updated screening and rehabilitation program

Red Hill Quarry

March 2007

PURPOSE OF THIS DOCUMENT

This Management Plan is prepared in response to Ministerial Statement 705 issued by the Minister for Environment; Science as a Section 46 Environmental Protection Act 1986 Statement in relation to the relocation of the Herne Hill operation; issued 21 December 2005.

See Section 1.0 for a copy of Ministerial Statement 705.

Ministerial Statement 705 *modifies Ministerial Statement 199, Assessment Number 354, (EPA Bulletin 510)* issued on 4 December 1991, in response to the preparation of the Public Environmental Review.

A number of Rehabilitation Plans have been prepared for the operations and this report seeks to update those reports and combine them into one document.

Rehabilitation is a key aspect of the process of quarrying to minimise any impacts associated with excavation in the longer term and is the responsibility of Hanson.

Rehabilitation is conditioned in the various approvals.

CONTENTS

PURPOSE OF THIS DOCUMENT

FIGURES

APPENDICIES

1.0 BACKGROUND

The Red Hill quarry lies within an area of the Darling Scarp covered by remnant vegetation that provides a buffer for the quarry. The quarry and associated infrastructure lie on the southern side of Susannah Brook, extending to Toodyay Road.

The Red Hill Quarry was opened and brought into production in 1996. This involved clearing for both the quarry site and the infrastructure associated with the quarry. In the early years the only land available to be restored was the batters and bunds surrounding the development areas. These were landscaped and revegetated as part of the landscaping of the site.

The quarry is located on land held by Hanson that had comprised 1,035 hectares, however during 2003 a portion of the land in the north western corner was sold to the Government for inclusion in the Darling Range Regional Park, leaving approximately 800 hectares owned by the Company.

Of the 800 hectares held by Hanson, only approximately 40 hectares has been currently cleared for the Red Hill Quarry. Almost all the site is indigenous vegetation in good condition and currently the plan is to leave it that way to act as a buffer for the Red Hill Quarry.

Over time the amount of disturbed land will increase to approximately 180 hectares, but not all this will be open as rehabilitation will progressively follow excavation and a substantial proportion of the 180 hectares is planned to be rehabilitated at that time.

A vegetation study (1989) was completed as part of the Public Environmental Review (1990) for the Red Hill Quarry which identified the local indigenous flora. As this was some time ago an updated vegetation study of the area immediately to be cleared was conducted in April 2006 to provide additional information about the pre-excavation indigenous vegetation. See Appendix 2. The vegetation study, which is still in progress is being extended over a wider area in spring 2006.

Re-establishment of the local flora was deemed a key principle in the rehabilitation to be used on site and this was picked up in the Rehabilitation Plan developed and approved for the Red Hill Quarry in 1996.

Since 1996 nearly 45 000 tube plants have been planted at the Red Hill site in addition to over 100 kg native seed (25 kg in 1997 alone). This included a further 4 000 tube plants in 2002.

2.0 REGULATORY FRAMEWORK

A number of commitments and conditions were made as a result of the Public Environmental Review Process and resulted in *Ministerial Statement 199, Assessment Number 354, (EPA Bulletin 510)* issued on 4 December 1991.

Conditions relating to rehabilitation and visual management are relevant to this report

To these conditions have been added conditions of the Department of Environment and Conservation Licence 4414/10. No conditions of the Licence relate to rehabilitation or visual management.

The quarry has Planning Consent issued by the Western Australian Planning Commission under the Metropolitan Region Scheme.

Planning Consent was obtained from the Western Australian Planning Commission for a period of 5 years from 17 November 2004. An Extractive Industries Licence was subsequently issued by the City of Swan for a period of five years. The DOE assessed and provided input to the decision making process.

Both Ministerial statement and Department of Environment and Conservation Licence 4414/10 are issued under the *Environmental Protection Act 1986* which overrules all other legislation. Therefore if there is a conflict in the conditions applying to the site those issued under the *Environmental Protection Act 1986* will prevail.

The Ministerial Conditions relating to rehabilitation and visual management that are still current from the 1991 Ministerial Statement are listed below.

Ministerial Statement 199, Assessment Number 354, (EPA Bulletin 510).

Condition 4

4-1 Within twelve months of the date on this statement, the proponent shall prepare detailed plans for the ongoing rehabilitation of Pioneer No 1 and Pioneer No 2 quarries. These plans shall be to the satisfaction of the Environmental Protection Authority on advice from the Shire of Swan.

4-2 Subsequent to Condition 4-1, the proponent shall implement the approval plans, and updates as required by Condition4-3, to the satisfaction of the Environmental Protection Authority on advice of the Shire of Swan.

4-3 Subsequent to Conditions 4-1 and 4-2, the proponent shall review the rehabilitation plans annually for the first two years and thereafter at five yearly intervals. The reviews shall be to the satisfaction of the Environmental Protection Authority on advice from the Shire of Swan.

Commitments

8 Site clearance and vegetation removal will be minimised by survey control and supervision of personnel engaged in clearing activities.

9 All vehicles entering the site from regions identified as potentially contaminated with dieback disease will be thoroughly washed to remove adhering soil and weed seeds. All fill or soil used on the site will be obtained from uncontaminated sources. Procedures for preventing its introduction will follow those laid down by CALM Dieback Manual.

11 Fire prevention measures as per relevant Shire and Brigade regulations will be enforced within the project area and on the rest of Pioneer's land holding.

12 Unauthorised vehicular access to the Pioneer landholding will not be permitted and the current practice of using security guards to patrol the area will be continued.

13 Pioneer will monitor the vegetation on its property to detect any outbreaks of dieback disease. If any is detected, Pioneer will consult with the Department of Conservation and Land management to determine a suitable treatment strategy.

