinsic value exists in all things yet it is not possible to protect all things given the utilisation needs of humans. In management and conservation, decisions need to be made that weight the relative importance of features. The decision approach that is most consistent with the concept of intrinsic value is to determine the extent of the value (ie. how much we have of it) and whether there will be an adequate amount of the value remaining unaffected after the development proposal is implemented. If little of the value remains, it can be said to be rare. The determination of 'adequate

amount' and 'rarity' both depend on defining an appropriate typology and levels of detail for the values and, where relevant, an appropriate geographical scale. The thresholds for 'adequate amount' and 'rarity' and the typology, levels of detail for the values, and geographical scale are all based on human judgement. The application of the human judgements embodied in these management considerations may appear to add weighting to intrinsic values creating, in effect, a rating system for values, which is contrary to the definition of intrinsic value. With this in mind it is useful to adopt an approach that clearly distinguishes between intrinsic value and the human-related judgements that are applied to them for management purposes.

In addition to protecting an adequate amount of value types and rare values, conservation management typically protects in reserves a good example of each type regardless of how rare or widespread they are. In this case, the reservation status of the values will provide high levels or complete protection. Traditionally, this reservation, in relation to geodiversity values, is usually for scientific or aesthetic reasons rather than for intrinsic value.

Some of the principles discussed above in relation to intrinsic values, also apply to other values assessed in this report.

2.1.2 ASSESSMENT

The assessment of intrinsic values in this study, like other assessments dealing with a localised project, need only target geodiversity features of the types found at the project area. The main geodiversity feature types found at Mesa A can be classified within an hierarchy based on scale (see Table 1 below).

Table 1 - Feature types found at Mesa A, grouped according to scale.

Scale	Feature Type
Broad (main geodiversity type)	A. Mesa of Robe Pisolite;
Landform (general geomorphic expression)	B. Partial mesa of Robe Pisolite with relatively flat top and one side merging seamlessly with the adjoining landform;
Component (main components of the landform)	C. Single tier escarpment with obvious dissection, buttresses and adjoining talus and tors; D. Scree slopes with minor outcropping and talus; E. Gentle slope merging with adjacent landform; F. Major gully with escarpment sides (with an obvious watercourse and associated vegetation); G. Major gully with scree slope sides (with an obvious watercourse and associated vegetation);
Detailed	H. Wall or buttress with a group of pigeon hole formations; I. Escarpment with a group of large caves.

These Feature Types are also in order of assessment priority for intrinsic value. Highest priority is given to feature types at the broad scale and the least priority is given to detailed features. Detailed features may also require extensive assessment resources and may be viewed as minor variations of the main intrinsic value – Robe Pisolite in mesa formation.

Landform and Component Scales are moderate to high priority. These allow us to differentiate between the mesa formations of Robe Pisolite.

Broad Scale

Mesa formations are very common in the western Pilbara and are associated with several geology types including Robe Pisolite. More than 600 individual occurrences of the Robe Pisolite have been mapped across six 1:250 000 geological map sheets[1].

[1] Environmental Protection Authority, 1991. *Proposed Mesa J Development, Report and Recommendations.* EPA Bulletin 574, Assessment 590.

The best examples of mesa formation Pisolite are the Robe River Pisolite formations. The exceptional nature of the Robe River exposures has, however, been widely recognised, including by MacLeod[2]:

> *'The lower section of the Robe River, between Pannawonnica Hill and Warramboo, contains the most prolific development of pisolitic limonite in the Hamersley Iron Province.'*

by Harms and Morgan:[3]

> *'The Robe River limonite deposits are the largest of this type known.'*

and by Williams:[4]

> *'These deposits are dissected and form mesas, some crudely terraced, that stand up to 100 feet above the present plain level. They are best developed along the Robe River .....'*

An aerial survey was undertaken of these formations, together with Pisolite occurrences in the Wyloo 1:250,000 Geological Series map sheet. This area was chosen because:

- it contained a high number of occurrences of Robe Pisolite; and
- there was a good variety of adjacent sediments/formations.

Within the Wyloo map sheet area, many occurrences were not obvious exposures with less than half those surveyed demonstrating exposed mesa type formations. If we assume we can extend the results of this sample to other known occurrences across the six map sheets, there may be 250-300 exposed mesa formations of Robe Pisolite.

Images of the mesas highlighting these features are on Page 16-24. A complete photographic inventory is available on CD with this report.

Landform Scale

Landform type provides a simple classification for the Robe mesa formations. Two main types can be defined:

- discrete mesas;
- partial mesas that have a section that merges with adjacent landform;

The Robe River mesas are generally discrete mesas. Brief descriptions of these mesas based on field observations are;

Mesa A

- a partial mesa with the landform merging with the plain to the south-west;
- a small number (3) of well-separated, distinct, deeply incised gullies;
- a variable escarpment, varying from scree with talus to prominent buttresses and walls;
- the mesa top is relatively flat;
- low to moderate height.

Mesa B

- discrete mesa;
- double-tiered escarpment;

[2] MacLeod, W.A., 1966. *Geology and Iron Deposits of the Hamersley Range Area*, W.A. Bulletin 117, Geological Survey of Western Australia, p. 134.
[3] Harms, J. E. and Morgan, B. D., 1964. Pisolitic Limonite Deposits in Northwest Australia. AIMM Proc. No. 212, December 1964, p. 91.
[4] Williams, I. R., 1968. *Yarraloola, Western Australia, 1:250 000 Series Explanatory Notes.* Geological Survey of Western Australia, p. 16.

- ridges extending out from the main body of the mesa, alternating with valleys that vary from short bowls to short narrow valleys.
- contiguous flat top.

Mesa C

- discrete mesa;
- long, large valleys that extend well into the body of the mesa;
- various tiers – single, double and triple tiered, the latter especially on the ends of the mesa;
- relatively high with substantial scree footslopes;
- contiguous flat top.

Mesa D

- discrete mesa but highly eroded, heavily dissected with complex valley systems that penetrate through the body of the mesa;
- valleys vary from long and broad to short and narrow;
- various tiers – with obvious triple and quad tiers (the latter at the south-east end of the mesa);
- the horizontal distance between tiers varies – in some places very close, on other places well separated;
- the top is a relatively small area with rounded ridges;
- moderate angled scree footslopes.

Mesa E

- discrete mesa, similar to Mesa D but a more simple landform (ie. fewer valleys and dissections).

Mesa F

- discrete mesa(s);
- variable landform with small discrete mesas making up the western end;
- relatively high footslopes on the northern (Robe River) side and low on the southern side with low escarpment;
- long, broad valleys penetrate the mesa;
- rolling top;
- the eastern side has a very large lower tier with long narrow valleys and rounded tops in the south and a rolling top without valleys in the north;
- sections of the eastern side are similar to Mesa A, with distinct gullies.

Mesa G

- dominant scree slope with many minor tiers;
- highly dissected by valleys and the top is rounded and generally contiguous;
- similar formation to Mesa B but more heavily eroded;
- stronger mesa formation at eastern end with escarpment and major valleys;
- relatively high.

Mesa H

- discrete mesa, although tends to blend into the adjacent landform in the south-east;
- moderate sized escarpment on the river/west side;

- has a second tier in places;
- shallow valleys and rounded tops on south side
- long valley separates two forms;
- highly eroded with small mesas in the south-east;
- eroded with rounded forms in the east;
- stronger mesa formation in north-east.

Mesa I

- discrete mesa;
- gentle footslopes;
- moderate height;
- small fragmented escarpment giving way to small outcrops and talus.

The *partial mesa* formation of Mesa A is not common in the Robe River/Deepdale formations but was observed in the mesas on the surveyed area of the Wyloo Map sheet. Images of the mesas highlighting these features are on Page 16-24. A complete photographic inventory is available on CD with this report.

Component Scale

All the component scale feature types were observed in many locations during the field survey. Gullies with the characteristics of the eastern gully of Mesa A (Gully2, see Map2) were not common. Similar gullies were found on the eastern side of Mesa F.

Detailed Scale

The detailed scale feature types were observed in many locations throughout the areas surveyed. They are considered to be common. An inventory was not created for these.

Plate 1 – Looking across the northern end of Mesa A showing the western escarpment and the flat mesa top.

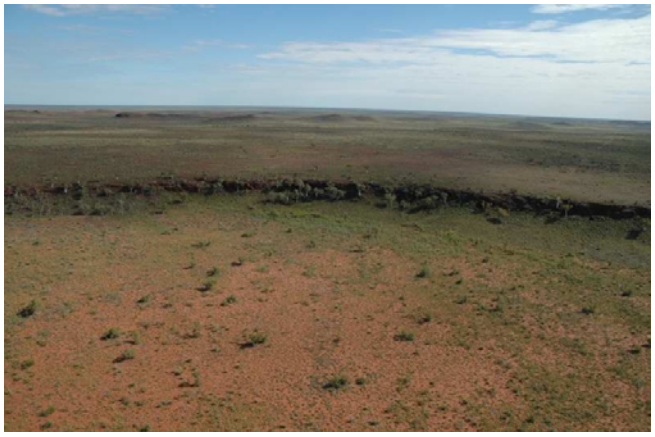


Plate 2 – Looking across the middle of Mesa A showing the eastern escarpment and the sand sheet in the foreground.

Plate 3 – Looking across Gully2 (see Map2)*of Mesa A showing its enclosed nature and the sharp abutting of the gully walls and the mesa top.*

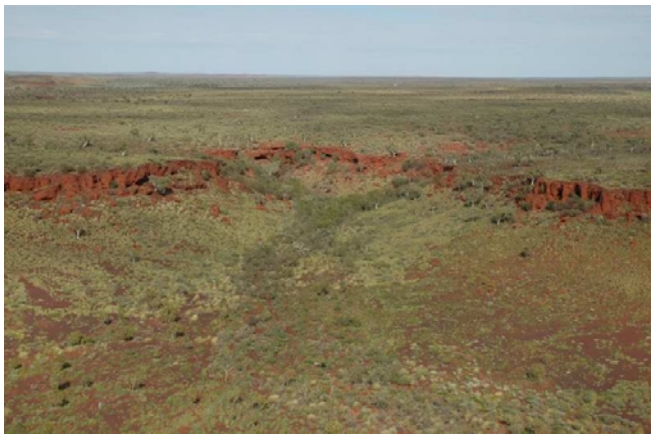


Plate 4– Looking across the northern gully of Mesa A (Gully1, see Map2).

Plate 5 – Looking across the western end of Mesa B showing the pattern of gullies and ridges and the eroded lower tier with associated outcropping/escarpments.

Plate 6 – Looking across the middle of Mesa B showing rounded ridge tops and the pattern of gullies and ridges and the eroded lower tier.

Plate 7 – Looking along the escarpment of Mesa B showing the pattern of gullies and ridges and the eroded lower tier.

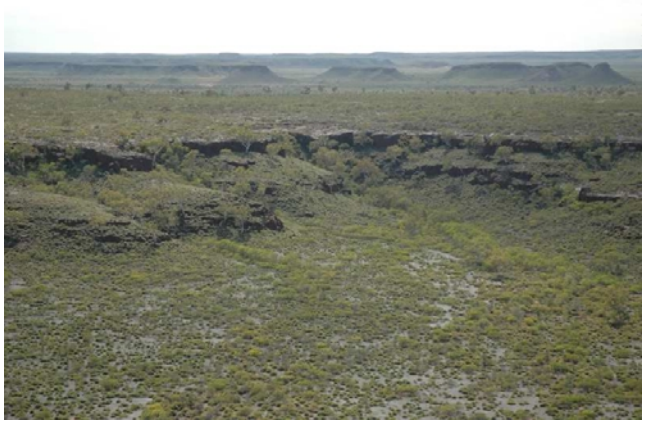


Plate 8 – Looking across the escarpment of Mesa B showing the pattern of gullies and ridges and the eroded lower tier.

Plate 9 – Looking across Mesa C near its northern end showing the large valley, and multiple tiers.

Plate 10 – Looking across Mesa C showing the flat mesa top and lower tier.

Plate 11 – Looking across Mesa C showing another large valley.

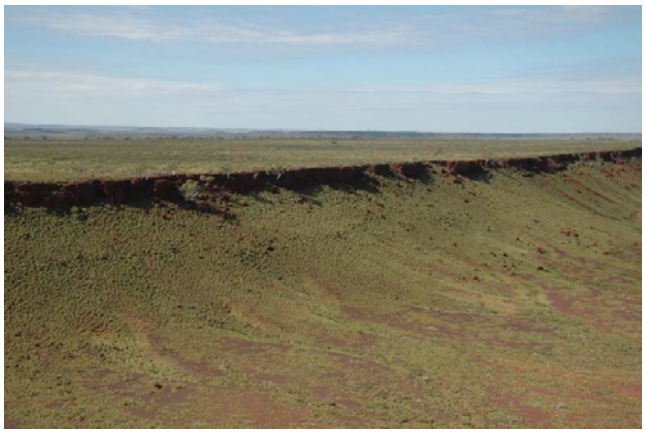


Plate 12 – Looking along Mesa C towards its northern end showing the consistent nature o f the escarpment.

Plate 13 – Looking across Mesa D showing its fragmented/dissected nature, rounded tops and subtle tiers.

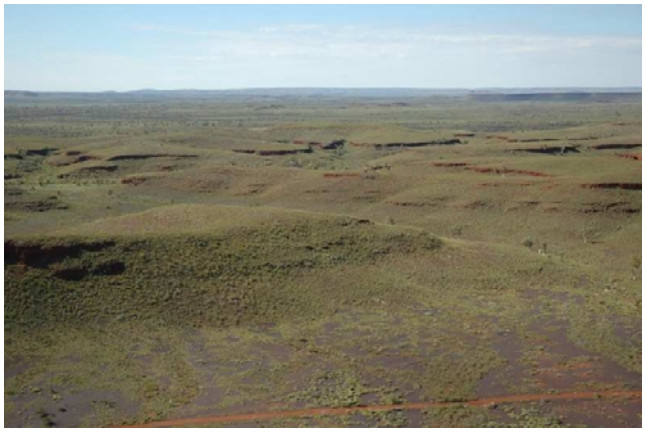


Plate 14 – Looking across Mesa D showing its fragmented/dissected nature, rounded tops and areas without escarpment.

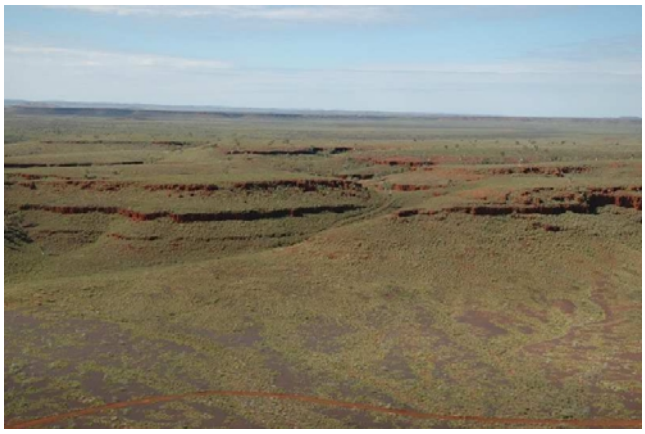


Plate 15 – Looking across Mesa D showing obvious tiers.

Plate 16 – Looking across Mesa D showing closely spaced tiers.

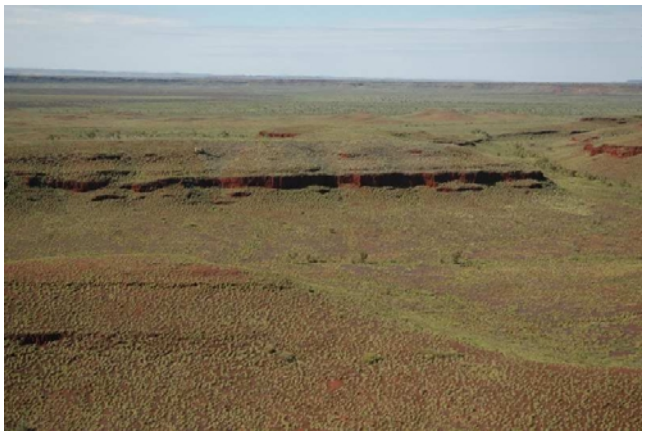


Plate 17 – Looking across Mesa E showing its fragmented/dissected nature, larger valleys and ridges than Mesa D, rounded tops and subtle tiers.

Plate 18 – Looking across Mesa E.

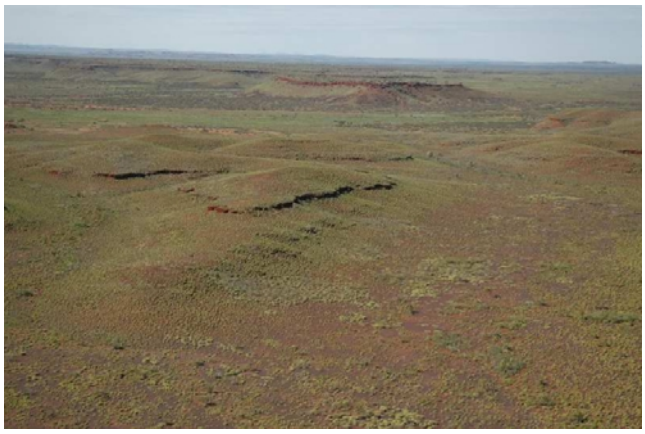


Plate 18 – Looking across Mesa E near its southern end towards Mesa F.