Ministerial Statement 705 as a Section 46 *Environmental Protection Act 1986*

On 21 December 2005 the Minister for Environment; Science issued Ministerial Statement 705 as a Section 46 *Environmental Protection Act 1986* statement in relation to the relocation of the Herne Hill operation; issued 21 December 2005.

This statement is reprinted on the following three pages in its entirety to provide greater explanation of the intent;

MINISTER FOR THE ENVIRONMENT; SCIENCE

Statement No.
000705

Section 46
Environmental Protection Act 1986

STATEMENT TO AMEND CONDITIONS APPLYING TO A PROPOSAL

RELOCATION OF HERNE HILL QUARRY OPERATION

Proposal: The quarrying of hard rock by blasting and/or excavation by wheeled loader, now located at Lot 11 Toodyay Road, Red Hill, City of Swan.

Quarried rock is transferred to an onsite crushing and screening plant where it is converted into various products required in the construction of buildings, roads, railways and other infrastructure.

Proponent: Hanson Construction Materials Pty Ltd

Proponent Address: 123 Burswood Road, Victoria Park WA 6100

Assessment Number: 1511

Previous Assessment Number: 354

Previous Statement Number: 199 (published on 5 December 1991)

Report of the Environmental Protection Authority: Bulletin 1152

Previous Report of the Environmental Protection Authority: Bulletin 510

The implementation of the of the proposal to which the above reports of the Environmental Protection Authority relate is subject to the conditions and procedures contained in Ministerial Statement No. 199 (5 December 1991), as amended by the following:

1. **Condition 1 replaced**

Condition 1 of Statement No. 199 is deleted and the following condition is inserted:

"1 **Proponent Commitments**

1-1 The proponent shall implement the environmental management commitments attached to Statement No. 199, except commitments numbers 10, 14, 16, 17, 22, 26, 32 and 33, to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority.

Published on
21 DEC 2005

1-2 The proponent shall implement the environmental management commitments included in schedule A to this statement, to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority."

2. Condition 4 amended

Condition 4 of Ministerial Statement 199 is amended as follows –

(1) Amend the title of the condition to "Screening and Rehabilitation"

(2) In condition 4-1 –

(a) delete "and Pioneer No.2 quarries" and insert "quarry"; and

(b) delete "Shire" and insert "City".

(3) In condition 4-2, delete "Shire" and insert "City".

(4) In condition 4-3, delete "Shire" and insert "City".

(5) After condition 4-3, insert the following –

"4-4 (a) Within 12 months of a notice being issued under section 45(7) of the *Environmental Protection Act 1986* in respect to Statement No.705, the proponent shall prepare a Screening and Rehabilitation Plan for all disturbed areas at Pioneer No. 2 quarry to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority.

(b) The objective of this Plan is to ensure that rehabilitation of the Pioneer No.2 quarry achieves a stable and functioning landform which is consistent with the surrounding landscape and which minimises visual impacts of the quarry operations on other land.

(c) The Plan shall:

1. identify land within a 5 kilometre radius of the Pioneer No.2 quarry from which the operations are visible;

2. detail the rehabilitation practices to be implemented over the life of the operations (which must include planting of indigenous vegetation) for all disturbed areas, including stockpiles, overburden dumps and quarry pits;

3. specify the short and long term measures to be taken to address visual impacts from the operations, particularly for land identified in subparagraph (1); and

4. include time frames for the implementation and completion of all screening and rehabilitation measures.

4-5 The Screening and Rehabilitation Plan referred to in condition 4-4 is to be prepared in consultation with owners and occupiers of the land referred to in condition 4-4(c)(1).

4-6 The proponent shall implement the Screening and Rehabilitation Plan referred to in condition 4-4 in accordance with the timeframes specified therein.

4-7 (a) The proponent shall report to the Minister for the Environment on the compliance with the Screening and Rehabilitation Plan referred to in condition 4-4 every two years, commencing 31 December 2007.

(b) The compliance report is to be prepared by a consultant approved by the Minister for the Environment.

(c) The compliance report is to be provided to owners and occupiers of land referred to in condition 4-4(c)(1).

4-8 The proponent is to review the Screening and Rehabilitation Plan referred to in condition 4-4 annually in consultation with owners and occupiers of land referred to in condition 4-4(c)(1) to the requirements of the Minister for the Environment.

4-9 The proponent shall make the Screening and Rehabilitation Plan required by condition 4-4 and any subsequent updates made under condition 4-8 publicly available, to the requirements of the Minister for the Environment."

3. **Schedule A inserted**

Ministerial Statement 199 is amended by inserting Schedule A.

Dr Judy Edwards MLA
MINISTER FOR THE ENVIRONMENT; SCIENCE

21 DEC 2005

Environmental Protection Act 1986 Section 45C

In 2006, Hanson sort approval for a 5.6 ha extension to the Red Hill Quarry pit under section 45C of the *Environmental Protection Act 1986*. Approval for the extension was granted by the Minister for the Environment on 22 September 2006.

Proposed Red Hill Quarry development

In February 2007, Hanson referred to the Environmental Protection Authority a proposal to continue to develop the Red Hill Quarry to the north and north-west of the existing pit. This proposal will increase the disturbance footprint of the operation by around 80 ha and will be subject to formal assessment under Part IV of the *Environmental Protection Act 1986*.

3.0 EXISTING REHABILITATION

Rehabilitation plans have been prepared for the Red Hill Quarry and Herne Hill Quarry as part of ongoing management of environmental issues associated with opening the Red Hill Quarry in 1996 and the placing of the Herne Hill Quarry into "care and maintenance" pending decisions on its future use.

Rehabilitation has always been a major part of the excavation and quarrying effort and this led to the rehabilitation at the Herne Hill Quarry site being awarded the Greening Australia Award for rehabilitation in 1992.

This report also contains summaries of the assessments of the success of the rehabilitation program conducted in 2002 and 2006, attached as Appendix 1.

The Red Hill Quarry was opened and brought into production in 1998. In the early years the only land available to be restored was the batters and bunds surrounding the development areas. These were landscaped and revegetated as part of the landscaping of the site.

The sites rehabilitated during construction in 1996 and 1997 included the batters of the dams, around the site office, access roads, stockpiles and entrance statement. Since 1996/1997 revegetation has concentrated on infill planting and revegetation of the rear of completed benches and extension of the batter slopes to the south of the stockpile areas and an overburden dump.

A number of studies have been undertaken and documents prepared relating to rehabilitation of the Red Hill Quarry.

These are;

YEAR	REPORT	COMMENT
1990	Public Environmental Review - Herne Hill Quarry Relocation	Advertised and accepted by EPA
1991	Relocation of Herne Hill Quarry operation, EPA Bulletin 510	Published by EPA
1996	Rehabilitation Plan – Environmental Management Red Hill Quarry Site	Approved by DEC and EPA in 1996
1996	Visual management Plan Red Hill Quarry Site	Approved by DEC and EPA in 1996
1995 -1996	Annual Environmental Summary Report Pioneer Quarries Herne Hill – Red Hill	Submitted to DEC and City of Swan
1997	Rehabilitation Plan for the Decommissioning of Herne Hill Quarry Site	Approved by DEC and EPA in 1996
1997 - 1998	Annual Environmental Summary Report – Red Hill Quarry	Submitted to DEC and City of Swan
1999	Visual Resource Assessment and Landscape Management Plan, prepared by Thompson - Palmer	Submitted to DEC and City of Swan
1999	Annual Environmental Summary Report – Red Hill Quarry	Submitted to DEC and City of Swan
2000	Annual Environmental Summary Report – Red Hill Quarry	Submitted to DEC and City of Swan
2000	Visual management, Proposed Extension - Red Hill Quarry (included in 2000 Annual Summary Report)	Submitted to DEC and City of Swan
2001	Annual Environmental Summary Report – Red Hill Quarry	Submitted to DEC and City of Swan

2002	Annual Environmental Summary Report – Red Hill Quarry	Submitted to DEC and City of Swan
2002	Overview of rehabilitation completed in 1996/1997	Submitted to DEC and City of Swan
2003	Annual Environmental Summary Report – Red Hill Quarry	Submitted to DEC and City of Swan
2004	"Excavation and Rehabilitation Management Plan, Lot 11 Toodyay Road, Red Hill",	Submitted to City of Swan and WAPC, reviewed by DEC.
2004	Overburden Dump Management Plan	Submitted to DEC and City of Swan
2004	Annual Environmental Summary Report – Red Hill Quarry	Submitted to DEC and City of Swan
2005	Annual Environmental Summary Report – Red Hill Quarry	Submitted to DEC and City of Swan
2006	Flora and vegetation Survey of the Proposed Clearing for Red Hill Quarry - Hanson	Submitted to EPA
2006	Changes to Proposal for Assessment under S45C Approval Process,	Submitted to EPA and Minister for Environment
2006	Annual Environmental Summary Report – Red Hill Quarry	In preparation

Table 1 Reports on rehabilitation

4.0 VISUAL AMENITY

The Red Hill site lies behind the Darling Scarp on the southern side of Susannah Brook valley. The site was chosen because the pit is almost completely hidden from the Swan Coastal Plain. The green painted processing plant can be seen in the distance from some parts of the Swan Coastal Plain.

Most areas of close range visibility lie either on land held by Hanson or adjoining land held by Midland Brick Co Pty Ltd which is currently used for clay extraction and is an approved hard rock quarry site.

Longer range visibility of the site can be glimpsed from the top of the plateau on the northern side of Susannah Brook where subdivision has occurred. While the land identified as potentially able to be seen is much wider, in reality the actual area from which the pit can be seen is much smaller because of intervening remnant vegetation, planted trees, and the landform. See Figures 2 to 4. Almost all this land is rural land or resource zoned land as shown on Figure 4.

The number of dwellings from which the pit can be seen is relatively small, although it is possible that additional dwellings may have glimpses of the pit as the quarry footprint progresses to the west. See Figure 2.

Trees and local vegetation, combined with local developments, can obscure the quarry. The main areas of potential visibility have been determined from basic visual assessment. These are shown in Figure 2. In Figure 2 no distinction is made of which parts of the site are visible. For example in some locations bare quarry face may be glimpsed whereas in other locations only rehabilitation may be seen.

However only the processing area or rehabilitated bunds are potentially seen from south of Toodyay Road. The pit cannot be seen from that location

Parts of the quarry are visible from the southern end of Daniel Place, the northern end of Joshua Mews and possibly a small section of Weir Road in Baskerville. In most cases the pit is only visible where trees have been removed, or, in the case of Daniel Place, glimpses from dwellings between the trees. There are two or three dwellings in Joshua Mews from which the quarry may be visible as the pit can be seen from a small section of the road reserve in the north. See Figures 2 and 5.

The pit can also be viewed from some rural land to the north east that contains several dwellings. Further away on the rural land it appears that remnant vegetation, landform and planted trees prevent the quarry from being seen, or minimise the view. See Figures 2 and 5.

The rehabilitated stockpile area is visible from a small section of Toodyay Road, and the green painted top of the processing plant is visible from a wider area including parts of the nearby Swan Coastal Plain. See Figure 2.

4.1 What is the status of land from which the quarry can be seen?

The largest proportion of land from which the quarry can be seen is owned by Hanson. The adjoining land to the east is held by Midland Brick Co Pty Ltd and is itself subject to use as an Extractive Industry site.

The land in Baskerville on which most dwellings lie is zoned “Rural” with “Additional Uses” It is also zoned as “Landscape”. See Figure 4.