Plate 20 – Looking north along Mesa E with Mesa D and C in the background. The ridges and valleys are less distinct than at the northern end of the mesa.

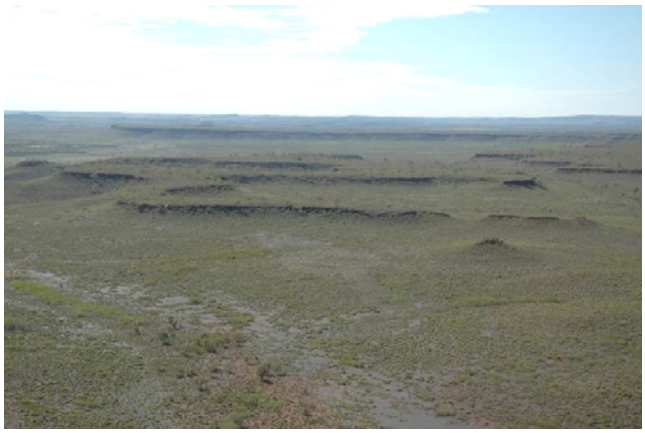


Plate 21 – Looking across the western end of Mesa F showing its fragmented nature and flat mesa tops.

Plate 22 – Looking across Mesa F showing the flat mesa top and rounded mesa edges.

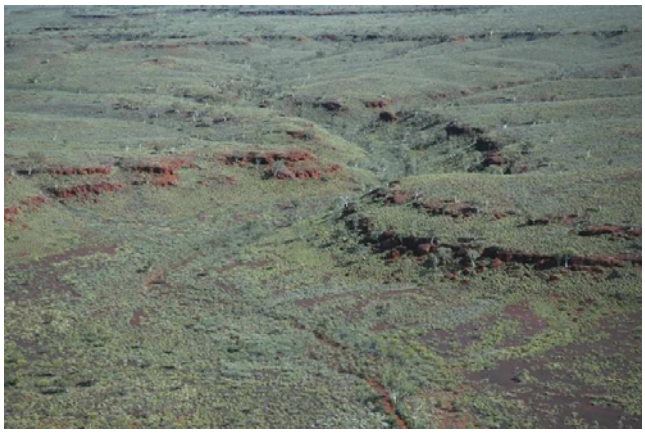


Plate 23 – Looking across the eastern side of Mesa F showing the extensive lower tier with its valleys and rounded ridges.

Plate 24 – Looking across the eastern side of Mesa F showing a gully with very similar characteristics to the gully in the north of the eastern side of Mesa A.

Plate 25 – Looking across the western end of Mesa G showing the tiers, small escarpments and rounded top.

Plate 26 – Looking across Mesa G showing the dissecting valleys and rounded tops on the ridges.

Plate 27 – Looking across the western end of Mesa G showing the tiers, undulating top and large dissecting valley.

Plate 28 – Looking across Mesa G showing a gully similar to Mesa A but with more rounded landforms.

Plate 29 – Looking across the western end of Mesa H with the Robe River in the foreground.

Plate 30 – Looking north-west across Mesa H showing the large dissecting valley.

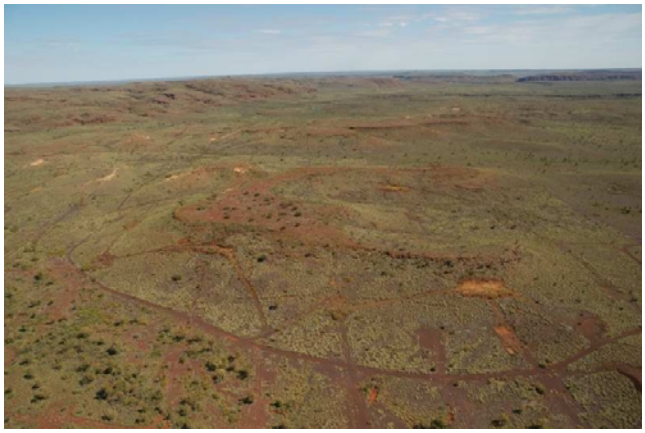


Plate 31 – Looking west across the southern end Mesa H showing its indistinct forms merging with adjacent landforms.

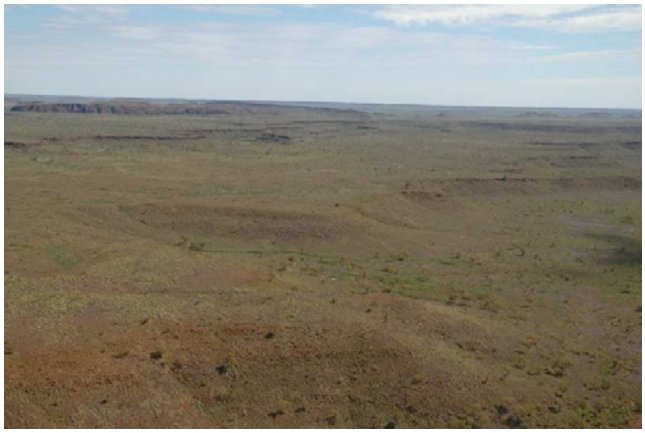


Plate 32 – Looking north along the eastern side of Mesa H showing the rounded landform in the foreground and the steeper, more abrupt landforms in the background (RHS).

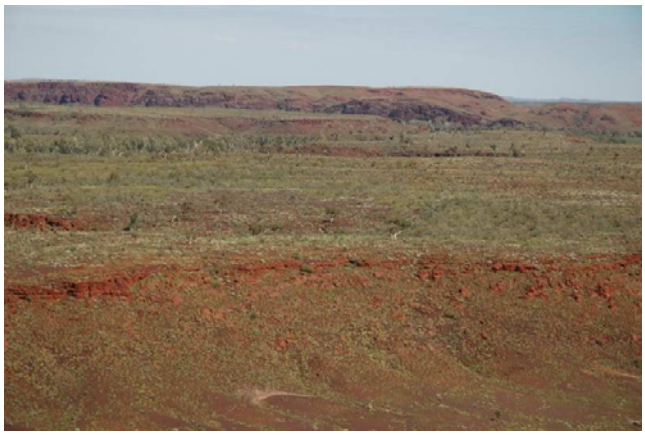


Plate 33 – Looking south-west across Mesa I with Mesa H in the middleground and Yeera Bluff in the background.

Plate 34 – Looking south-east across Mesa I with the Robe River in the middleground.

Plate 35 – Looking south-west across Mesa I showing the main section of the escarpment.

Plate 36 – Looking across the western end of Mesa I and the Robe River in the vicinity of the Type Section (and Deepdale Homestead ruins).

2.2 Ecological Values

2.2.1 BACKGROUND TO THE ASSESSMENT

Geodiversity forms the geological, geomorphic and soil base for ecosystems. Effects on geodiversity can often be translated to effect on other biotic parts of ecosystems. Conversely, if biotic parts of ecosystems are assessed as having high significance then the geodiversity that partly supports them may also be considered to be significant, particularly in relation to conservation status.

2.2.2 ASSESSMENT

The most recent flora survey undertaken for the area identifies one vegetation type of conservation significance, which is 'S1 (vegetation of the sand dune and sand sheet adjacent to Mesa A) is considered likely to be restricted in distribution in both the local area and region, and supports species restricted to the deep sands of this particular habitat' (Biota 2005).

The same survey also identifies two Priority Flora Species:

- *Abutilon trudgenii,* which was found on the mesa plateaus, particularly on clayey to stony plains, and is thought to be widespread; and
- *Sida sp.*, which was also found on the mesa plateau.

No Declared Rare Flora was found in the area of Mesa A, nor would be expected to occur (Biota 2005).

2.3 Scientific Values

2.3.1 BACKGROUND TO THE ASSESSMENT

Scientific value criteria focus on formations that demonstrate particular aspects of geological and geomorphic process. It will often focus on the best examples of a type. Nominations in established lists/registers may be used.

There are four main categories of scientific value used in this study:

- **Natural processes -** Degree or excellence which a feature displays aspects of geological, landform and soil related processes.
- **Type Section -** Use as a Type Section.
- **Citation -** Degree to which a feature is cited in literature.
- **Knowledge -** Whether the feature was involved in an important 'scientific' discovery, or its use or potential use as a teaching site.

2.3.2 ASSESSMENT

Natural Processes

Four hypotheses have been advanced for the origin of the pisolite:[5]

- direct chemical precipitation as bog iron ore;
- replacement and desilicification of jaspilitic debris in fluvial sediments;
- clastic accumulation as fluvial sediments; or
- lateritisation of fluvial sediments.

Whether any single mechanism was responsible for the development of the pisolite is open to doubt, as the circumstances of deposition of the ores are likely to have varied considerably, influenced by the distance from the source of the iron and the nature of channel development at any particular point in any given palaeo river channel. Geological staff at the mine are of the view that the high-grade ores were deposited in well-defined channels, whereas lower grade ores, diluted by clays and clastic material, were deposited in a more dispersed river environment.[6]

With respect to the deposits of the Robe River, the distinctive topographic variations among Mesas A to N without doubt reflect a combination of variations in channel development and depositional environment. For example, the well defined escarpments and high grade ores at Mesa J and Mesa A originated in sharply defined channels, whereas the more undulating landscape and lower grade ores of Mesa G are likely to have their origin in a more braided channel environment. The layered nature of some mesas, such as Mesa B, suggests more complex variations through time in the evolution of the channel at that point.

Thus, all the Robe River pisolite mesas have scientific value for what they can, as palaeo-channel deposits, reveal about the evolution of the area (and the origin of the ores). Mesa A demonstrates a particular variation in this evolution but is not unique in this regard.

[5] Hocking, R. M., Mears, H. T., and Van De Graaf, W. J. E. ** *Geology of the Carnarvon Basin Western Australia*. Geological Survey of Western Australia Bulletin 133, p.175. See also MacLeod (1966) and Harms and Morgan (1964)

[6] Discussions with Anil Subramanya, Supervising Geologist, and Brett Hodgins, Superintendent Mine Planning, 15, 17 June 2005.

Type Section

The geological type section of the Robe River Pisolite is recorded as being 'east of Deepdale homestead in the north face of a large mesa on the south bank of the Robe River'[7]. This is contradictory, as it cannot be both east and south of Deepdale. Mesa I is east of Deepdale, whereas Mesa H is to the south. Thus the location is uncertain and in any event, its existence was unknown, and of no interest, to the geological staff of the mine.[8]

The type section of the Robe River Pisolite (when located) is likely to be of some scientific value, but no single section is likely to represent the variability of the formation throughout its occurrence.

Citation

An examination of the heritage registers of the Heritage Council of Western Australia, the Australian Heritage Commission and the National Trust did not reveal any previous records of sites of significance in the Robe River valley. The only site of scientific significance in the region ('Indicative place', Register of the National Estate) is the Duck Creek Gorge Area, Mount Stuart via Pannawonica, W.A. This is of some interest because of the types of values in the Statement of Significance.

It displays exceptional exposures of the Pre-Cambrian Duck Creek Dolomite, which have allowed detailed reconstruction of the conditions of deposition, sequential changes and stromatolite developments that occurred about 2,000 million years ago. It is an important site for stratigraphic and palaeontological research and is a geological type section. Research in this area forms an important part of the ongoing research into Pre-Cambrian stromatolites and is recognised internationally.

Knowledge

Key features for knowledge value include:

- the type section;
- features related to the development of the iron ore mining industry (see Historic Value later in this report):
  - The Robe River mesas form the basis for Robe River mining operations, which, in general, are significant in the development of the Western Australian iron ore mining industry.
  - Mesa F has moderate significance due to it being the location of the first recorded identification of iron ore in the Hamersley Iron Province by A. Gibb Maitland in 1906.
- Mesa A has no specific value otherwise related to knowledge.

[7] Hocking, et al
[8] Discussions with Anil Subramanya, Supervising Geologist, and Brett Hodgins, Superintendent Mine Planning, 15, 17 June 2005.

Part Three - Landscape Values

The assessment of landscape values includes a range of human-related values that stem from the relationships between people and places. These values include values that flow from personal interaction, use and enjoyment of places as well as values that are applied remotely, based on human notions of the importance of the places around them.

These human-related values can be grouped as follows:

- **Landscape Character** - The nature of places, classified into types or units.
- **Landscape Significance** - The most valued landscape features.
  - **Aesthetic** – Features that contribute most to the enjoyment of people through sensory paths.
  - **Social** - Features that most represent the associations between the community and a place, including for cultural/spiritual reasons.
  - **Historic** - Features that most demonstrate the degree of connection between a feature and past important people or events
- **Views** - The extent of views from a location.
- **Access** - The nature of access to a location.
- **Wilderness Quality** - The level of disturbance.
- **Recreation and Tourism Value** - The degree to which a feature contributes to recreation and tourism.

There are theoretical reasons for these groupings of values. The groupings also reflect the general types of values often talked about by people when dealing with landscape values. For example, in discussion and responses to questions relating to landscape values, people often talk about 'the local character', 'special features', access to places, views, and a 'sense of remoteness'. These have been incorporated into the assessment process as landscape character, landscape significance, access, views, and wilderness quality. Thus, the type and nature of the values assessed has been largely defined by general community sentiment. Understanding the range of values also helps with defining the assessment criteria.

There are a number of approaches commonly used in the assessment of these values, including:

1. Assessment by 'experts' using broad, often immeasurable, criteria. This is typically used in 'heritage' assessment (eg. historic, National Estate).
2. Assessment by specialists using established procedures and measurable criteria, often based on research. This is typically used in 'traditional' landscape assessment.
3. Assessment by 'experts' using principles derived from experience, established principles and theory, or community/management/client requirements. Not widely used on its own for landscape assessment these days, this approach is sometimes used to supplement other approaches.

The assessment process used in this study largely uses Approach 2. Historic and social values that are included (rather than assessed) are based on Approach 1. Discussion of recreation and tourism values includes Approach 3.

As highlighted in Part Two, the procedure used for assessing these values is consistent with the approach taken in similar assessments (Cleary 1998, Cleary et al 1999) and includes three main components:

1. an understanding of theoretical or researched landscape values;
2. formulation of criteria that define the value types;
3. systematic assessment of the study area using the defined criteria.

The assessment approach is discussed further in the following sections.

3.1 Landscape Character Classification and Description

Landscape character classification and description identifies and describes broad patterns of environmental characteristics (classifying them into types, units or sub-units) according to their relevance to human interaction. It addresses the 'local character' often referred to in community comment.

The photographs in Plates 1-36 and 37-38 provide an indication of the character of the study area.

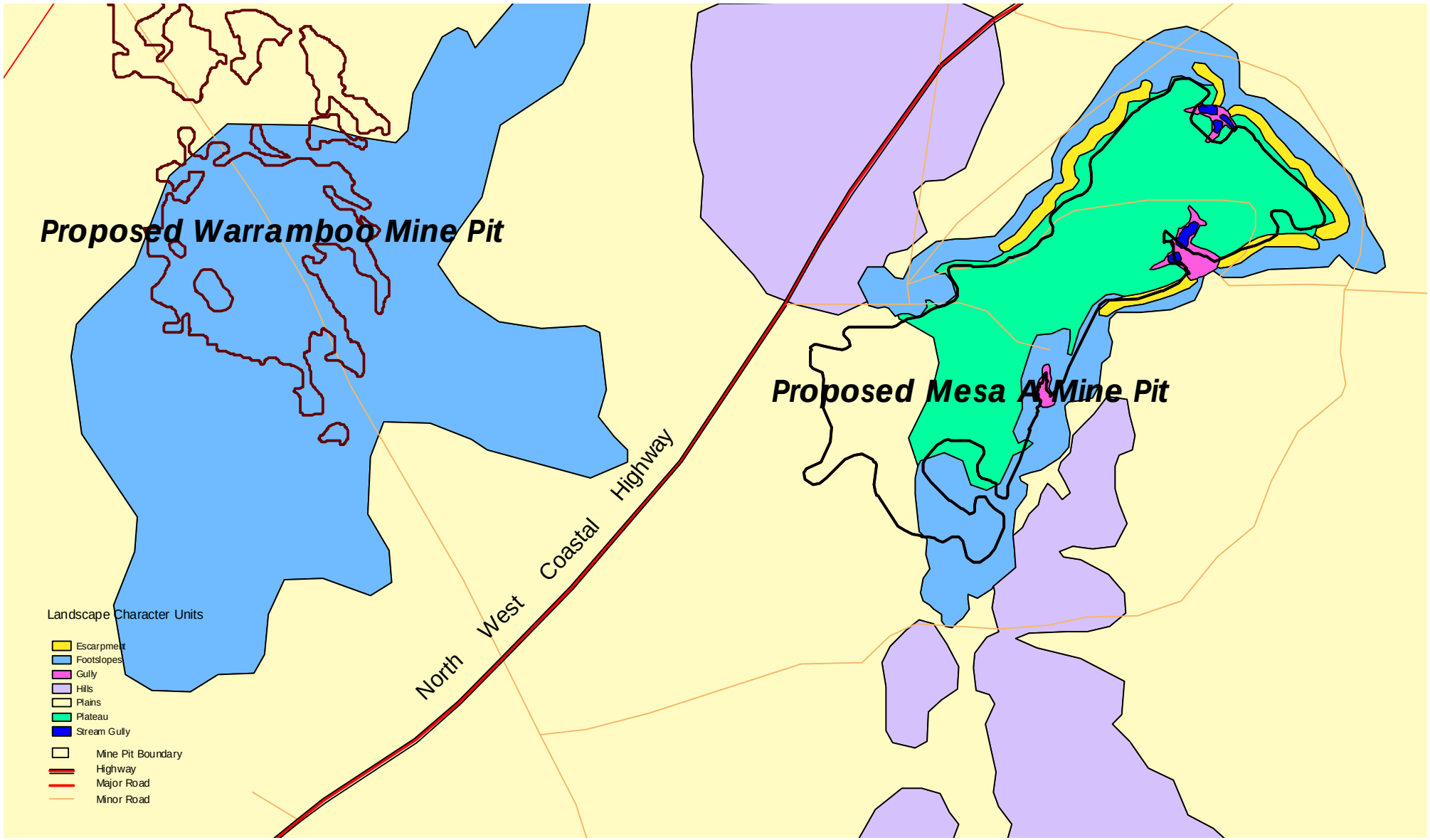
Six character units have been identified (see Map 2) based on the characteristics of Mesa A and adjacent areas. These units are:

- *Plains Unit, which* includes the relatively flat land near and between the hills and mesas.
- *Plateau Unit, which* includes the flat mesa top where the proximity to the escarpment is apparent.
- *Escarpment Unit, which* includes the eastern, northern and western sides of Mesa A where there are obvious rocky escarpments.
- *Escarpment Gully Unit, which* includes the two gullies on the eastern side of Mesa A and the gully on the northern side.
- *Stream Gully Unit, which* includes the confined gullies where the streambed is dominant.
- *Footslopes Unit, which* includes the slopes leading up from the plain to the escarpment or mesa top except where there is rocky escarpment.
- *Hills Unit, which* includes the small and medium-sized hills on the western side of Mesa A (ie. either side of the highway) and mesas to the south east of Mesa A.