Land to the east where there are scattered dwellings is zoned “Rural” / “Landscape Resource”.

The quarry area and adjoining land owned by Midland Brick is zoned “Rural” and “Resource” to provide for continued rural land uses as well as protecting the extraction of basic raw materials.

The land in Daniel Place and Weir Road, Baskerville is covered by the Millendon/Brigadoon Locality of the Darling Range Regional Park proposal, (Darling Range Regional Park, Ministry for Planning, October 1995). This land has been classified as having high landscape protection and it is thus unlikely that any of this land will be permitted to be further subdivided. The land in Joshua Mews is not covered by the Darling Range Regional Park and this land provides restricted views of the quarry , particularly if trees are not removed.

The Darling Range Regional Park proposal recognises that the land held by Hanson is required for basic raw materials. The Red Hill site is classified as Key Extraction Area 21/27 in Statement of Planning Policy 2.4 Basic Raw Materials.

4.2 How can the Landscape of the Area be Managed?

The landscape and local visual amenity is regarded as significant in a number of documents that are listed in the preceding section.

The main methods available to manage the local visual amenity are;

POSSIBLE MITIGATION	COMMENTS
Maintaining suitably large buffers.	• Hanson currently holds approximately 800 hectares of the surrounding land predominantly to the west and north. 235 hectares of buffer was sold to the Government for incorporation into the Darling Range Regional Park in 2003.
Locating and designing the quarry to minimise visual impact.	• The design of the pit takes into account, the nature of the resource and the local landscape. For example whilst it is possible to place the quarry on top of the ridge this may not be desirable because the ridge has very deep overburden which has to be removed to access the fresh rock. This would create a much larger pit and would result in a large amount of overburden that will have to be removed and itself is likely to become a temporary visual issue when a dump is formed. • Care is taken in the design process to not sterilise resources or create problems where rehabilitation has to be removed or major future earthworks required which in themselves may create an unacceptable visual issue.
Locating the quarry behind a ridge	• When working on a north facing slope there is limited landform to locate the quarry behind. • The quarry is visually well protected from Toodyay Road, for example, but less visually well protected from the north. • Locating the quarry on the northern side of Susannah Brook was less desirable because the quarry would have to be accessed from across Susannah Brook and the working faces would be much closer to the developed areas in Baskerville.
Working as an inside out operation from the floor or benches of the pit.	• The pit is always worked as an inside out operation, from the floor and internal benches. The only time that excavation works on the natural land surface is during land clearing which is addressed in Section 9.0 Rehabilitation Plan.
Working behind vegetated landscape bunds	• When working on a north facing slope it is often difficult to form a large enough bund to provide adequate screening to the north. The bund itself will form a temporary visual issue and there is limited landform to locate the quarry behind. • However, where possible, this is used and the current access road to the north west of the pit is constructed on a bund that provides visual protection to the lower benches of the quarry. • Bunds have been very successfully used to the south where a revegetated bund of 5 to 7 metres high has been constructed inside the property. This visually protects the processing area from Toodyay Road. See Figures 9A – 9D.

Rehabilitation of completed areas as soon as practicable.	• Rehabilitation has always been completed as soon as possible. • The methods of rehabilitation are discussed in 9.0 Rehabilitation. • Since 1996 nearly 45 000 tube plants have been planted at the Red Hill site in addition to over 100 kg native seed (25 kg in 1997 alone).
Rehabilitation of the upper rear quarry faces and overburden faces	• The upper rear quarry faces have been completed as soon as possible and rehabilitated by placing overburden on the benches and planting trees. See Figures 6 - 8and section 9.0 Rehabilitation.
Painting of infrastructure.	• All infrastructure is painted dark green too reduce reflections and better match the surrounding landscape.
Planting screening trees.	• Trees have been planted wherever possible. • However there are limitations in that there are only four local tree species on site and there is frequently very shallow soil that will not support trees. The site is naturally covered by shrubs and not trees because of the shallow rocky nature of the soils. Therefore to plant screening rows of trees on the site in natural soils is not possible. Any trees used may also interrupt the natural ecosystems, particularly if non local species are used. • It is possible to plant local trees along the boundaries of Hanson land such as near Daniel Place. However some of the four local species of trees are restricted in their growth rates in shallow clayey soils (*Eucalyptus wandoo* and *E. marginata*). The location of a row of trees along a boundary adjoining a dwelling may not be acceptable to a landholder because it may disrupt the view and increase the fire hazard. Therefore this option has not been used, but it is possible.
Use of curved access roads	• The access road from Toodyay Road has been curved to prevent a straight line of site into the crushing and processing area. • Other roads and features are located and designed to minimise visual impact. See Figures 9A – 9D.

Most of the above measures have been used. However at times compromises must be made. For example the quarry can only be located where there is suitable resources of stone. The landform is out of the control of Hanson and whilst all efforts are made to use natural screening there are times when the pit may be visible from a particular location due to lack of full protection by the natural landform.

All methods are constantly under review will be used as appropriate.

Visually sympathetic design of the pit, followed by a comprehensive Rehabilitation Program, has always been used and remains the best option for visual management both in the short and long term.

All land disturbed by the construction process, which is not immediately required, will be revegetated using techniques outlined in 9.0 Rehabilitation.

An assessment of the success of the past rehabilitation is attached as Appendix 1.

5.0 PHYSICAL AND BIOLOGICAL ATTRIBUTES OF THE SITE

5.1 PHYSICAL ENVIRONMENT

5.1.1 Geology and Geomorphology

The quarry lies on the dissected edge of the Darling Plateau, approximately 1 km from the brow of the plateau. The excavation and processing area is located on a north facing slope, dropping from 260 m AHD adjacent to Toodyay Road down to 100 m AHD in the base of the valley of Susannah Brook.

Elevation of the surface in the vicinity of the quarry varies from 280 m AHD in the south and east dropping to just under 255 m AHD in the north west.

The area is underlain at depth by granite associated with the Western Gneiss Terrain of Archaean age that has been intruded by a series of generally north striking dolerite/diorite dykes. These dykes have been dated in other localities at about 660 million years old.

It is possible that the valley of Susannah Brook is located on a small east west trending cross fault. Any faulting will have locally influenced the strength of the rock and resulted in the ability of the Brook to cut down into the edge of the Darling Scarp.

The granite and dolerite have been subjected to intense and deep weathering since the mid to late Tertiary leading to widespread laterite development which sheets the site as gravel and duricrust. The deeply weathered soil profile remains as a mantle on the upper slopes in the south where it is up to 30 metres thick. The laterite soil profile drapes the valley slope, indicating its development on a partially dissected landscape.

The soil profile is typical of the Darling Scarp and consists of a shallow layer of yellow brown laterite gravel, overlying a laterite duricrust up to 1 metre thick above a pale gibbsite rich zone and a pale to mottled thick kaolin rich clay subsoil that caps saprolite and saprock (weathered rock) and weathered rock.

The down cutting of Susannah Brook has removed the thick soil profile on the valley slopes, cutting down to outcrops of fresh or partially weathered granite. The slopes with scattered granite basement outcrop have been identified as the key resource area because of the reduced covering of soil.

5.1.2 Soils

On the granite resources the soils vary from 1 – 4 metres, increasing in more weathered areas and up slope under the laterite profile. Soils are commonly pale yellow loams and sandy loams on weathered granite with red brown loam on weathered dolerite dykes.

A thin dark brown to grey brown sandy loam and loam topsoil covers the sloping valley soils.

The subsoils are pale white and red brown mottled gibbsite and kaolin rich loams and clays.

The soils and weathered rock forms, the overburden, must be removed to provide access to the granite basement. These overburden materials are used to create screening bunds and to backfill completed parts of the pit as part of the rehabilitation and screening process.

The overburden therefore forms the main substrate for rehabilitation. The amount of overburden available depends on the thickness of the soil profile that is cleared. The topsoil is thin, making it difficult to separate from the overburden when clearing land. Topsoil is therefore available in only limited amounts for use in rehabilitation.

5.1.3 Climate

The climate of the area is classified as Mediterranean, with dry hot summers and cool wet winters.

The most comprehensive data is recorded at the Upper Swan Research Station but as this is 6 km to the west on the Swan Coastal Plain other data may be more relevant. Precipitation is recorded at Gidgegannup where the annual average is 921 mm, of which 79% falls in the five wettest months, May to September inclusive. Evaporation exceeds rainfall in all but the four wettest months.

Average maximum temperatures at Kalamunda reach 30.8 degrees Celsius for the hottest month, February, but fall to 15.4 degrees Celsius in July. The average minimum for the coldest month August is 7.8 degrees Celsius. Maximum temperatures in summer at the Red Hill Quarry may be a degree or two hotter than at Kalamunda, which is 16 km to the south

In summer wind blows from the east 70% of the time at 9.00 am and from the west/south west for 60% of the time at 3.00 pm. Summer wind speeds tend to be 6 to 10 km/hour at 9.00 am and between 11 and 20 km/hour at 3.00 pm.

The winter wind directions are more even, but there is a slight predominance from the east at 9.00 am and south west at 3.00 pm. The average speeds are between 1 to 10 km/hour.

Prior to commencement, and during the early years of the quarry development, Hanson undertook on site climate monitoring. This was discontinued after some years because the data collected provided no increase in knowledge compared to official meteorological weather stations. The most useful information relates to the weather conditions at the time of each blast and this continues to be recorded.

5.1.4 Hydrology

The pre-clearing soils on site are well drained because of their elevation, deep free draining weathered subsoils on the upper slopes and relatively steeply sloping form on the valley slope.

The vegetation and north facing slope which increases solar radiation contribute to evapotranspiration and a drying of the soils in summer.

The quarry site is characterised by three small intermittent watercourses that only flow in response to winter storm events. Susannah Brook flows most of the year although it dries up for several months in dry summers. Several small and

intermittent pools occur in Susannah Brook predominantly fed from inflow from the Brook but potentially have in some places small seepages from the adjoining valley sides.

Strelly Brook drains the southwestern portion of the Hanson landholding. This is outside any land surface or catchment that could be influenced by the westwards progress of the quarry.

5.2 BIODIVERSITY

5.2.1 Flora and Vegetation

A vegetation study (1989) was completed as part of the Public Environmental Review (1990) for the Red Hill Quarry, and identified the local indigenous flora. As this was some time ago an updated vegetation study was conducted in April 2006 to investigate the vegetation on the interim excavation area (approved through a Section 45C approval under the Environmental Protection Act 1986, in September 2006).

A further vegetation study is being conducted to provide additional information about the pre-excavation indigenous vegetation of the interim excavation area and the areas that may be disturbed by the long term development of the quarry. This study is not yet available

The 1989 vegetation study identified the following communities.

VEGETATION COMMUNITIES (Identified in earlier studies and currently under review)	**HABITAT AND SOIL**
Open Forest of Jarrah - Marri	Lateritic gravels of the ridge tops
Woodland of Wandoo - Marri	Deeper younger red clayey soils of the upper slopes and developed on dolerite dykes.
Low Woodland of Rock Sheoak	Skeletal soils associated with granite outcrops.
Open to closed Heath	Granite outcrops
Herblands or Lithic Complex	Granite outcrops
Rehabilitation Areas	Rehabilitation of old gravel and clay pits

Table 2 Vegetation communities identified in 1989.