With the exception of Stream Gully Unit, these character units are well represented in the study area. Some of these units, such as the Gully units and the Escarpment Unit are also relevant to aesthetic significance (see following section).

Plate 37 – Typical plain and mesa character.

Plate 38 – Typical mesa footslopes and escarpment character.



Map 2 - Landscape Character Units

3.2 Landscape Significance

3.2.1 AESTHETIC SIGNIFICANCE

The assessment of significance identifies features in the study area that are most important to the experience and enjoyment of people, using criteria established through research, local community input, or other assessments and lists. These significant features are often called 'special features' by people when they talk about the values they attach to areas or the things that should be protected.

This community input is used with key research (see Anderson et al 1976, Zube *et al* 1974, Williamson and Chalmers 1982) that allows us to assume that landscape significance increases with:

- increased topographic ruggedness;
- increased naturalism;
- increased land use compatibility;
- increased presence of water forms and extent of water area and edge; and
- increased presence of outstanding natural features.

Other studies also suggest that landscape significance increases with:

- increased legibility of features;
- increased spatial definition;
- increased sympathy in land use response to natural features;
- increased pattern and texture in rural uses.

There are other studies that provide an insight into community perceptions and sentiment relating to landscape values (eg. Cleary *et al* 1999). Key conclusions include:

- that people regard landscape values as extremely important;
- that there is little correlation between features regarded as important for landscape reasons and those having important biological values;
- that people may be more likely to recognise places of landscape value than those having important biological values
- that people are more likely to regard places as important if they have first-hand experience of those places;
- that the attractions of an area are more likely to be landscape features than biological features;
- that higher levels of naturalness are more highly valued;
- that impacts that are detectable but below a visual magnitude may not be recognised by people and may not impact on their experience;
- that water features are valued highly, particularly if the water body is visually enclosed.

The criteria for assessing the aesthetic value natural values are listed below in Table 2. These are well-established criteria, widely used in landscape assessment. There are other criteria for assessing rural use areas and settlement areas but these are not relevant to this study.

Table 2- Criteria for significant natural aesthetic features (not all are relevant to the study area).

Landform	• High points and prominent ridge crests; • Steep slopes (compared to surrounding landforms); • Pronounced gullies; • Features - very flat plains or plateaux, rock outcrops, cliffs, caves and distinctive dune/sand formations.
Vegetation	• Areas with distinctive variation in communities, structure or species; • Feature plants of impressive size, colour or form.
Water	• Ocean, major permanent or rocky, semi-permanent water features, rivers, creeks, estuaries, waterfalls.
Coast	• Indented shoreline, coves, rocky points, short beaches with rock ends, stacks, rock pools and platforms; • Gently curved shoreline with steep natural slopes or cliffs as backdrop or very wide tidal zone.
Wildlife	• Areas with abundant, obvious wildlife.

These criteria were used to identify and map significant features (See Map 3), including:

- The most prominent sections of the escarpment;
- Areas with large caves;
- The three main gullies in the escarpment of Mesa A;
- Clusters of snappy gums;
- Diverse stands of vegetation including the stream-related vegetation;
- The stream gullies and their settings, extending to the mesa plateau.

Examples of these significant features are shown in Plates 39-40.

A list of additional data sources for landscape significance is provided in Appendix 2, some of which relate to scientific, social and historic aspects of places.

3.2.2 SOCIAL SIGNIFICANCE

Social significance stems from the associations between the community and a place, including for cultural/spiritual reasons. There is no known social significance associated with Mesa A stemming from recent use of the area. Indigenous people attach special value to parts of the mesa, including much of the escarpment.

3.2.3 HISTORIC SIGNIFICANCE

Description

Historical records tell us that on March 12, 1866 an exploring party (sent on behalf of Denison Plains Co.), consisting of Harry Whittall Venn, Roderick McKay, Robert Fraser and C. Cane, left Nicol River station 'Cowarinda' and travelled to

the Ashburton River, naming Robe and Cave Rivers. The explorers' journal reads in part:

> 'Monday 19th Broke camp at 7am bearing SW and after crossing one or two water courses in 7 miles we came upon a larger bed more deserving of the name of a river – with fine high banks of light rich soil considering this to be of some importance as to pastoral interest a .... [unintelligible word] from the great quantity of game seen ..... We named this water course the "Robe River."'[9]

The origin of the name 'Robe' is uncertain, the best guess being that it is the same Robe commemorated in South Australia. The possibility is strengthened by the S.A. connections of H.W.Venn, who was born there in 1844. F.H.Robe was appointed Governor of S.A. in 1845. Early settlers called the Robe 'Taylora Creek'. Up to 1865 the upper reaches were called 'No-name Creek', but it was established that this was the headwaters of the (now) Robe River. The river has the Aboriginal name 'Multhowarra' attributed to it, but it is more likely that this refers to a pool or other specific locality on the river than to its entire system.[10]

The prominent topographic expression of the pisolitic iron ores led to their being the first of the iron ores to be recognised in the Hamersley Iron Province. Government Geologist A. Gibb Maitland recorded the presence of bedded ironstones on the northern cliffs of what is now known as Mesa F in 1907, and in the mid 1950s BHP geologists noted the extensive development of mesa form pisolitic iron deposits in the Robe River and Duck Creek areas. However, it was not until the partial lifting of the embargo on the export of iron ore in the 1960s that the deposits attracted serious interest, including surveys by BHP and Rio Tinto in 1961.[11]

The Robe project began in 1962, [12] when the Cleveland Cliffs Iron Company (an American iron and steel producer) recognised the export potential of iron ore reserves in the Robe valley. Ten years of exploration and testing followed, and in 1970 construction commenced of a mine site, railway, processing facilities and two company towns – Pannawonica and Wickham. Two years later, Robe[13] started to produce pellets and sinter fines ore, and in October 1972 the first shipment of ore left Cape Lambert (Port Walcott). Pellet production was discontinued in 1980 due to changing economic conditions and the entire capacity of the operation was converted to the production of sinter fines.

In 1994, mining activities were consolidated on a single large-scale deposit at Mesa J. Robe pioneered the development of pisolite lump ore in 1995, initially at a rate of almost one million tonnes per year. Major steel mills in Japan and Europe quickly seized upon the product, with exports steadily increasing to more than 7.6 million tonnes by the end of 2002. Mesa J today remains the largest supplier of lower-grade iron ore in the world.

In 1998 Robe embarked on the development of West Angelas. The West Angelas mine became fully operational in 2002 after the construction of mine facilities including a 300-bed village, processing plant, new railway infrastructure and expansion of port facilities at Cape Lambert.

This brings us to the present time, with reserves of high-grade ore at Mesa J approaching exhaustion (though stockpiles of lower grade ore will be

[9] Denison Plains Company, 1866. Journal of an exploring party [manuscript]. Held in the Battye Library.
[10] Information verbally from DOLA, Geographic Names section, June, 2005.
[11] MacLeod, W.A., 1966. *Geology and Iron Deposits of the Hamersley Range Area*, W.A. Bulletin 117, Geological Survey of Western Australia, pp. 123, 140.
[12] Company information from http://www.roberiver.com/about/history.html, consulted 20 June 2005.
[13] Majority ownership of the project had changed hands in 1986 when it was taken over by North Ltd. In 2000, the acquisition of North by Rio Tinto saw Rio Tinto take a 53% stake in Robe River Iron Associates.

processed there for up to 20 years[14]) and attention turning to other deposits such as Mesa A.

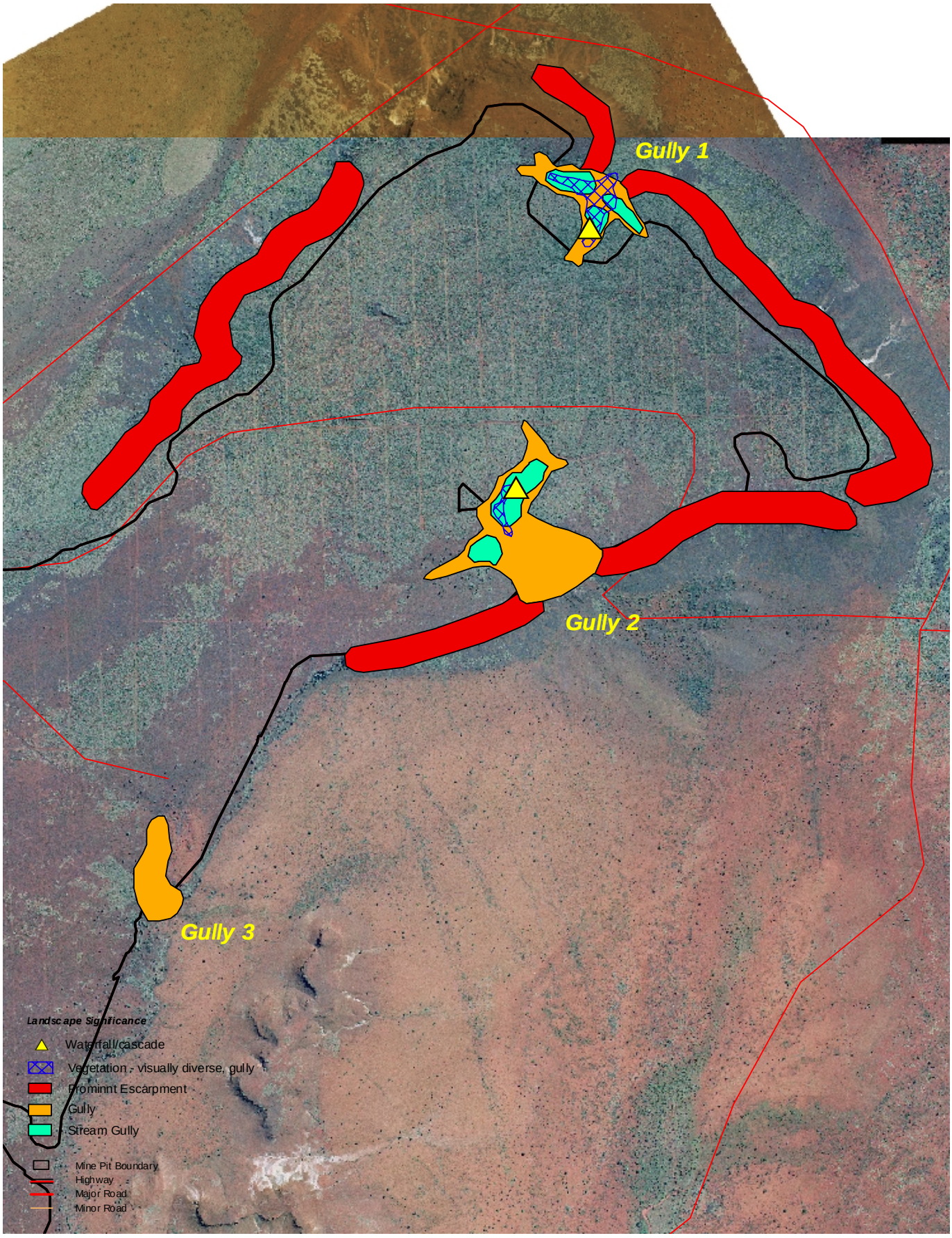
Assessment Summary

- There are no specific recorded sites of historic significance related to the early exploration of the area.
- The Robe River mining operations in general are significant in the development of the Western Australian iron ore mining industry.
- Mesa F has moderate significance due to it being the location of the first recorded identification of iron ore in the Hamersley Iron Province by A. Gibb Maitland in 1906.
- Mesa A has no specific historic significance.

[14] Discussion with Brett Hodgins, Superintendent Mine Planning, 17 June 2005.

Plate 39 – Significant features - the stream, waterfall and walls of Gully2 at Mesa A (see Map2).

Plate 40 – Significant features - the walls of Gully2 at Mesa A (see Map2) with dense and varied vegetation.



Map 3 - Landscape Significance

MESA A-WARRAMBOO ROBE RIVER
Landscape & Geodiversity Assessment Study

NORTH

0 500 1000 m

1:40,000

JOHN CLEARY PLANNING

3.3 Community Use

The assessment of community use identifies and maps the location, type and degree of community use of the area. It addresses values related to access and use that are often referred to in community comment. It includes spot (localised) use areas and access routes (air, ground, water), types of recreational and non-recreational (including industrial or residential) use, ground travel route physical characteristics (such as class, surface, markings and intended traffic type), and existing and expected volume of users. The assessment also includes the classification of use areas (sensitivity levels) and defines distance zones from these areas. These are detailed in the following sections.

3.3.1 CIRCULATION AND ACTIVITIES

Access routes

The North West Coastal Highway is the main travel route though the region. Main link roads extend from it to Onslow and Pannawonica. Other roads are generally unformed pastoral access roads, many also used for mining exploration.

These access roads are shown on the maps in this report.

The North West Coastal Highway carries a mix of local, industrial, and tourist use. Pannawonica Road carries traffic largely related to the mine operations in the area.

Localised Use Areas

Areas of high localised use (other than land use) in the study area are concentrated around settlements, the main one being Pannawonica.

3.3. 2 SENSITIVITY LEVELS & DISTANCE ZONES

Sensitivity Levels

The travel routes have been classified into sensitivity levels based on established criteria (see Appendix 3). Sensitivity levels are an indication of the importance of those routes to the experience of people and are established on the levels of people using the area, the type of use, and an understanding of their preferences. The criteria used to determine sensitivity levels in this study emphasise the informal or formal recognition of the type and levels of use.

There are four classification levels (1, 2, 3 and 4), with level 1 being the highest sensitivity rating. A high sensitivity level may be the result of either high levels of use or high 'sensitivity' user types.

Classification of levels focussed on the access routes (the localised use areas were generally encompassed by these). The levels are shown in Table 4, below.

Table 3 – Sensitivity levels of use areas (See criteria in Appendix 3).

Level 1	North West Coastal Highway, Pannawonica Road, Onslow Road.
Level 2	-
Level 3	-
Level 4	The remaining roads.

Distance Zones

Distance zones provide an indication of an area's spatial relationship to community use. Distance is an important variable in determining the visual magnitude of features. For example, a feature located in the foreground will generally have greater visual magnitude than a similar feature located in the middleground. It is assumed that these closer features will consequently have a greater role in determining human experience (and values) than distant features. This is often an important consideration in setting management/conservation priorities.

Distance zones were identified and mapped based on distance ranges from travel routes and other use areas. Six possible distance zones were considered in this study, listed as follows:

- foreground (0-300m);
- close middleground (300m-1km);
- middleground (1-3km);
- distant middleground (3-6km);
- background (6-15km);
- distant background (>15km).

These distance zones are further described in Table 11 in Section 5.2.

The Mesa A ore body is approximately 500m (Close Middleground) from the North West Coastal Highway (Level 1 travel route). The Warramboo ore body is approximately 2400m from the highway (Middleground). The haul road will cross the highway (*via* underpass) and other mine operations such as bunds or waste dumps will also be in the same distance zones as indicated above.

Pannawonica Road is approximately 7km from Mesa A.

These distance zones are also used to rate the area potentially visually affected included later in this report.

3.4 Views and other Sensory Characteristics

Sensory characteristics were examined to provide an indication of the way people receive environmental information. This part of the study focused on view characteristics. It is recognised that other sensory characteristics play an important role in some areas and for some people.

Views can be assessed and described based on a range of variables. The variables used in the field survey for this project are included in Appendix 4. These variables are considered to provide a good indication of the ability of

people to read (see and identify) areas adjacent to the travel routes (as well as providing information on the nature of the immediate road environment).

The generally flat terrain around Mesa A, particularly along the highway means that the potential for good, long-distance views is high. In some areas close to the Mesa A, low hills and outcrops restricting views to the foreground and close middleground (see Plates 1-4).

The vegetation, particularly trees, tends to be very sparse (except where there are watercourses), which also allows expansive views (notwithstanding landform).

There are good views to both the Mesa A and the Warramboo areas from most locations on the highway as it traverses the area.

The most critical views are those from the highway. These views to the mine operations are likely to improve when the proposed highway realignment and overpass is constructed.

3.5 Wilderness Quality

Wilderness Quality is an indication of the naturalness of the area and has been generally assessed.

Wilderness quality or 'sense of remoteness' is often highlighted as a value in community comment (as in the comments made in consultation for this study) and forms part of the landscape values of the area. Wilderness Quality rating provides an indication of the *actual* naturalness of the area, whereas Natural Land Use character (discussed in Section 3.1) is the perceived character. An area might be quite disturbed in unseen areas but perceived as quite natural.

Wilderness Quality is based on remoteness and bio-physical naturalness. Remoteness is generally based on the distance from access routes, settlement areas and disturbed areas. Bio-physical naturalness can be determined in a simple form by using land use mapping, remnant vegetation mapping and field surveys. These components can be combined to provide composite wilderness quality. This approach is generally consistent with the National Wilderness Inventory procedure (Lesslie & Taylor 1995).

The vegetation appeared to be in good condition during field visits and the main disturbance was the mining exploration tracks, drilling sites, and related works. Biota reported (Biota 2005),

> 'The vegetation of the Mesa A and Mesa G areas was generally in very good to excellent condition. The main disturbance comprised numerous exploration tracks, particularly on the mesa crests. There were no major weed infestations, and the small number of weed species are all common and widespread species in the Pilbara.'

This suggests that the area, although having relatively natural vegetation, has moderate levels of disturbance that could be considered to be high for an otherwise natural area. The sites are also close to other roads, including the North West Coastal Highway.

Consequently, the Wilderness Quality can be considered to be Low-Moderate.

3.6 Recreation And Tourism Values

There are no known recreation and tourism activities in the vicinity of the proposed mine. Mesa A provides a feature that contrasts with the scenery otherwise experienced by travellers on the North West Coastal Highway. In this regard it contributes to the tourism experience in a very small way.

Ironically, the mine, being the closest Pilbara iron ore mine to the North West Coastal Highway, may attract interest from travellers.

Part Four - Planning Framework Objectives

Management and conservation of geodiversity and landscape values are guided by principles that apply generally to a range of environmental values. These principle are expressed in:

- formal planning framework statements, policies and guidelines that apply to the area;
- project-level objectives, set by the responsible agency (Department of Environment) or established by the proponent or assessment staff.
- management and conservation guidelines and practices that commonly apply to the subject values.

Relevant management objectives and standards are detailed in this section. These focus on the main ways of influencing physical and aesthetic changes to the environment, including:

1. by excluding change from areas (such as areas with significant features, regardless of their location);
2. by controlling the nature of environmental change at use areas according to the nature of the use and the distance of the change from adjacent use areas;
3. by encouraging in all areas the use of planning and design principles that enhance, protect or minimise impact on landscape values.

4.1 Planning Framework Objectives

Discussions with Department of Environment staff during the initial phase of this assessment study confirm the requirement to appropriately identify both geodiversity values and landscape values and to apply typical conservation practices to them. The assessment and management approaches for landscape values are relatively well established in Western Australia and Department of Environment objectives usually provide general direction for project-level objectives that are defined during the assessment. Formal geodiversity assessment has not been established as a stand-alone environmental assessment topic but some aspects of geodiversity assessment have been included in heritage assessments. Department of Environment staff have expressed the need to develop a model for geodiversity assessment and that this should consider work in other states, particularly Tasmania (see Sharples 2002).

The Department of Environment has a responsibility to ensure projects meet environment-related requirements pursuant to the *Environmental Protection Act 1986*. Typical general objectives that can be applied to geodiversity and landscape values are:

- ensure the values of the area are not significantly affected by implementation of the proposal;
- ensure that adequate amounts of the values are maintained, avoiding changes that create rarity; and
- ensure that good examples of the values are protected.

4.2 Project Management Objectives

Project management objectives have been defined for the project, covering the following landscape value components:

- Geodiversity and landscape significance;
- Landscape character;
- Access;
- Views;
- Wilderness quality

These objectives are designed to complement the range of planning framework policy objectives outlined in the previous section. They relate to values identified earlier in this report.

4.2.1 GEODIVERSITY AND LANDSCAPE SIGNIFICANCE

Table 4 – Project Geodiversity and Landscape Significance Objectives

Objectives	• These features and their settings should be broadly maintained (or enhanced), focussing on their visual and physical integrity. • Priority for protection should be given to features that are not well represented, including rare features. Development should generally be excluded from these areas. • For well-represented features, any changes should ensure large proportion of the significance is protected and that good examples of feature types are protected.

4.2.2 LANDSCAPE CHARACTER

Table 5 – Project Landscape Character Objectives

Objectives	• Changes to land use character should be minimised.
	• Priority for protection should be given to land use character types or areas:
	  • that have high levels of naturalness;
	  • that are not well represented; or
	  • close to locations with high sensitivity levels (ie. Level 1 and 2).
	• In natural land use character areas, the character of use areas with high sensitivity levels (for example, Level 1 and 2 use areas) should be protected. This means that change should not be recognised from these areas regardless of distance. As a guide, to achieve this, development will need to be unseen in distance zones less than middleground (1-3km) and very low impact in greater distance zones.
	Exceptions to these standards include:
	  • low-impact recreation and safety facilities, which may be seen in the foreground;
	  • changes that are evident for a short period.
	• In semi-natural land use character areas, change should be minor and should ensure that the natural character remains dominant, keeping in mind the cumulative effect of all development in the area. Development in these areas should be consolidated where possible.
	• In cases of land use 'succession', where the land use character changes to a more developed type, the more developed type/area should include, as far as possible, pre-change characteristics of the area.

4.2.3 VIEWS

Table 6 – Project View Objectives

Objectives	• General view patterns should be broadly maintained. • Unique (ie. poorly represented) types of key views should be protected. • Priority for protection should be given to use areas with high sensitivity levels (eg. Level 1 and 2).

4.2.4 ACCESS

Table 7 – Project Access Objectives

Objectives	• Provide sufficient access to allow people to experience and enjoy areas without impacting on other landscape values. • Existing positive experiences should be maintained through the access network. • Unique (ie. poorly represented) types of access should be protected. • Priority for protection should be given to use areas with high sensitivity levels (eg. Level 1 and 2). • Access routes should be maintained to an aesthetic standard appropriate to the sensitivity level.

4.2.5 WILDERNESS QUALITY

Table 8 – Project Wilderness Quality Objectives

Objectives	• The extent and integrity of high quality areas should be maintained. • Development should generally be excluded from high quality wilderness areas.

Part Five - Impact Assessment

5.1 Development Elements and Physical Changes

The main project elements are summarised below. A notional, generic layout is shown below in Figure 2.

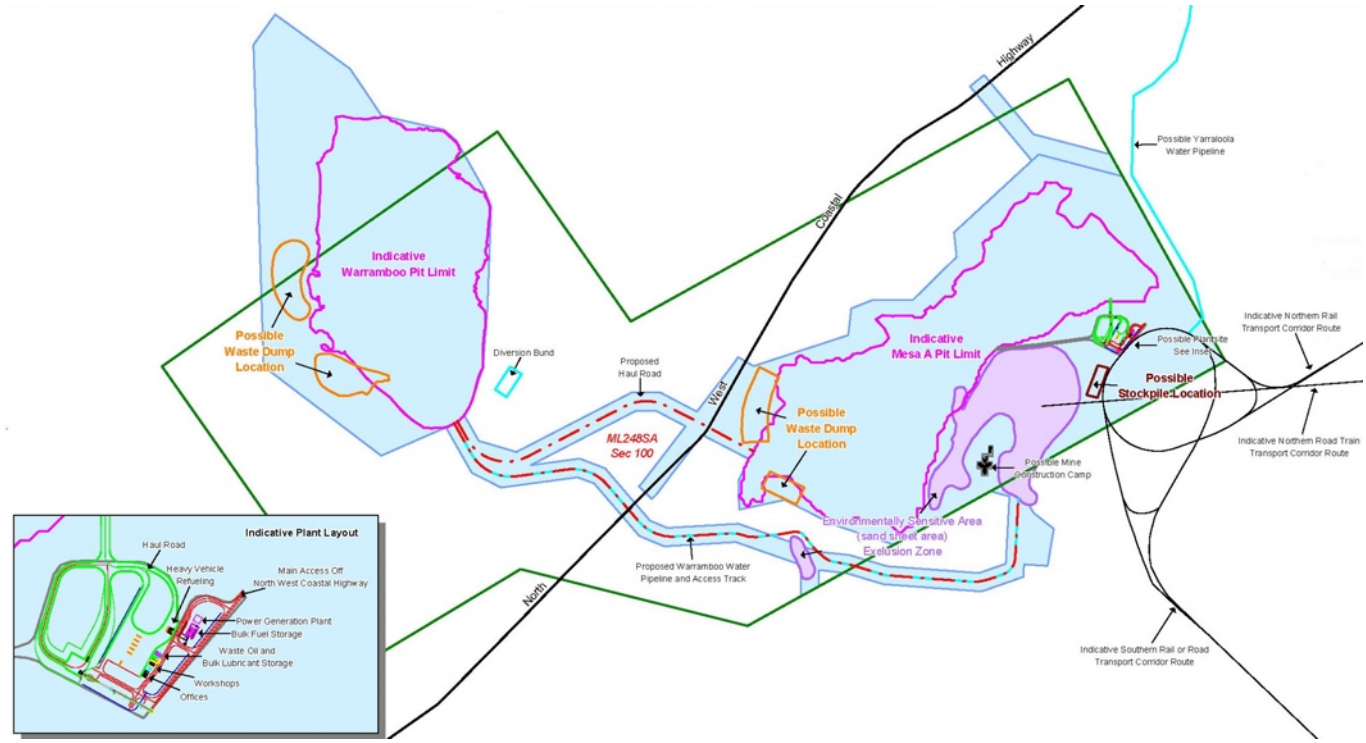


Figure 2 - Plan view of the notional layout of the project (The haul road that heads north from the plant area has been deleted in the latest mine plan).

The proposal includes:

- two mine pits, (one at Mesa A, one at Warramboo), to be partly backfilled by the end of operations;
- a haul road and light truck roads between the two pits and road or rail link to Mesa J;
- a crusher/loader plant area;
- waste rock dumps;
- top soil dumps;
- bunds to protect adjacent areas;
- re-alignment/raising of the North West Coastal Highway to allow an underpass for the Mesa A – Warramboo haul road;
- possible diversion of the creek at Warramboo; and
- fencing adjacent to the highway.

The area of the mine pit at Mesa A is expected to be approximately 500ha. The area of the mine pit at Warramboo is expected to be approximately 340ha. The haul road between the two areas is expected will be

approximately 4.5km in length and the mine road will be approximately 9km in length.

The North West Coastal Highway is to be re-aligned over a distance of approximately 1.4km to a height of approximately 12m. This is to allow the construction of an overpass for the highway to cross the haul road between the two mine areas.

Bunds and waste dumps will be located adjacent to the mine areas, including on the southern sides, and a fence will separate Mesa A from the highway corridor.

5.2 Areas Potentially Visually Affected

The extent of area visually affected by the project is generally determined by the screening ability of the vegetation and terrain, and the size and contrast of the project elements, particularly the taller/larger elements.

The areas that will potentially be visually affected by the project have been analysed. The sparse nature of the taller vegetation in the area suggests that landform will be the main determinant of the area potentially visually affected (in other project areas where there is substantial tall vegetation the main project components are often screened from many view locations).

As distance increases the impact of the project on areas affected will generally decrease. This is due to decreases in visual magnitude corresponding with distance (ie. twice the distance = quarter of the visual magnitude) and contrast (ie. less contrast at greater distances). At great distances the development may be technically visible but not detectable because of the small visual magnitude and low contrast. Table 11 on the following page provides further description of these distance zones.

Given the flat terrain of much of the land surrounding the project components, large areas will be potentially visually affected by the project. As highlighted above, the sparse vegetation will do little to screen views of the project areas.

The terrain at Warramboo falls away to the north-north-west, dropping approximately 25m over the pit areas. This aspect generally restricts the area potentially affected by the mine pits to areas in the north of the pit area (ie, most of the pit area slopes away from key views). The waste dumps have the potential to affect greater areas, including areas to the south and near the highway.

The terrain at Mesa A rises gently from the plain in the south, rising approximately 10m over the pit area, and then drops abruptly at the mesa escarpment in the north, falling approximately 40m to the plain. The escarpment defines the mesa on the western, northern and eastern sides. A well-defined valley that stems from the south and a series of hills lie to the west of the mesa and a series of small mesas lie to the south-south-east. The general aspect of the landform, together with the nature of the adjacent landforms, restricts views of the mine pit from locations in the north and west, provided the mesa escarpment is retained. If the mesa escarpment is breached, the breach would be highly visible (given the exposed nature of the escarpment) and would open up views to the pit and increase the area potentially visually affected. Views of the mine pit may be possible from locations in the south due to the inclined nature of the mesa and the lack of an escarpment on this side of the mesa.

Table 9 – Typical effects in each distance zone.

Distance Zone Name	Distance Zone	Description	Typical visibility rating in this zone (where visible).
Foreground	0-300m	This zone (in relation to the highway) includes parts of the mine road and the haul road and fencing. These are likely to be highly visible from the highway overpass and all minor elements, including vehicles, will be clearly identified.	Dominant
Close Middleground	300m-1km	This zone includes parts of the mine road, the haul road, fencing, the western parts of Mesa A, a bund, and possibly a waste dump. Most of these are likely to be highly visible from the highway overpass and the raised nature of the bund and the waste dump mean that they will be visible from a substantial part of the highway. The western part of the Mesa A mine pit may be detected but the pit walls here will face away from the highway. At these distances, minor elements, including vehicles, will still be identified, especially if clear views are available and the observer is travelling slowly or is stationary.	Prominent.

Table 9 continued….. – Typical effects in each distance zone.

Distance Zone Name	Distance Zone	Description	Typical visibility rating in this zone (where visible).
Distant Middleground	3-6km	This zone includes most of the project elements. The western and southern pit walls of Mesa A are likely to be identified from the highway overpass and may also be detected from the existing highway. The pits at Warramboo may be technically visible from the highway overpass but it is likely that they will not be detected. Other project elements on the highway side of the pits, such as the bunds and the waste dumps will be visible from a substantial part of the highway. At these distances, only larger project elements or elements with high contrast will be identifiable, especially if the observer is travelling quickly.	Visible and often noticed.
Background	6-15km	This zone includes most of the project elements as seen from the highway to the north and south of the mine areas. It also includes the views to Mesa A from Pannawonica Road. The western and southern pit walls of Mesa A may be detected from the existing highway but may not be recognised as cutting faces. The waste dumps are likely to be visible from a substantial part of the highway south of the mine areas.	Recognisable, sometimes not noticed.
Distant Background	>15km	This zone is similar to the Background zone, except that project elements will be smaller and less detectable due to the increased distance.	Detectable, often not noticed.

5.3 Visibility and Appearance

5.3.1 GENERAL CONSIDERATIONS

The visibility and appearance of the development can be discussed in relation to a number of variables, including visual magnitude, visual contrast, and duration.

Visual magnitude is largely dependent on the size of the project component, the distance between the component and observers, and the proportion of the component visible to observers. The proportion of the component visible to the observer is largely dependent on vegetation and landform screening and the position of the observer.

The visual magnitude of the mine pits will be hard for observers to identify given much of the pit areas will be screened by the Mesa A escarpment, landform and the aspects of the pit areas. The best opportunity to identify the visual magnitude will be from the highway overpass, where the outline of the Mesa A pit will be generally detectable. Even though these will be low-angle views, they are likely to create perceptions of the size of the mine area.

Where waste dumps are visible from the highway, their visual magnitudes will be relatively easy to identify and will be generally larger than other project elements.

Visual contrast is largely dependent on the colour of the project components, the pattern of the components' elements, the backdrop to the components, and atmospheric and lighting conditions. Visual contrast will also be higher when the components are seen in the foreground, and lower at greater distances where atmospheric effects reduce contrast. Where components are seen to breach the skyline, visual contrast can often be high, depending on how well the above factors are addressed in design.

Usually, relatively tall components, such as the waste dumps, will have high contrast, as the proportion of them seen against the sky or distant hills will be high. This will be exacerbated where viewing distances are short. The visual contrast stemming from this will vary with the time of day. Visual contrast will be reduced where/when the colour and lightness of elements and the sky are similar.

The main contrasts of the project will be the contrast of the roads and the pit walls against the natural ground level soils and vegetation, and the contrast of the waste dumps against the sky.

At night, lighting has the potential to highlight the location and magnitude of the mine, and the contrast between lights and the night sky has the potential to be very high. The highest contrast will be where the light sources are seen. Where light sources are hidden from view, the glow from light reflecting on the atmosphere is likely to be seen if lighting levels of the plant are high.

Pattern/composition is the way the various components appear to be in relation to one another and surrounding land use/land cover features. Where the pattern and composition reflects natural patterns, the contrast will be less.

Perceived setting depends on the location of the mine, the landform, land cover and the position of the observer. Given the relatively flat nature of the site, most of the surrounding area will play a role in determining perceived setting. The perceived setting of the mine will be relatively natural.