In April 2006, Mattiske Consulting Pty Ltd was commissioned to define the botanical values and the condition of the vegetation of the proposed clearing area at Red Hill Quarry for Hanson. The first part of the survey was carried out in April 2006 on the interim excavation area. Additional studies were undertaken in spring 2006 and continue on the proposed long term development area. The results of the latest studies are not yet available. total of four site-vegetation types were defined and mapped for the survey area, shown in Figure 7 of the Flora report (Appendix 2). These vegetation types are a combination of Havel's (1975a and 1975b) site-vegetation types, for the Darling Ranges forest region. They were described by Mattiske 2006 as listed below. A plan showing the distribution of the vegetation types is included in the full Mattiske report attached as Appendix 2.

Vegetation Type H -

Woodland to Open Woodland of *Eucalyptus marginata* subsp. *thalassica* – *Corymbia calophylla* with scattered understorey, including *Dryandra lindleyana*, *Xanthorrhoea gracilis, Calothamnus sanguineus* and *Lepidosperma squamatum*.

This site-vegetation type occurs on low undulating sandier soils, although the soils can range from grey leached surface sands to sandy-gravels. This site-vegetation type occurs in other conservation areas, both within the eastern and northern parts of the Jarrah forest and as such is not restricted (Heddle et al. 1980b; Department of Conservation and Environment 1980; Department of Conservation and Land Management 1987).

Vegetation Type HG-

Woodland to Open Woodland of *Eucalyptus marginata* subsp. *thalassica* - *Corymbia calophylla* with low dense understorey, including *Dryandra armata* var. *armata, Hakea undulata, Hakea stenocarpa, Hakea trifurcata* and *Lepidosperma squamatum*.

This site-vegetation type occurs on low undulating sandy gravel to gravel soils over shallow soils. This site-vegetation type occurs in other conservation areas, both within the eastern and northern parts of the Jarrah forest and as such is not restricted (Heddle et al. 1980b; Department of Conservation and Environment 1980; Department of Conservation and Land Management 1987).

Vegetation Type MG-

Open Woodland of *Eucalyptus wandoo* subsp. *wandoo* and *Eucalyptus accedens* with dense understorey, including *Hakea incrassata, Allocasuarina humilis, Dryandra armata* var. *armata, Hakea undulata* and *Hakea trifurcata.*

This site-vegetation type occurs on the upper slopes of the undulating hills with clay-loams on shallow soils. This site-vegetation type occurs in other conservation areas, both within the eastern, western escarpment and northern parts of the Jarrah forest and as such is not restricted (Heddle et al. 1980b; Department of Conservation and Environment 1980; Department of Conservation and Land Management 1987).

Vegetation Type G-

Open to Closed Heath of Proteaceae - Myrtaceae species, including *Hakea incrassata, Hakea stenocarpa, Dryandra armata* var *armata, Hakea undulata, Melaleuca trichophylla*, *Calothamnus rupestris* (Priority 4), *Allocasuarina humilis* and *Hypocalymma angustifolium*.

This site-vegetation type occurs on the shallow soils on or surrounding outcrops on the upland and valley systems on the Darling Ranges. This type is restricted in distribution within the northern Jarrah forest, but is well represented in the conservation estate, e.g. near Mt Cooke and Mt Windsor

(Heddle et al. 1980b; Department of Conservation and Environment 1980; Department of Conservation and Land Management 1987).

Mattiske 2006 notes that the vegetation is dominated by specific herb and shrub species, which reflect the soils and moisture associated with granite outcrops on the Darling Ranges.

A total of 68 taxa (species, subspecies and varieties) from 22 families and 39 genera were recorded at the proposed clearing site. Three introduced (weed) species were recorded during the survey, none of which are listed by the Department of Agriculture and Food (2006) as a Declared Plant or a Pest Plant.

No Declared Rare species pursuant to Subsection 2 of Section 23F of the Wildlife Conservation Act (1950), and listed by the Department of Conservation and Land Management (2006a), were located during the survey.

No endangered or vulnerable taxa, pursuant to S179 of the Environmental Protection and Biodiversity Conservation Act (1999) were located during the survey.

One Priority species, *Calothamnus rupestris* (P4), as listed by the Department of Environment and Conservation (2006a) was located throughout the survey area. This species is known from 46 records at the State Herbarium and is relatively widespread on the granitic soils of the Darling Scarp and the northern Jarrah forest. This species has been used extensively in rehabilitation areas near the Darling Scarp and in gravel pits within the northern Jarrah forest.

Mattiske 2006 concluded that the vegetation communities were well represented within the conservation estate (both on the Darling Scarp and in the northern and eastern sections of the Darling Ranges). They also concluded that the proposed quarry developments would have minimal impact on the vegetation values within the southwest forest region.

Mattiske 2006 found the quarry to be located on the Darling Scarp Vegetation Complex as defined by Heddle et al. (1980) and updated by Mattiske and Havel (1998). This vegetation complex is restricted to the western fringes of the Darling Ranges and is less well represented in the conservation estate, with 7.86% represented in the formal and informal reserves, based on data in the Forest Management Plan (Conservation Commission 2004). See Mattiske 2006 for the full report and references. See Appendix 2.

Mattiske 2006 found the vegetation condition of the quarry footprint, including the interim extension, as varying from modified (rehabilitation areas) to excellent (remnant native vegetation).

No plant communities listed as threatened under *the Environmental Protection Biodiversity Conservation Act 1999* were located within the survey area. No plant communities listed as threatened ecological communities by the Department of Conservation and Land Management (2006d) were located within the survey area.

A species list for the site vegetation can be found in the Vegetation Survey, attached as Appendix 2.

It should also be noted that much of the vegetation of the ridge where the infrastructure, site office and stockpiles are located was already disturbed and degraded as a result of earlier gravel and clay excavation.

The species on these disturbed sites prior to construction were generally non local Eucalypts and *Acacias.* Some were eastern states varieties and out of character with the area. The remainder of the site, including the pit footprint, was indigenous vegetation from a range of the plant communities listed above.