Duration simply refers to the visual lifespan of the component or its visible contrast or magnitude. It is expected that the mine and its components will be

in place for an extended period of time (eg. 15 years) and are classed as long term temporary changes.

Other Variables

There are a number of other variables that will affect the visibility and appearance of the project, including observer related variables such as observer activity and speed of travel, typical view directions, and focal sightlines. For example, increased observer speed will generally narrow the focal area within the view, landform may help direct views away from the mine sites, or, focal sightlines (for example along the highway corridor) will reduce the likelihood of viewing the mine pits when they are at right angles to the direction of travel. No attempt has been made to measure these variables in this study. The discussion of views and the simulations are based on a stationary observer looking directly at the target mine pit and, as such, present the highest visibility potential.

5.3.2 VISIBILITY AND APPEARANCE FROM LOCATIONS WITHIN THE STUDY AREA

There are a number of areas within the study area that have views to the mine components, as indicated earlier, including views from the North West Coastal Highway. The appearance of the proposed min pits and related components is illustrated in the 3Dmodeling/renderings in Plates 41-52 on the following pages. The modelling has been generated based on likely pit contours after 9-10 years of operation. A discussion of 3Dmodeling/renderings techniques and accuracy is contained in Appendix 5. The visibility and appearance demonstrated in these images are consistent with the general considerations discussed above.

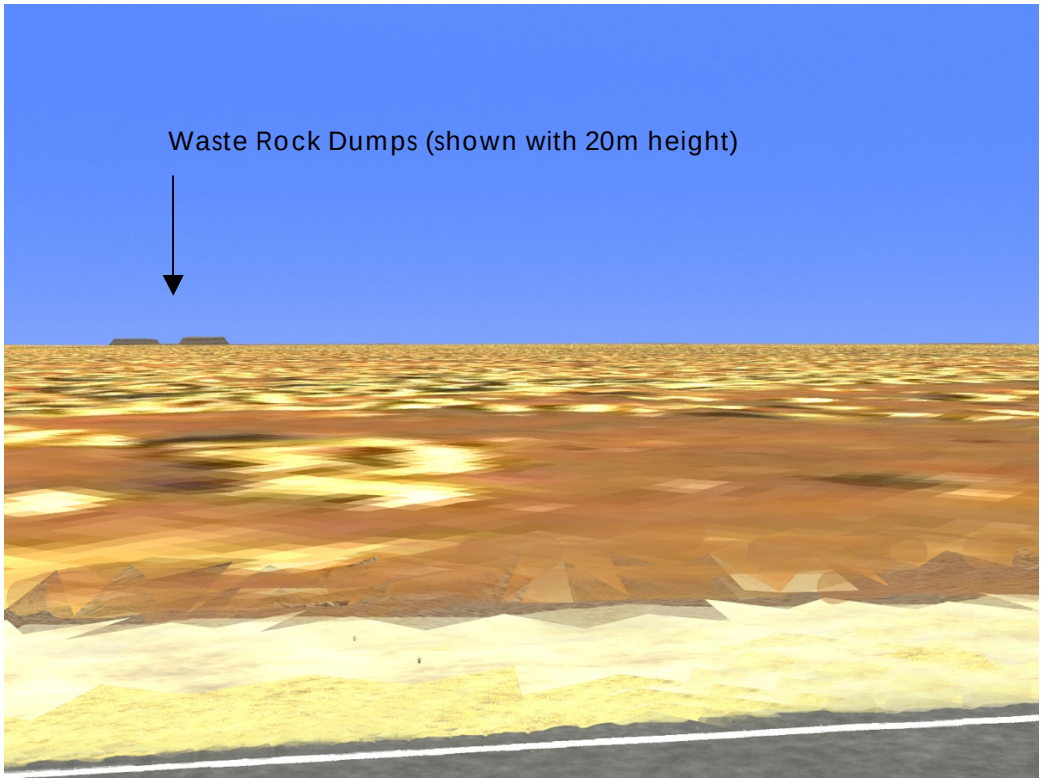


Plate 41 – Simulated view from the NW Coastal Highway, south of the project area, looking towards Warramboo. The latest mine plan has reduced the height of the waste rock dumps to 10m.

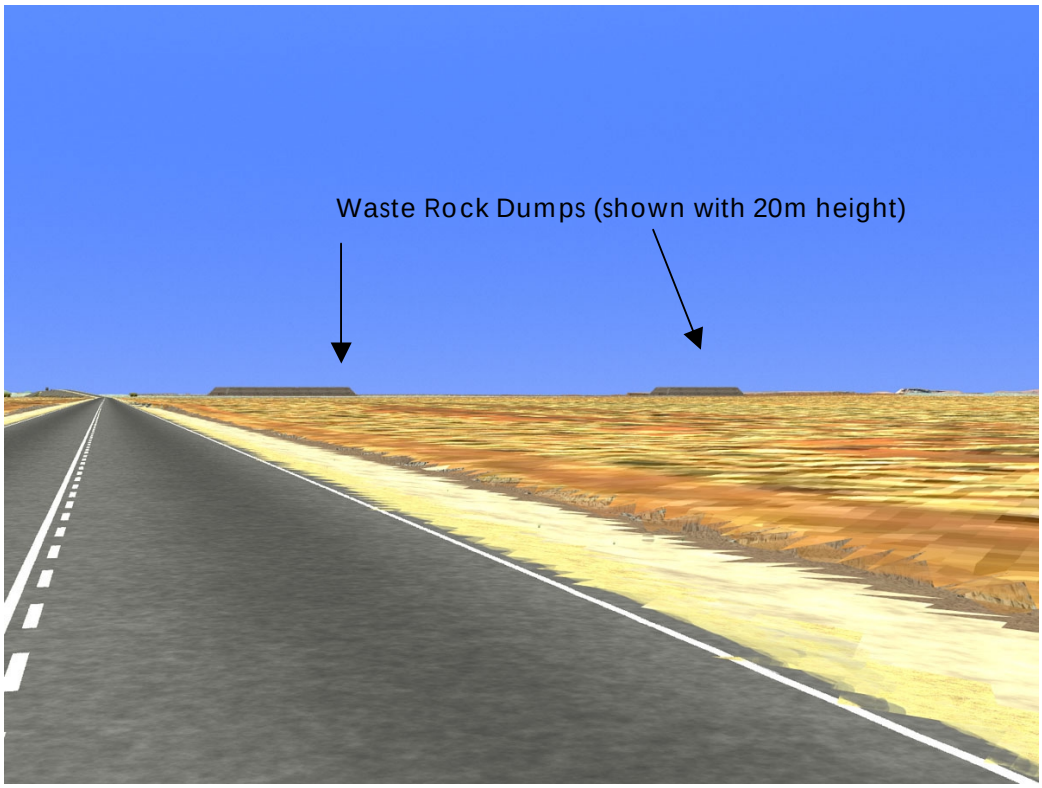


Plate 42 – Simulated view from the NW Coastal Highway, south of the project area, looking towards Mesa A. The latest mine plan has reduced the height of the waste rock dumps to 10m.

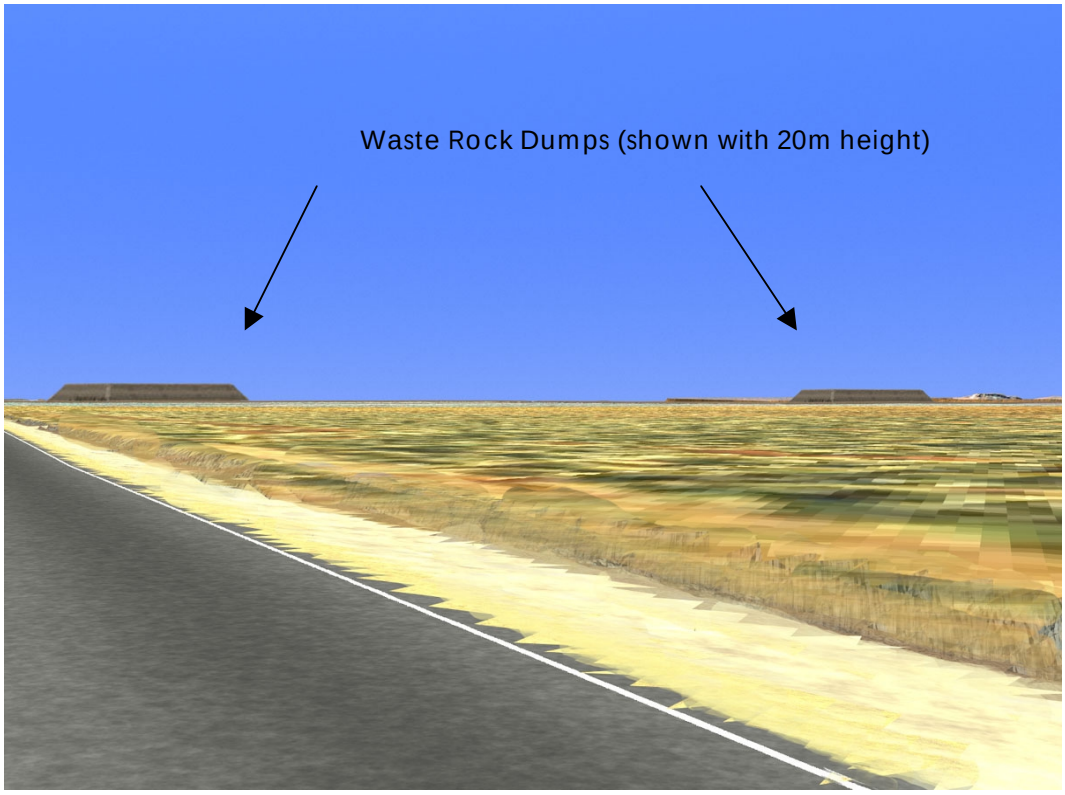


Plate 43 – Simulated view from the NW Coastal Highway, near the southern end of the proposed highway re-alignment, looking towards Mesa A. The latest mine plan has reduced the height of the waste rock dumps to 10m.

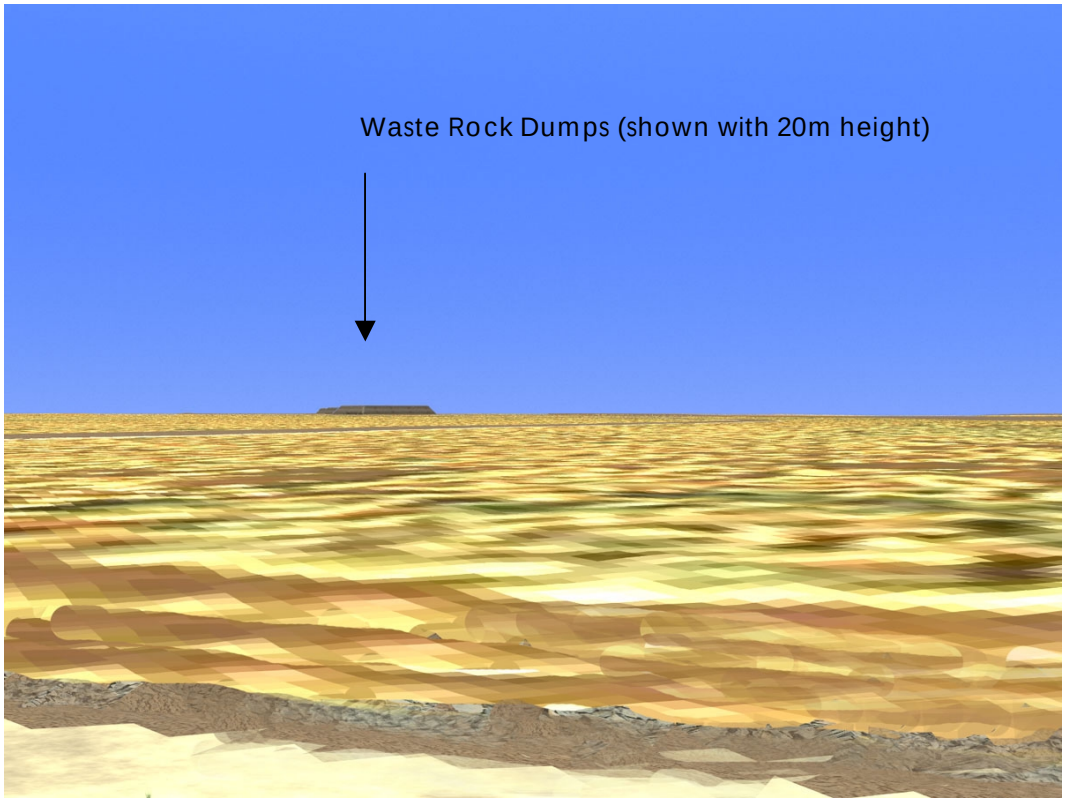


Plate 44 – Simulated view from the NW Coastal Highway, near the southern end of the proposed highway re-alignment, looking towards Warramboo. The latest mine plan has reduced the height of the waste rock dumps to 10m.

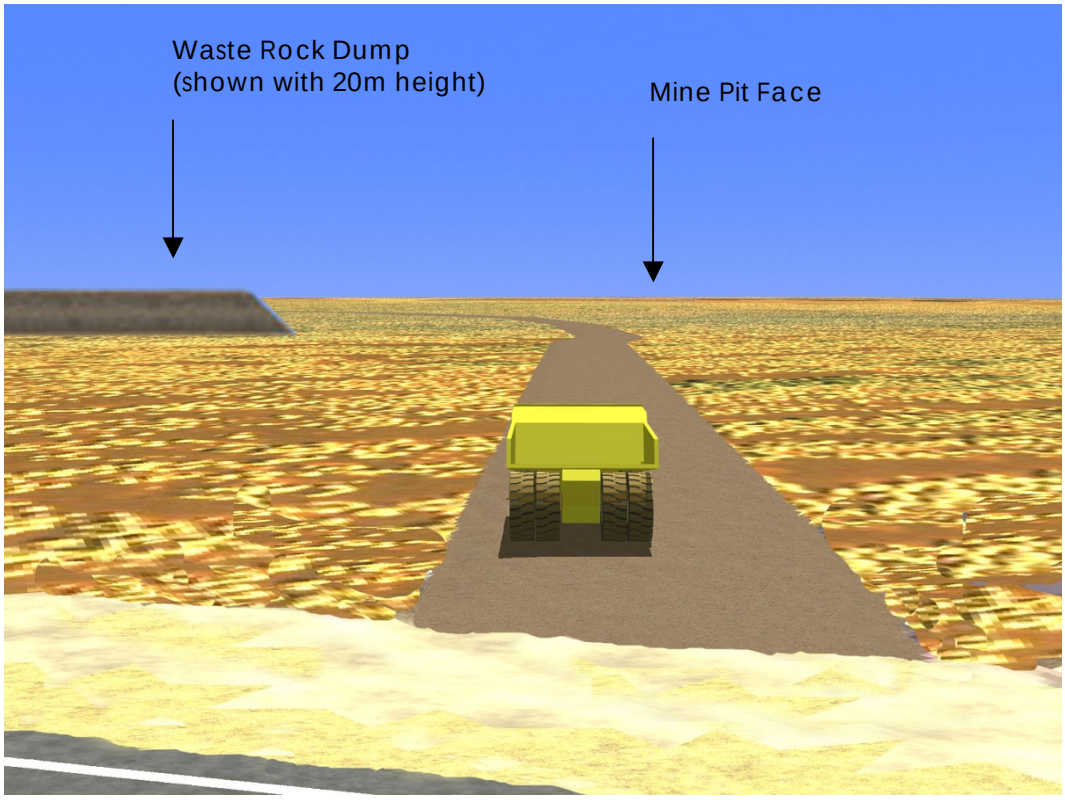


Plate 45 – Simulated view from the proposed overpass on the NW Coastal Highway, looking towards Mesa A. *The latest mine plan has reduced the height of the waste rock dumps to 10m.*

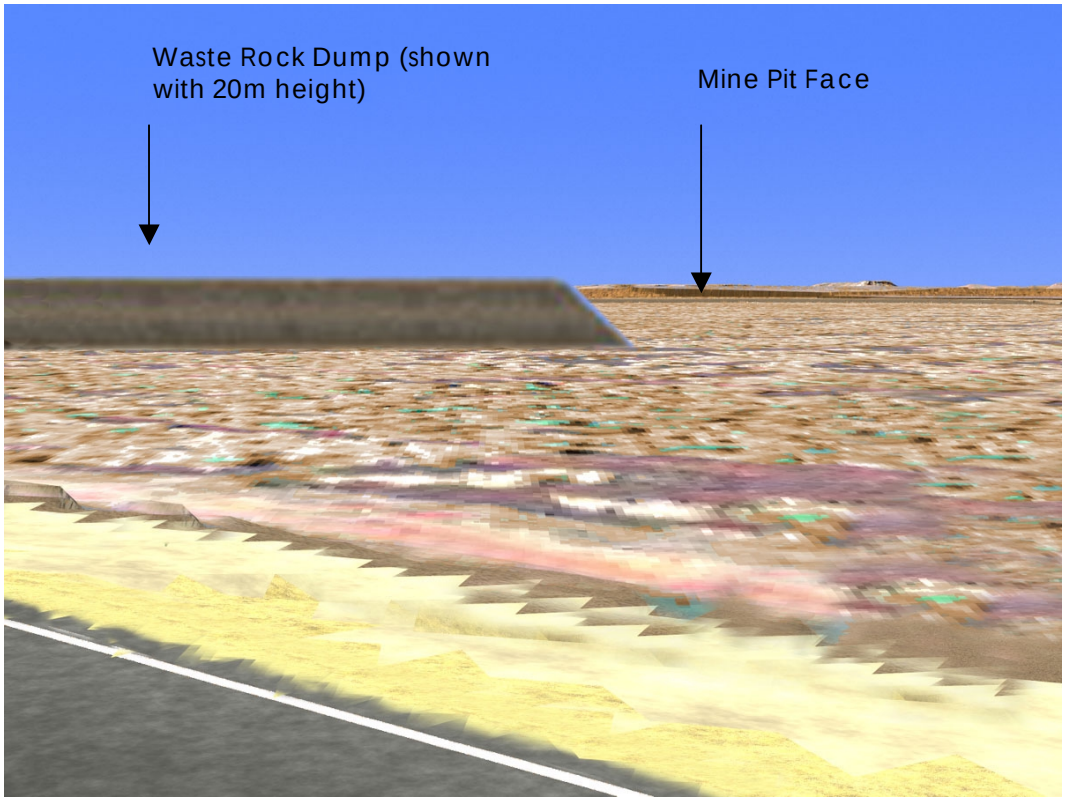


Plate 46 – Simulated view from the proposed overpass on the NW Coastal Highway, looking towards Warramboo. The latest mine plan has reduced the height of the waste rock dumps to 10m.