5.2.2 Fauna

A fauna study was completed as part of the original research for the 1990 Public Environmental Review.

The fauna is currently being reassessed for the quarry area and a wider area to the west and north west covering the proposed future quarry development area.

The two fauna studies conducted in 1986 and 1990 revealed the presence of 46 bird species, 6 species of mammal, 12 species of amphibians and reptiles. To this was added the potential for other local species to be present taking the totals that could occur on site to 85 species of birds, 29 species of mammal and 54 species of amphibians and reptiles.

In 1986 and 1990 no Rare or Endangered fauna were recorded on site, although a number such as the Peregrine Falcon, Chuditch, Carpet Python and Dells Skink could possibly occur.

A fauna study is being conducted in 2006 – 2007 to update the original survey because of changed conservation status of some species and to determine what effects quarrying might have on the fauna. In addition some attention is being given to the short range invertebrates that might occur on site.

6.0 DEVELOPMENT OF THE REHABILITATION PLAN

The site was studied intensively during the *Public Environmental Review 1990* for the proposed Red Hill Quarry for all environmental and physical features and included the geology, soils, vegetation and fauna. Weather recording stations were established and the data had been collected for a number of years. Therefore there is good baseline information on the plant and animal communities of the Red Hill Site.

This baseline information will not be repeated in this rehabilitation management plan, but is currently being updated through a new vegetation study of the pre-excavation vegetation communities in 2006 by Mattiske Consulting.

A rehabilitation program was initially developed in the Public Environmental Review and updated into the 1997 Rehabilitation Management Plan which expanded the original program to show in greater detail the revegetation techniques that would be used in rehabilitation.

6.1 Aims of the Rehabilitation Listed in the 1990 PER can be Summarised as;

In the 1990 PER rehabilitation was treated in more general terms, but the aims can be summarised as;

- reducing the visual impact
- restoring soil and soil based organisms
- restoring vegetation cover
- reducing erosion
- restoring habitat for fauna
- reducing noise and dust arising from the quarry operation

In 1997 those aims were expanded to try and achieve a higher standard of rehabilitation in line with community expectations. This resulted in the 1997 Rehabilitation Plan.

Some of the methods described in the PER were not used. For example cover crops were not planted even as interim soil cover because of the risk of introducing weed problems. Rather the aim in the 1997 Rehabilitation Plan was to return each completed area to a self sustaining planting of local indigenous species suited to each microhabitat.

Whilst the aims of the original Rehabilitation Plan (1990) generally remained the same, the rehabilitation methods were expanded and slightly varied. These were summarised into the key directions, in the 1997 Rehabilitation Plan.

6.2 Key Directions to the Rehabilitation Program in the 1997 Rehabilitation Plan:

The 1997 Rehabilitation Plan expanded on the aims of the PER and developed the following key directions, which were to direct the rehabilitation program.

- *The use of local species to maximise the habitats available.*
- *The matching of the species to the microhabitat of each site.*
- *The use of the rarer species to increase their numbers and compensate for any that had to be cleared.*
- *The need to consider fauna habitats and use species that are capable of supplying nectar breeding sites and other resources.*
- *Vegetation should become self sustaining and maintenance free.*
- *Areas of rehabilitation should not add to the fire risk of the site.*
- *The provision of a weed management program.*
- *The use of a dieback prevention program.*
- *Raising the awareness of the work force to encourage "ownership of the program.*
- *Involvement of local people and groups.*
- *Establishment of a seed orchard of on site species.*
- *Rehabilitation must not compromise the safety of the site.*
- *Bushland conservation has a high priority.*

However, once site works and initial rehabilitation of non essential areas commenced it quickly became obvious that the protection of the visual landscape

was a very important focus, and significant rehabilitation effort was directed towards this goal.

The use of rehabilitation to manage visual issues was also included in the 1996 Visual Management Plan and was expanded upon in the 2000 *Visual Management – Proposed Quarry Extension, Red Hill Quarry 2000* that was included in the *Year 2000 Annual Environmental Summary Report.*

The 2000 Visual Management Plan, on page 5 of that report, added another key direction to the above list to improve the potential for better visual management

- *The use of fast growing local species in areas where visual management is a priority.*

A further Key Direction is added here to minimise the potential disruptions to fauna or genetic exchange that might be caused by the impacts of excavation and processing. For example a fauna corridor will be maintained and enhanced.

- *Vegetation linkages and fauna corridors will be maintained and enhanced where suitable situations exist or where the exchange of fauna may be restricted.*

6.3 Summary of the Rehabilitation to 2006

The key directions of the rehabilitation of the site, up to this point, are listed with a comment on each as described in the table below.

Rehabilitation through tube planting has been conducted during winter each year, generally June to August. The species used have been local provenance. Leguminous seed which has been scarified has often been spread in late summer.

In the ten years since opening the site, nearly 45 000 tube plants have been installed on site together with the direct return of topsoil and the addition of over 100 kg of local provenance seed.

	KEY DIRECTION	**COMMENT ON REHABILITATION**
1	Summary of rehabilitation in 2006	• No ground was ready for seeding or tube planting in 2006. This is the first year that no rehabilitation has taken place on site.
2	Rehabilitation should use local species to maintain the available habitats. (Red Hill and Herne Hill)	• Local provenance species continue to be used for rehabilitation. • Since 1996 a total of 44,884 tube plants have been planted at the Red Hill site in addition to over 100 kg of local provenance native seed. (29kg of seed was spread in 1997 alone). • Topsoil that has been stripped from ahead of excavation has been used in rehabilitation.