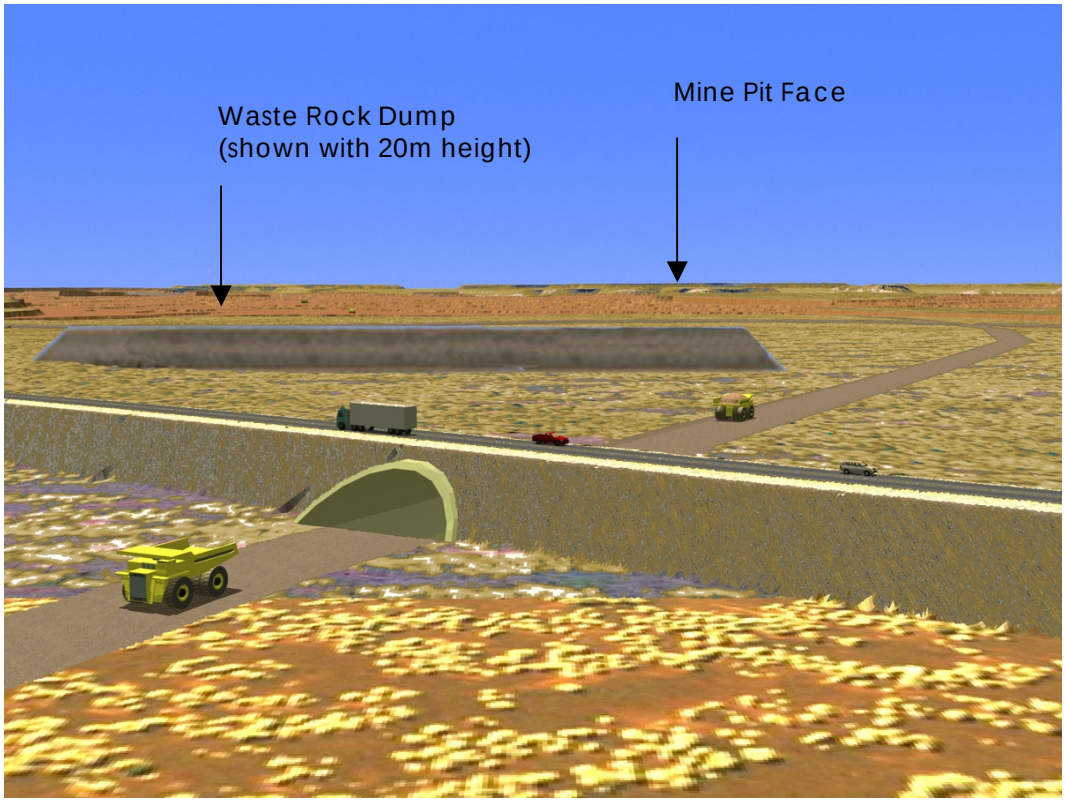


Plate 47 – Simulated view from near the proposed overpass on the NW Coastal Highway, looking towards Mesa A. The latest mine plan has reduced the height of the waste rock dumps to 10m.

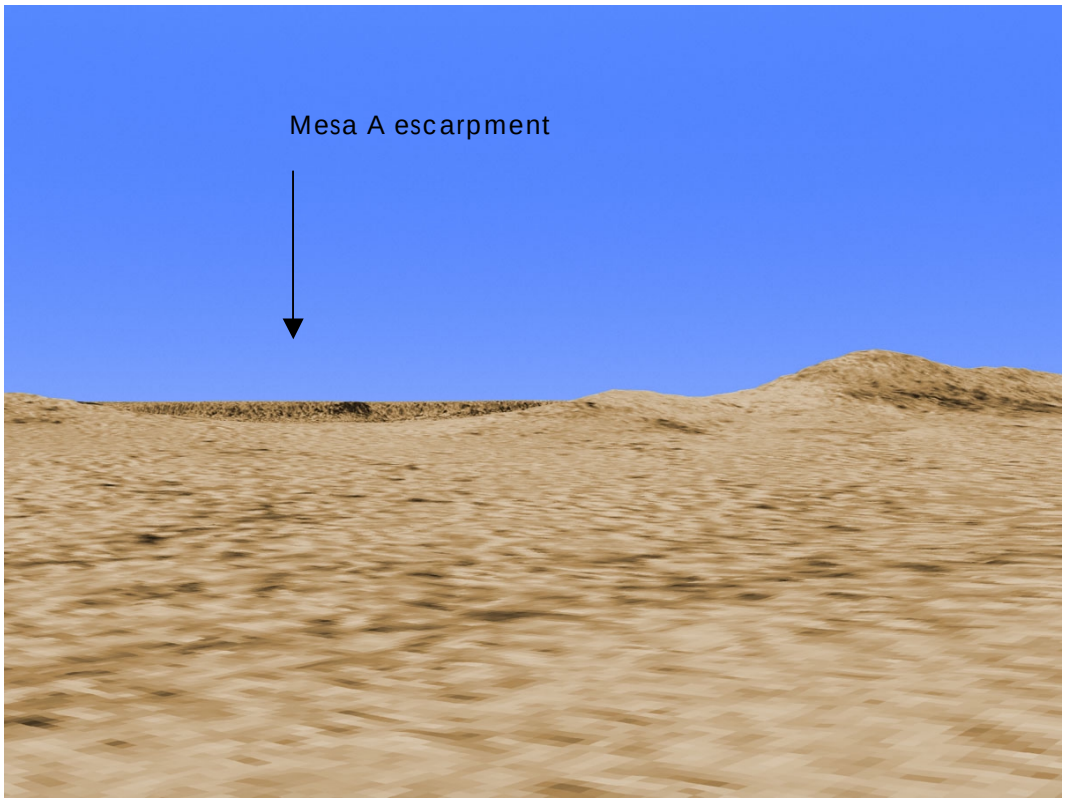


Plate 48 – Simulated view from the NW Coastal Highway, west of Mesa A, looking towards Mesa A.

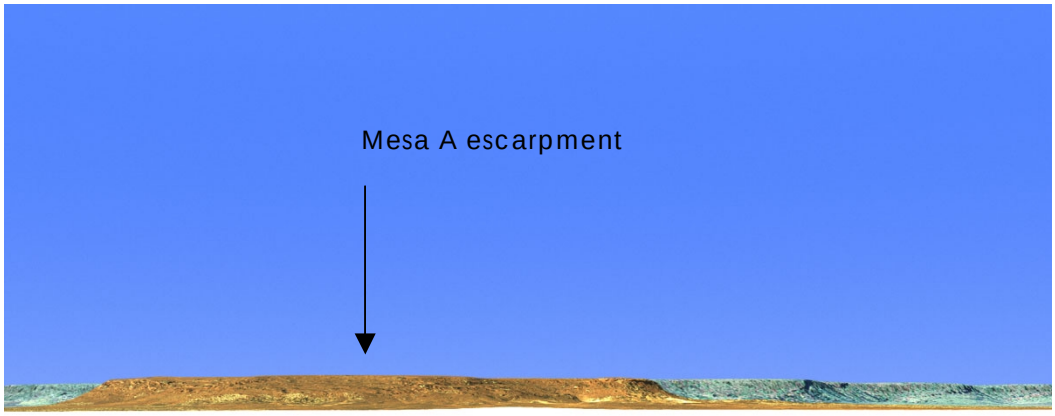


Plate 49 – Simulated view (white foreground) from the NW Coastal Highway, north-west of Mesa A, looking towards Mesa A.

Plate 50 – Simulated view (white foreground) from the NW Coastal Highway, north of Mesa A, looking towards Mesa A.

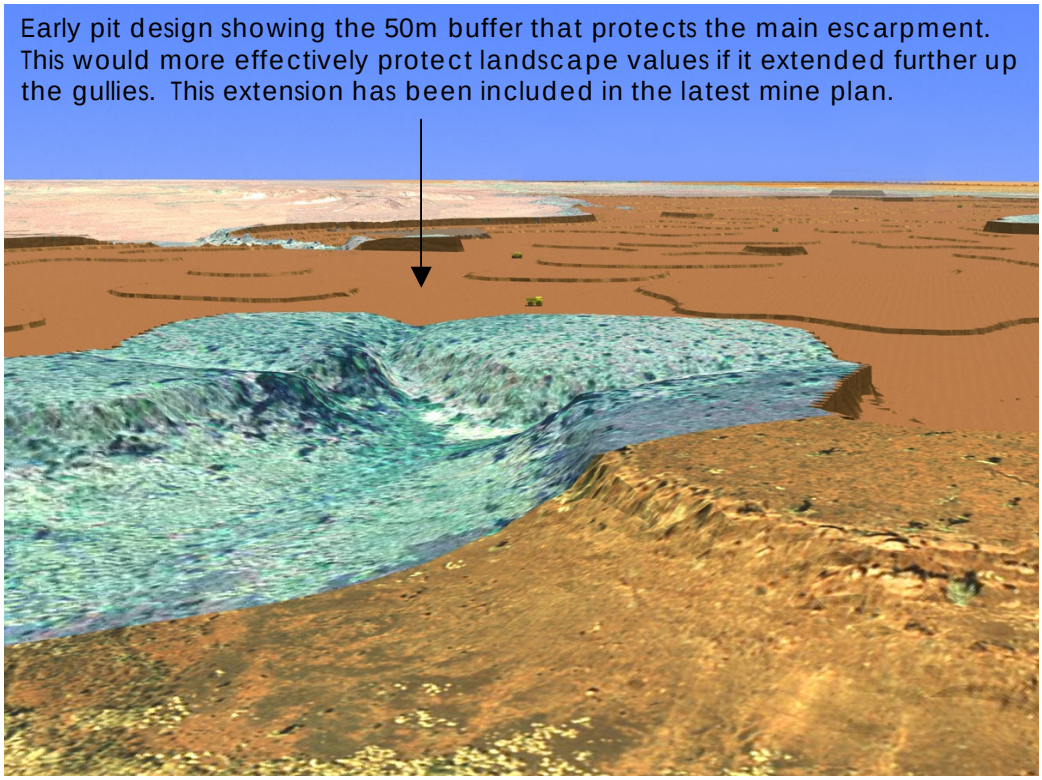


Plate 51 – Simulated birds-eye view looking south over Gully 1 (see Map 3) on the northern side of Mesa A. Mine pit only shown.

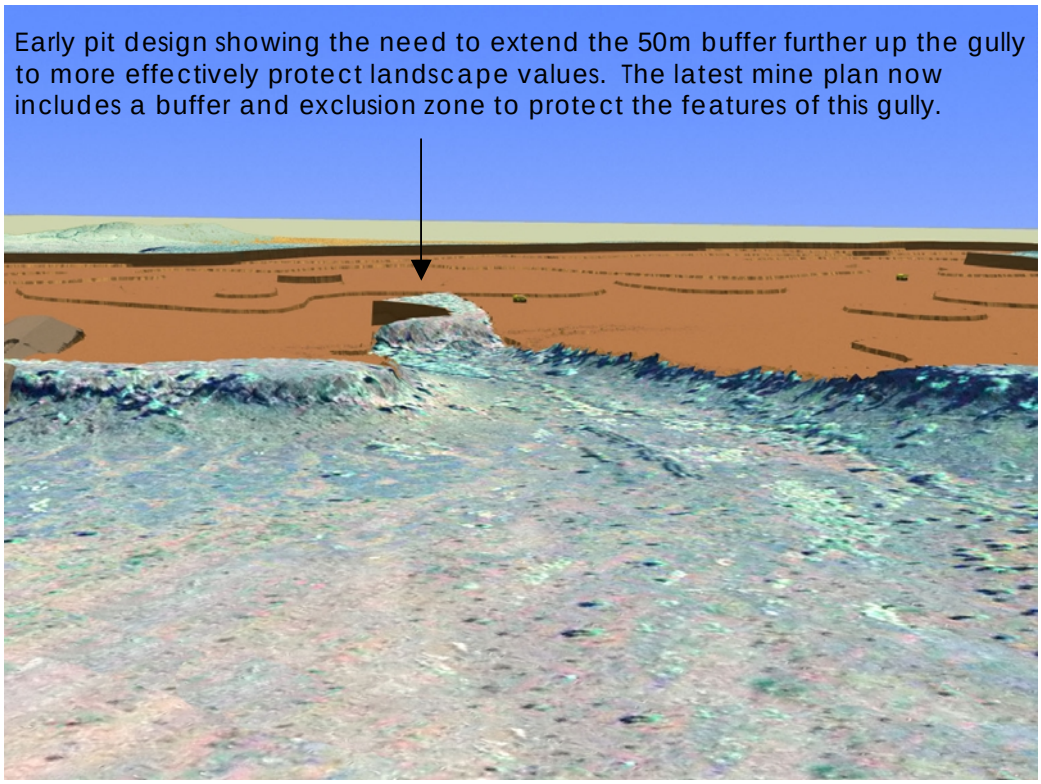


Plate 52 – Simulated birdseye view looking south over Gully 2 (see Map 3) on the eastern side of Mesa A. Mine pit only shown.

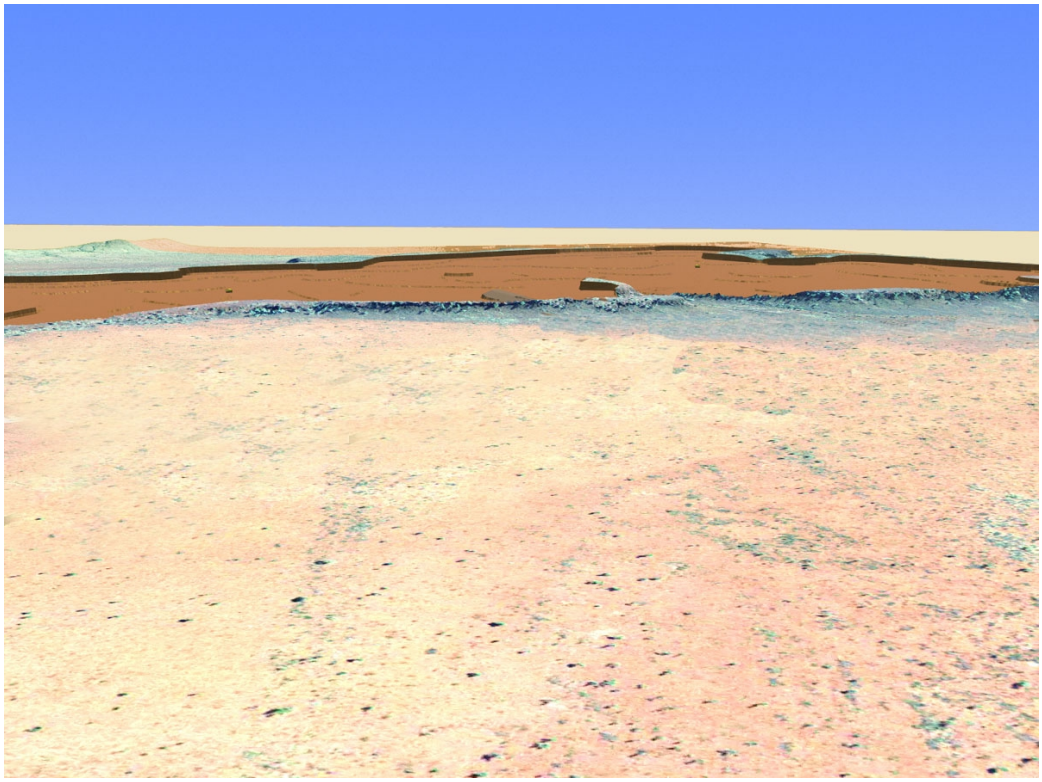


Plate 53 – Simulated birds-eye view looking towards Mesa A from the east. Mine pit only shown.

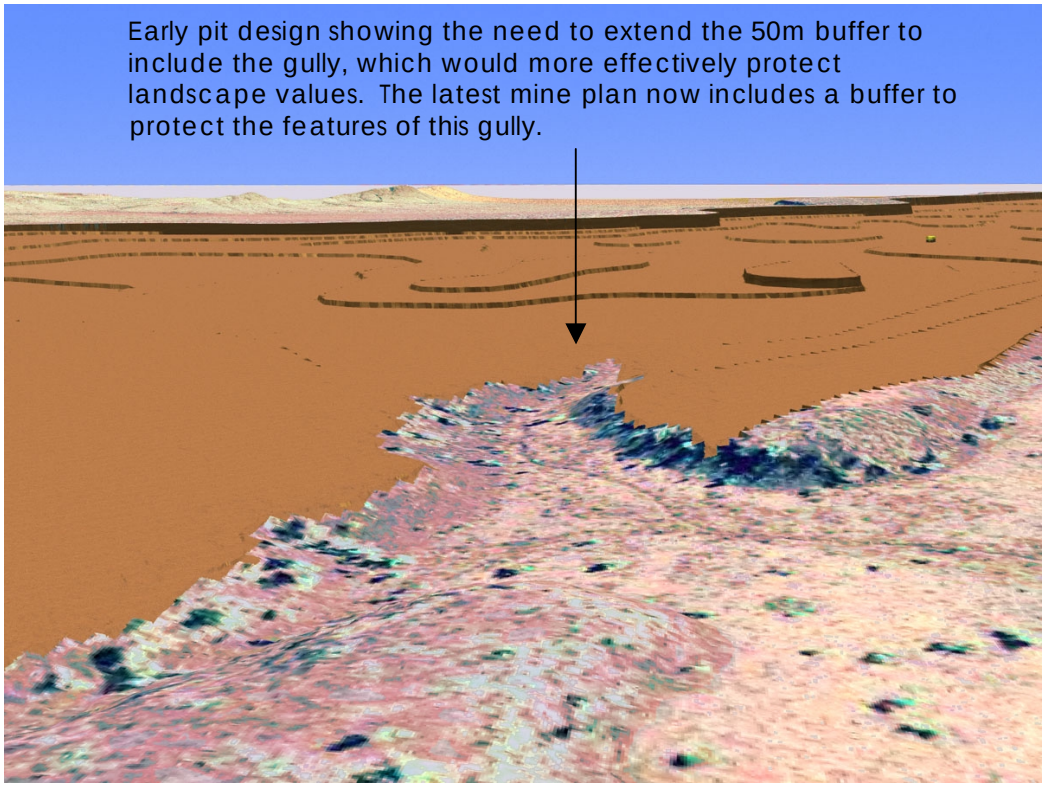


Plate 54 – Simulated birds-eye view looking south over Gully 3 (see Map 3) on the eastern side of Mesa A.

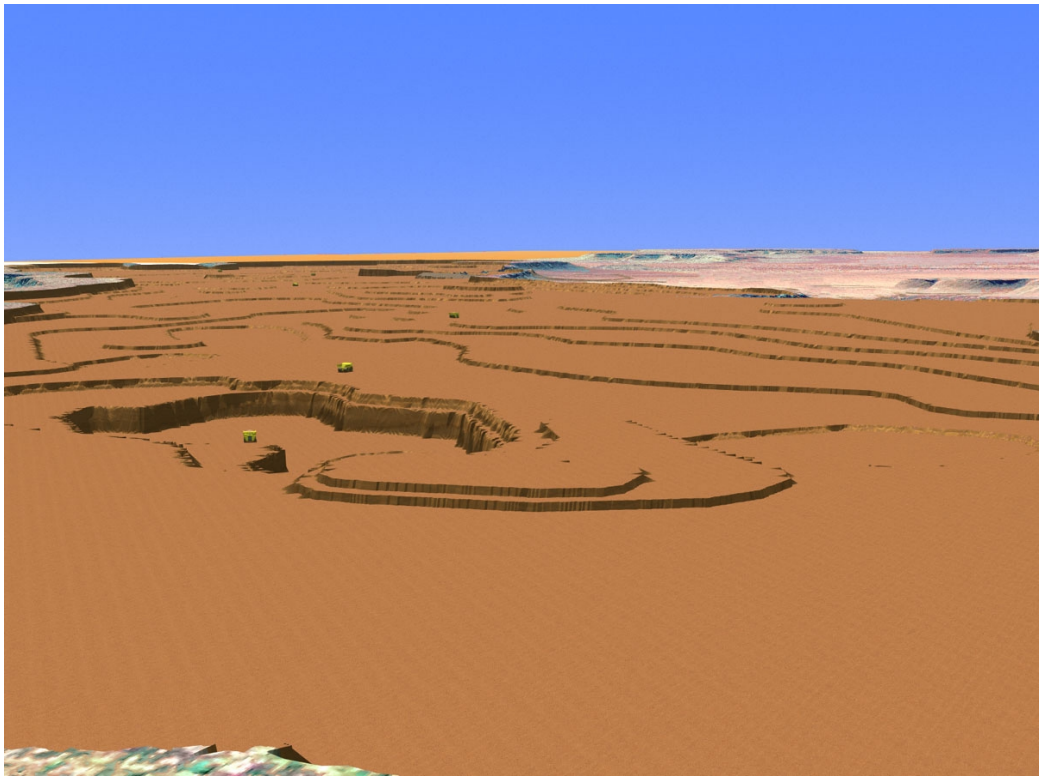


Plate 55 – Simulated birds-eye view looking north over Mesa A.

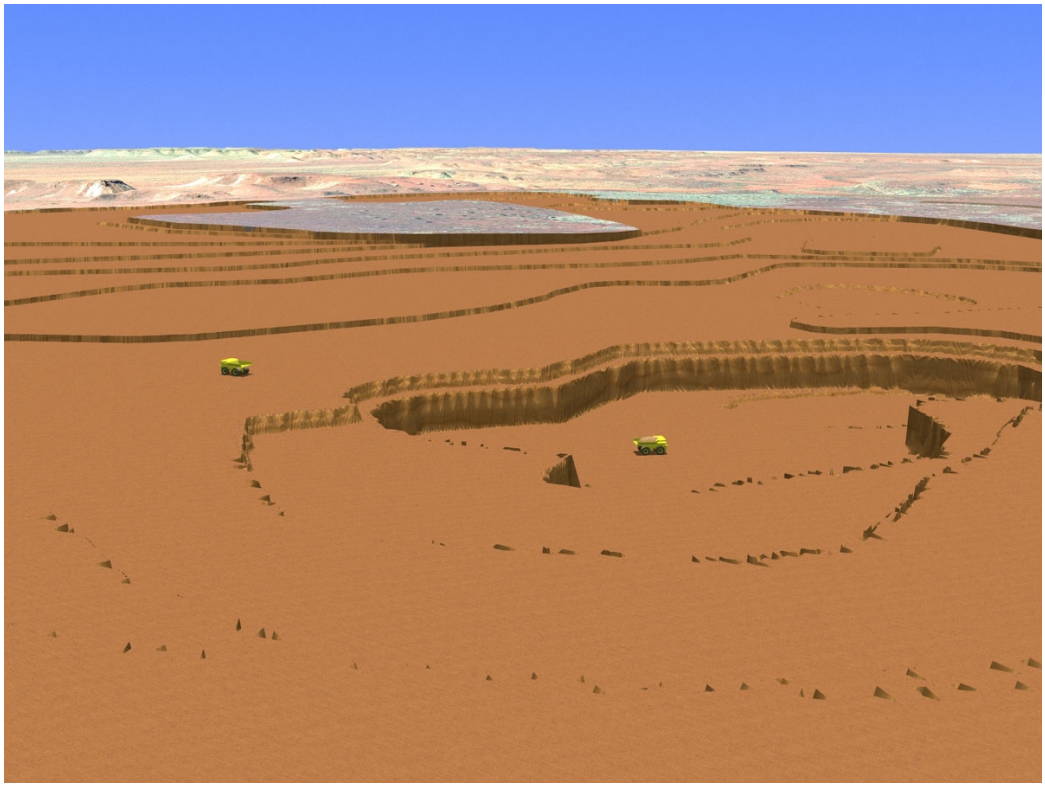


Plate 52 – Simulated birds-eye view looking south-east over the southern end Mesa A.

5.4 Impact on Values

Values have been identified in the assessment of values summarised in this report. The types of values have been identified as:

Geodiversity

- *Intrinsic Values;*
- *Ecological Values*;
- *Scientific Values*;

Landscape

- Human-related values, covering:
  - *Landscape Character*;
  - *Landscape Significance* ;
    - *Aesthetic*;
    - *Social*;
    - *Historic*;
  - *Access*;
  - *Views*;
  - *Wilderness Quality*; and
  - *Recreation and Tourism Value*.

This section describes the impact of the proposed project on these values. These impacts are determined and described in Table 12, on the following pages, according to a number of key questions. These questions are:

1. How is the value generally affected?
2. How much actual or perceived change will there be? (described by type, extent, degree, rating).
3. Does the change affect the extent of the value, create rarity, or affect rare features? (described by extent of change as a proportion of total extent of value, rating).
4. How does the change affect high sensitivity level use locations? (described by assigned sensitivity level and distance zone, rating).

Further considerations include:

- *The degree and extent of change.* Change may be, for example, a high degree of change in a localised area or a low degree of change spread over a large area.
- *The composite nature of landscape character.* The change to landscape character needs to take into account the change at each location, the change to areas that affect that location and the resultant dominant character;
- *Priority/weighting applied to impacts.* Based on the degree of change, priority is given to change that threatens the level of representation of the value in a broadscale context. In the case of Character, Access, and Views, priority is also given to change that is close to *High Sensitivity Leve*l use areas. The level of representation of the value in these areas may also be considered. Weighting is divided equally between each of the relevant considerations. For example, for landscape character, access and views, equal weighting is given to degree of change, change that substantially affects the level of representation of the value, and change near high sensitivity level use areas (ie. one third each). For Geodiversity Value,

Natural Landscape Significance, and Wilderness Quality, no 'Proximity to *High Sensitivity Level* Use Areas' priority or weighting is given because these values exist regardless of levels of use.
The values are generally given equal weighting. Sometimes evaluation might focus on only one or two types of value because the others values are not affected by a proposal, but this does not affect weighting.

Table 10– Impacts on values.

Impacts on Values					
	Key Impact Questions				
Value	**How is the value generally affected?**	**How much actual or perceived change will there be?**	**Does the change affect the extent of the value, create rarity, affect rare features, or affect values of a composite nature?**	**How does the change affect high sensitivity level use locations?**	**Summary**
1. Geodiversity – Intrinsic Values	• Intrinsic geodiversity value is affected when the extent of the value changes. The effect can be rated according to how much of the value exists and how much is affected.	• There will be extensive physical changes to the Mesa A and Warramboo mine pit areas. The gullies at Mesa A and the adjacent escarpment may be affected by the mine pit if buffers are inadequate. The escarpment of Mesa A will also be affected in one location by a haul road. Apart from these localised changes, the escarpment will be unaffected.	• Robe Pisolite in mesa formations occur extensively in the region. • The lower Robe River formations are the largest deposits. • The change affects a small proportion of these occurrences. • Partial mesa formations do not occur as extensively as full mesa formations - Mesa A and Mesa H are the only mesas in the lower Robe River formations that are partial mesas. • Deeply incised gullies such as the one on the eastern side of Mesa A do not occur extensively.	• N.A. (not applicable).	• There will be extensive changes to Mesa A. Mesa formations such as at Mesa A occur extensively in the region, although the partial nature of Mesa A distinguishes it from many other mesas. • The gullies are affected and deeply incised gullies such as the one on the eastern side of Mesa A do not occur extensively.

Impacts on Values					
	Key Impact Questions				
Value	How is the value generally affected?	How much actual or perceived change will there be?	Does the change affect the extent of the value, create rarity, affect rare features, or affect values of a composite nature?	How does the change affect high sensitivity level use locations?	Summary
2. Geodiversity – Ecological Values	• Ecological geodiversity value is affected when ecological values are affected. This is typically determined in flora, vegetation and fauna assessments.	• As above. This will affect a number of vegetation types and species across the operations areas.	• Mine components will generally be located to avoid the significant species and vegetation types except the small area of S1 vegetation type located on top of Mesa A.	• N.A.	• The project will affect a number of vegetation types and species. Mine components will be sited to largely avoid significant ecological values.
3. Geodiversity – Scientific Values	• Scientific geodiversity values are affected when features that have been recognised for scientific reasons are directly affected.	• As above.	• Mesa A is a small part of the pisolitic iron ore deposits in the region that, as a group, have scientific value. The partial nature of Mesa A, while of interest, adds little to its scientific value.	• N.A.	• Mesa A is extensively affected but is a small part of the pisolitic iron ore deposits in the region that, as a group, have scientific value.
4. Landscape Character	• Landscape character will be affected in any location where there is a change in character type and the change can be seen (ie. perceived character). The change in value is	• As above. Detection of these changes will most likely to occur at locations on the Highway to the south of the pit areas. The pit, roads and waste rock	• The character units generally occur extensively.	• Many of the changes will be identified from a Level 1 travel route (North West Coastal	• Landscape character will be highly affected at the mine locations. The character types are occur extensively in the region. The changes will be observed fro

Impacts on Values					
	Key Impact Questions				
Value	How is the value generally affected?	How much actual or perceived change will there be?	Does the change affect the extent of the value, create rarity, affect rare features, or affect values of a composite nature?	How does the change affect high sensitivity level use locations?	Summary
	generally based on visibility (ie. seen or unseen) from use areas and the public sensitivity rating of the use areas.	dumps of Mesa A may be detected. At Warramboo it is unlikely that the pit will be detected.		Highway).	the North West coastal Highway (Level 1 travel route).
5. Landscape Significance - Aesthetic	• Landscape significance will be affected wherever the project physically or visually changes these features. Physical change may remove part or all of the significant feature (eg. vegetation). Visual change can also add a project element close to the feature in a way that affects the appearance of the significant feature. The value of the feature will decrease with an increase in physical or visual	• The gullies at Mesa A and the adjacent escarpment may be affected by the mine pit if buffers are inadequate. The escarpment of Mesa A will also be affected in one location by a haul road. Apart from these localised changes, the escarpment will be unaffected.	• The combination of characteristcs of *Gully 2 (see Map2)* at Mesa A has a low occurrence in the region (similar gullies occur on Mesa F).	• N.A.	• The gullies at Mesa A and the adjacent escarpment may be affected by the mine pit if buffers are inadequate. The escarpment of Mesa A will also be affected in two locations by haul roads. Apart from these localised changes, the escarpment will be unaffected.

Impacts on Values					
	Key Impact Questions				
Value	How is the value generally affected?	How much actual or perceived change will there be?	Does the change affect the extent of the value, create rarity, affect rare features, or affect values of a composite nature?	How does the change affect high sensitivity level use locations?	Summary
	effect on the area of significance.				
6. Landscape Significance - Social	• Features with social significance are affected when change directly affects the feature and its immediate setting.	• Social value is largely associated with the escarpments and gullies of Mesa A (assessed by others). The gullies at Mesa A and the adjacent escarpment may be affected by the mine pit if buffers are inadequate. The escarpment of Mesa A will also be affected in one location by a haul road. Apart from these localised changes, the escarpment will be unaffected.	• N.A.	• N.A.	• Social value is largely associated with the escarpments and gullies of Mesa A (assessed by others). The gullies at Mesa A and the adjacent escarpment may be affected by the mine pit if buffers are inadequate. The escarpment of Mesa A will also be affected by the haul road. Apart from these localised changes, the escarpment will be unaffected.
7. Landscape Significance - Historic	• Features with historic significance are affected when	• Mesa A has no specific historic significance.	• N.A.	• N.A.	• Mesa A has no specific historic significance.

Impacts on Values					
	Key Impact Questions				
Value	How is the value generally affected?	How much actual or perceived change will there be?	Does the change affect the extent of the value, create rarity, affect rare features, or affect values of a composite nature?	How does the change affect high sensitivity level use locations?	Summary
	change directly affects the feature and its immediate setting.	• The Robe River Pisolite deposits have historic significance because of their role in the development of iron ore mining in the Pilbara.			
8. Views	• Views will be affected wherever the project (or its elements) hinders or enhances views. The effect will be greatest for key views from high sensitivity level places, where the blocking is greatest and where the views would otherwise be to significant features.	• The overpass to be constructed on the highway will increase views to adjacent areas, allowing, for example, .the pit faces on the north and east sides of Mesa A to be seen.	• Views to mine operations are rare on the North West Coastal Highway.	• The affected views are on a Level 1 travel route.	• The overpass to be constructed on the highway (Level 1 travel route) will increase views to adjacent areas, including the mine areas, allowing, for example, .the pit faces on the north and east sides of Mesa A to be seen.
9. Community Use/Access	• Access will be affected wherever the project obstructs or improves access. Impact will be	• New roads will be constructed in the area but will not generally be available to the	• No change to public use.	• No change.	• New roads will be constructed in the area but will not generally be available to the

Impacts on Values					
	Key Impact Questions				
Value	How is the value generally affected?	How much actual or perceived change will there be?	Does the change affect the extent of the value, create rarity, affect rare features, or affect values of a composite nature?	How does the change affect high sensitivity level use locations?	Summary
	greatest for access routes with high sensitivity levels.	public.			public.
10. Wilderness Quality	• Wilderness quality will be affected where the project decreases naturalness and remoteness. Wilderness quality provides an indication of the actual levels of disturbance (and a stocktake of the remaining area with these levels) rather than perceived naturalness of the area (land use character addresses that latter).	• The existing wilderness quality is moderately low due to the proximity of the highway and because of the extensive network of tracks and drilling sites and related facilities. • There will be extensive physical changes to Mesa A. These will reduce the wilderness quality further.	• Extensive areas of relatively high wilderness quality occur in many other areas in the region.	• N.A.	• Wilderness quality is moderately low and is reduced further by the project. Extensive areas of relatively high wilderness quality occur in many other areas in the region.
11. Recreation & Tourism	• Recreation and tourism value will be affected when change directly affects activities or has a negative affect	• The potential use of Mesa A as a natural recreation and tourism destination is substantially reduced.	• No recreation or tourism value currently exists apart from the scenic value for travellers on the North West Coastal Highway.	• Any change affects Level 1 travel routes.	• The potential use of Mesa A as a natural recreation and tourism destination for travellers on the North West Coastal

Impacts on Values					
	Key Impact Questions				
Value	How is the value generally affected?	How much actual or perceived change will there be?	Does the change affect the extent of the value, create rarity, affect rare features, or affect values of a composite nature?	How does the change affect high sensitivity level use locations?	Summary
	on the settings for activities.	• Mine operations may be used to create an interpretative experience encompassing the historic and scientific value of the Robe Pisolite deposits and iron ore mining in the Pilbara generally.			Highway is substantially reduced. Mine operations may be used to create an interpretative experience encompassing the historic and scientific value of the Robe Pisolite deposits and iron ore mining in the Pilbara generally.

5.5 Cumulative Effect

Cumulative effect takes into account the effect on values over time, usually based on a nominated area. The area considered may reflect a regional scale or a local scale. A regional scale is usually used to consider and assess cumulative effect but the main objective of controlling incremental effects can also be applied at a local scale, particularly when developments are staged or expanded.

A high cumulative effect will be created when the level of impact stemming from developments and the density of developments are high compared to the extent of available values. It could be possible to have a relatively high density of developments and still achieve landscape objectives if the impact on values for each development is low.

The proposed mine is the only development of this nature west of Mesa J. At a regional level, the low density of similar development and the large extent of remaining, unaffected, similar values suggest that cumulative effect is low.

Part Six - Evaluation

An evaluation of the project can be made, based on the assessed impact and the compliance of that impact with the objectives and management standards that apply to the area and the values involved. A number of considerations in the impact assessment flow onto the evaluation. Key considerations are:

- the degree of change;
- changes to the extent of the value or rarity, or the effect on rare features or values of a composite nature;
- the effect on *High Sensitivity Level* use areas;
- community attitudes; and
- the effect on neighbours.

High Compliance

The project largely satisfies objectives relating to a number of geodiversity and landscape values, as follows:

- Robe Pisolite in mesa formations occur extensively in the region.
- The type section is not located in the mine areas.
- Mesa A and Warramboo do not have any specific scientific significance (although they are part of the Robe River Pisolite deposits that, as a group, have scientific value (for what they can, as palaeo-channel deposits, reveal about the evolution of the area (and the origin of the ores))).
- Mesa A and Warramboo do not have any specific historic significance (although they are part of the Robe River Pisolite deposits that, as a group, have historic value (for their role in the development of iron ore mining in the Pilbara)).
- The landscape character units/types present at Mesa A and Warramboo occur extensively throughout the region.
- Mine components will be excluded from the sand sheet and associated vegetation (Type S1) on the eastern side of Mesa A.
- Views will be improved.
- Most community access and use will be largely unaffected (there will be brief closures of the North West Coastal Highway for operational reasons during the life of the project).
- The mine areas have relatively low-moderate wilderness quality and extensive areas of high wilderness quality occur in surrounding areas.
- Potential use of Mesa A as a natural recreation and tourism destination is reduced (not currently used) but there is the potential to create an attraction based on the mine operations and the historic, scientific and aesthetic values.
- Anecdotal evidence suggests that the community has a relatively high acceptance level for mine operations in locations such as these.
- There are no neighbours that will be affected by the project.

Low and Moderate Compliance

A number of aspects of the project result in low or moderate compliance, as follows:

- Initial plans for the mine indicate that the deeply incised and enclosed Gully 2 on the eastern side Mesa A may be affected if buffers are inadequate. This type of gully is uncommon in the Robe River Pisolite deposits in the region. The latest mine plan now includes a buffer and exclusion zone to protect these features.
- Mesa A forms part of the Robe River Pisolite deposits that, as a group, have scientific and historic value. Removal of key features of the mesa will reduce these values.
- The changes to landscape character will be identified from the proposed overpass and to a lesser extent, other locations on the North West Coastal Highway and will be perceived as substantial changes. The waste rock dumps will be the most obvious, especially those proposed for the western and southern sides of Mesa A. The pit faces, have a lower visual magnitude but their scale is likely to be perceived by observers.
- The landscape significance of the Gully 2 (see Map 3) may be affected is buffers are inadequate. The combination of significant features found in the gully is uncommon in the Robe River Pisolite deposits in the region.
- The landscape significance of the other two gullies (Gully 1 and 3 (see Map 3)) at Mesa A may also be affected is buffers are inadequate. The latest mine plan now includes a buffer to protect these features.The significant features found in these gullies occur in other gullies in the Robe River Pisolite deposits in the region.
- Removal of parts of the escarpment may affect social/cultural values if major feature such as caves and overhangs cannot be avoided (Initial plans show that the effect will be minimised).

Part Seven - Recommendations and Modifications

As highlighted in Part 6, a number of aspects of the project have a substantial effect on geodiversity and landscape values. In all these cases it will be possible to control the operation so that these effects are reduced and compliance with objectives is improved. The following recommendations will help ensue these outcomes:

Protection of Gullies

1. The exclusion zone around Gully 2 (see Map 3) should protect the significant landscape features as mapped (see Map3) and should provide an adequate visual setting and meaningful catchment for the gully. It is recommended that the buffer include the gully to where it merges with the plateau, including the watercourse above the waterfall on the northern branch of the gully. This should include obvious side slopes leading into the gully. As a guide, the buffer to the side of the gully wall (or where the wall ends, the drainage line) should be a minimum of 50m, and this should extend to a minimum distance above the waterfall of 150m (The latest mine plan now includes a buffer and exclusion zone to protect these features).
2. The exclusion zone around Gully 1 (see Map 3) should include the significant landscape features as mapped (see Map3) and should include the deeply incised parts of the gullies to near where they merge with the mesa plateau
3. A 50m exclusion zone should be provided around Gully 3 to protect the significant landscape features (see Map 3) (The latest mine plan now includes a 50m buffer to protect these features).

Protection of the Escarpment

4. Backfilling near the northern and western escarpments should result in a plausible resemblance to a naturally occurring, linear mesa form. It is recommended that any rock backfill be kept away from the pit side of the retained mesa, creating an abrupt face. Where this is not possible, any rock backfill should be stacked to the height of the mesa tip and should be surface treated to resemble pre-mine conditions. As a guide, it is recommended that, if backfill is used, the remaining mesa top be a minimum of 100m. The south-eastern escarpment should also be protected, adjacent to the Gullies 2 and 3 (as detailed above), as well as between these gullies.

Protection of the Sand Sheet and Related Ecology

5. Operations should be excluded from the sand sheet as far as practicable. Measures to protect the adjacent escarpment should also help protect the sand sheet. Bunds should be used to divert possible runoff from the operations areas.

Minimising Changes to Landscape Character

6. Waste dumps and topsoil dumps should be located as far as practicable away from the North West Coastal Highway. Dumps should be consolidated into one large dump rather than two or more smaller ones, creating large, low landforms similar to those occurring naturally. The fill batters of these dumps should be a maximum slope of 50 percent, the shoulders should be rounded, and the boundaries and profile should be curvilinear.
7. The profile of bunds visible from the North West Coastal Highway (eg. the bund around the south-western end of Mesa A) should be kept as small as practicable.
8. Works and other disturbances should be minimised in the close foreground distance zone of the North West Coastal Highway and should ideally be

restricted to the mine road, the haul road and the highway re-alignment. Any fencing required should also be set back from the highway with a suggested minimum setback of 100m if possible (away from the haul road).

9. If lighting is required in areas visible from the highway, shielded or directional lighting (rather than omni-directional lighting) should be used where possible.

Tourist Interpretation/Observation Area

10. A roadside interpretation area should be built prior to the commencement of works that will be visible from the NW Coastal Highway. This should create better awareness and understanding of the project and the changes that it will bring. MRWA will need to be consulted.
    A strategy should also be developed that will address tourist interest in the project. This should include safety, control of access, and the desire to view the pit area.

Part Eight - Conclusion

This report documents the landscape and geodiversity assessment and related evaluation of the proposed Mesa A-Warramboo mine proposal located approximately 43km west of Pannawonica, adjacent to the North West Coastal Highway. The proposal includes two mine pits (one at Mesa A, one at Warramboo) and related development, such as roads, a crusher/loader plant area, waste and top soil dumps, bunds, and fencing adjacent to the highway.

The study finds that a range of geodiversity and landscape values exist in the area and in some case these will be affected by the project, as follows:

- The deeply incised and enclosed nature of Gully 2 at Mesa A has landscape significance and is uncommon in the Robe River Pisolite deposits in the region. The mine plan indicates that the escarpment and deeply incised and enclosed parts of this gully will be retained but the upper reaches of the watercourses will be affected.
- The sand sheet and associated vegetation on the eastern side of Mesa A have ecological significance and there is the potential for mine components to have a substantial effect on these.
- Mesa A forms part of the Robe River Pisolite deposits that, as a group, have scientific and historic value. Removal of key features of the mesa will reduce these values.
- There will be changes to landscape character that will be identified from the North West Coastal Highway and these will be perceived as substantial changes.
- The landscape significance of Gullies 1 and 3 will be reduced with the removal of the setting beyond the escarpment. The significant features found in these gullies occur in other gullies in the Robe River Pisolite deposits in the region.
- Removal of parts of the escarpment may affect social/cultural values if major feature such as caves and overhangs cannot be avoided (Initial plans show that the effect will be minimised).

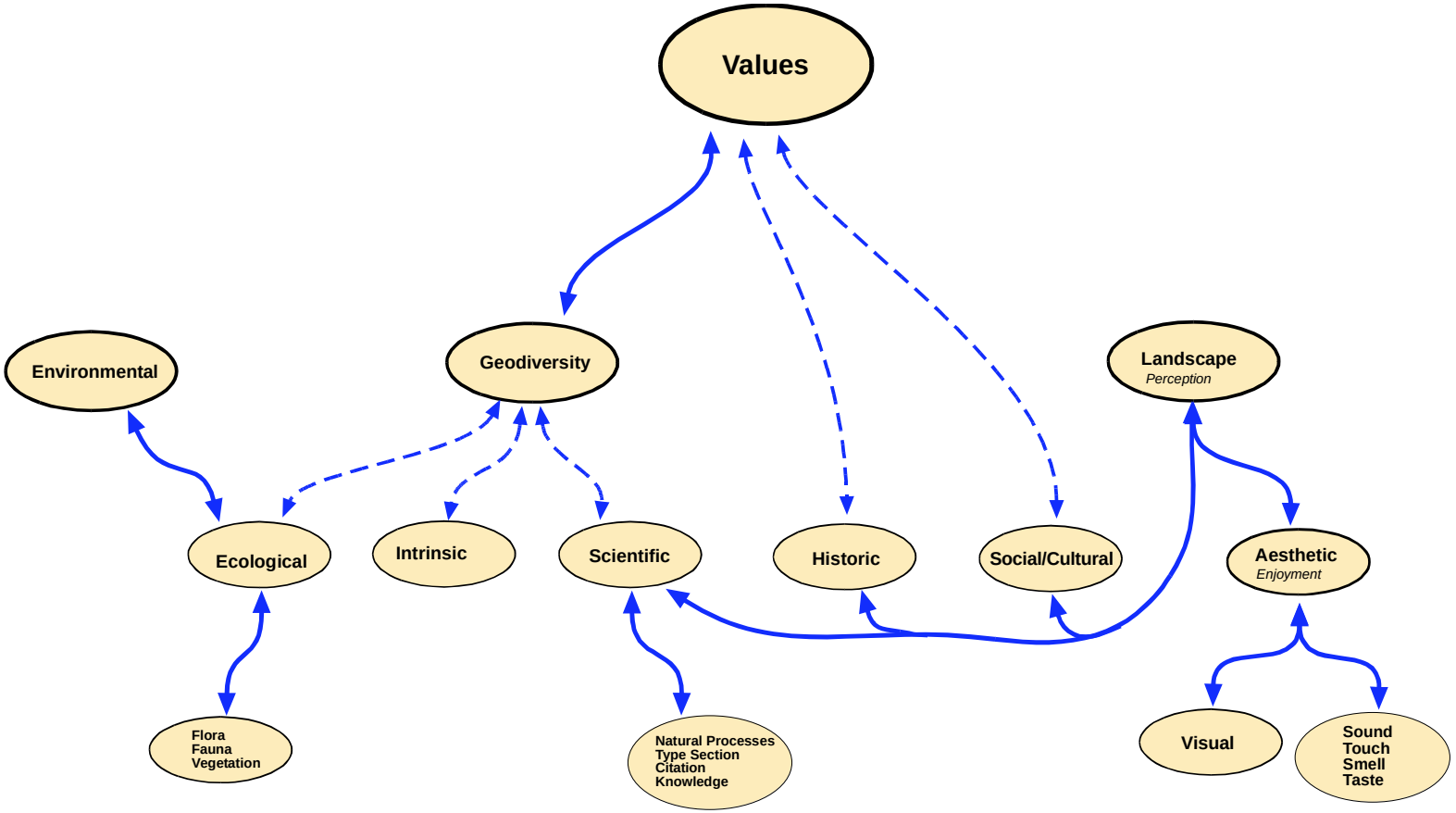
A number of modifications have been recommended to control the operation so that these effects are reduced and compliance with objectives is improved. These objectives and associated modifications are as follows (summarised):

- protecting much of the escarpment of Mesa A by improving the exclusion buffer around the escarpment;
- protecting the three main gullies on Mesa A by creating or improving the exclusion buffer around these gullies;
- protecting the sand sheet and associated vegetation by creating or improving the exclusion buffer around this area;
- minimising change to landscape character near the NW Coastal Highway by minimising works other then essential access roads and by keeping bunds and waste dumps distant and as natural looking as possible;
- facilitating awareness and understanding amongst tourists about the changes created by the project by creating an interpretative facility adjacent to the NW Coastal Highway.

The recommendations have either been included in the latest mine plan (eg. protection of the gullies) or are currently being considered.

Appendices

Appendix 1 – Types of Values



Appendix 2 – Data Sources for the Assessment of Aesthetic Values

(Adapted from Cleary *et al* 1999)

		Data									
		Lists								Assessment	
		World Heritage List	Register of National Estate	Register of Heritage Places	Municipal Inventory	Classification List	Register of Aboriginal Sites	Maritime Archaeology Databases	State Natural Resource and Parks Management Agencies	State Natural Resource and Parks Management Agencies	Other
		UNESCO WH Committee (Nomination doc.)	Australian Heritage Commission	State Heritage Councils	State Heritage Councils, LGAs.	National Trust	Aboriginal/Indigenous Affairs Dept.s	Maritime Museums	Various informal, in documents		
Significance Sub-theme	Natural										
	Natural Aesthetic										
	Cultural – Historic										
	Cultural – Social (Non Aboriginal)										
	Aboriginal										
	Maritime (Historic)										
	Scientific										

Appendix 3 - Sensitivity Level Criteria

The sensitivity levels of travel routes and use areas are an indication of the importance of those routes to the experience of people and are established on the volume of people using the area and an understanding of their preferences. The criteria for classification of sensitivity levels are summarised in the following table.

Classification	Type of Use - Existing or Formally Proposed		
	Non-recreation use rural and forest roads	**Recreation and tourism**	**Settlement**
Level 1 High Sensitivity	National & State highways. Links between cities and major towns.	Designated tourist roads. Major recreation sites recognised formally or informally at a national or state level, including walking tracks and lookouts. Primary access to these recreation sites or multiple level 2 use areas. Travel routes or sites through or adjacent to scenic or historic areas with recognised or assessed values of national or state importance.	Places with recognised or assessed scenic or historic values of national or state importance.
Level 2 Moderate Sensitivity	Main link roads between towns and highways.	Important but undesignated tourist and recreation roads. Recreation sites of regional importance, including walking tracks and lookouts. Primary access to these recreation sites or multiple level 3 use areas. Travel routes or sites through or adjacent to scenic or historic areas with recognised or assessed values of regional importance.	Places developed to capitalise on views or attractions. Neighbours close to proposed development.
Level 3 Low Sensitivity	Minor link roads.	Local recreation use.	Residential areas other than Level 1 or 2.
Level 4 Very Low Sensitivity	Roads receiving local non-recreation use.	-	Industrial areas.

Appendix 4 - View Data Variables

The following variables were used to record and assess views:

Location	location along the access route (lat/long);
Direction of view	Angle between the centreline of view and the centreline of the road (degrees);
Angle of view	field of vision (degrees);
Filtering	heavy filtered, light filtered, open;
Vegetation height	metres;
Distance to blocked view	metres;
Cause of blocked view	vegetation, landform;
Visibility of development	visible, non-visible;
Duration of view	ongoing, spot;
Viewer position	elevation difference between viewer and subject (superior, normal, inferior)
Vegetation type	species;
Photographic record	film frame numbers;
Subject of view	landmark focus, significant feature, natural landscape character;
Access characteristics	type of use, travel mode, recreation use, volume.

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