3	Species should be matched to the microhabitat	• When choosing species for rehabilitation, attempts are made to match the local vegetation. In visually sensitive areas the local species mix will be swayed towards achieving visual management rather than species richness. • In areas requiring quick visual coverage a greater number of faster growing taller species are used in the species mix.
4	Rarer species should be used to increase their numbers and compensate for any that have had to be cleared	• The majority of the species now chosen are the more common species, known to grow well in the soil conditions on site. In the past some less common species were chosen such as *Verticordia plumosa, Isopogon formosus, Melaleuca trichophylla, Anigozanthos humilis* and transplanted sedges.
5	Species that are capable of supplying nectar breeding sites, habitats and other resources should be used.	• A large number of the species used in rehabilitation provide food resources for fauna, particularly birds. For example the *Eucalyptus*, *Calothamnus, Melaleucas, Hakeas* and *Banksias*.
6	Vegetation should become self sustaining and maintenance free	• The leguminous component of the vegetation has grown rapidly and is providing cover and visual protection. Other species are growing more slowly and over time these will tend to become more prominent and self sustaining as they flower and produce woody fruit in which seeds are retained. If fire was to damage mature rehabilitation, stored woody fruit would open and the seeds released, as would occur under natural conditions. In addition the legumes such as *Acacia, Kennedia, Hardenbergia, Bossiaea* and the like will produce seeds that will drop to the ground and be buried by ants and will thus be available for germination following fire. • The assessment of the older vegetation showed that whilst some of the mature plants had died, opening up the vegetation, there has been good germination of several species such as *Calothamnus* spp and *Acacia* species such as *A. saligna.* These are self seeding, and lead to maintenance of a vegetation cover and self sustainability.

7	Areas of rehabilitation should not add to the fire risk of the site	• The rehabilitated areas are, in most cases, separated by roads which provide fire breaks, or are located on disturbed ground between roads/developments and the edge of the undisturbed vegetation. Whilst the taller *Acacias* will slightly increase the fire risk until the vegetation establishes, overall there will be little increase in fire risk over existing native vegetation. The increased access roads, acting as fire breaks, and presence of additional water sources, will all tend to reduce the fire risk.
8	A weed management program should be provided and implemented.	• Hanson maintains a weed management plan that includes a spraying program as necessary. • Watsonia was present in Susannah Brook for many years prior to commencement of siteworks, and there is little point addressing this species in isolation, except as part of a catchment program. • The potential for weed introductions through horse intrusions is of concern to Hanson but as horse numbers have dropped in the past few years, through greater vigilance and the change of ownership of nearby properties, the threat is reducing. • Hanson mechanically removes, destroys or sprays significant weeds when found at the Red Hill site.
9	Dieback management procedures should be developed and implemented.	• Hanson manages dieback in a way which is similar to the DEC (CALM) Dieback Hygiene Manual and restricts soil and vegetation material being brought to the site. • During normal operations the site runs as a split operation on bitumen and aggregate roads that would suggest a low risk of infection. • All vehicles used in stripping are cleaned during servicing at the workshop or prior to arriving at the site.
10	The awareness of the work force should be raised with respect to environmental matters, to encourage "ownership" of the rehabilitation	• The workforce is aware of the rehabilitation procedures through on site meetings and Hanson's Environmental Policy.

11	A seed orchard or access to local provenance species should be established.	• A seed orchard has not been established as it is seen as unnecessary nowadays when local provenance seed can be obtained from commercial sources. APACE are used for the supply of tube plants and they are able to supply local species as required. • When seed and plants are sourced for rehabilitation local provenance species are requested. Local provenance normally means northern Jarrah Forest in the Perth Hills. • Local species from the site are introduced from the use of topsoil, which is always collected separately and spread directly onto areas to be rehabilitated, wherever it is available. This ensures that species from the site are always included within the rehabilitation. • As a general principle, where visual screening is not the main aim, a structurally similar plant community using local flora species to adjoining existing native vegetation is used.
12	Rehabilitation must not compromise the safety of the site	• The rehabilitation has had little or no impact on safety. In visually critical areas such as near road junctions, trees have been deleted from the species to allow better sight lines.
13	Bushland conservation has a high priority	• With the exception of the land that had to be cleared to permit construction, the balance of the site remains as indigenous vegetation. Land to the north of Susannah Brook is currently maintained by Hanson as a private flora and fauna reserve. A parcel of land in the north western corner has been sold to the Government for inclusion into the Darling Range Regional Park. Currently approximately 800 hectares of native vegetation is retained by Hanson as buffers.
14	Local people and groups should be informed of the revegetation and involved as appropriate.	• APACE continues to be used to undertake the rehabilitation. Hanson has an "open door" policy to the Gidgegannup Progress Association, City of Swan and various Government authorities such as Department of Environment and Conservation, Environmental Protection Authority and Department of Industry and Resources. • Hanson has commenced assistance to the Gidgegannup Primary School in helping them establish a native garden area that will be used for schools visiting Gidgegannup. 500 native plants were supplied to the Gidgegannup Primary School in 2006 in addition to assistance with materials to establish the gardens. Further assistance is planned for ongoing years.

15	Fast growing local species should be used in areas where visual management is a priority.	• In recent years there has been a greater component of these species used in the more visual areas such as the rehabilitated top benches.

Table 3 Key directions in rehabilitation

7.0 SUCCESS OF THE CURRENT REHABILITATION PROGRAM

An overview of the rehabilitation was conducted in 2002. This consisted of examining rehabilitation undertaken during the 1996 – 1997 planting years. At that time a large number of species were used in the seed and tube plant mixes. However no data other than visual information had been gathered on the success of particular species.

As a result of the study the rehabilitation methods were changed slightly in terms of the species used. Less species have been used in recent rehabilitation, with the species being selected because of their fast growing ability, local provenance and known success.

Sample plots of $10m^2$ established in the 1996 – 1997 rehabilitation were counted to determine the species present, plant density and lateral and vertical coverage provided by the rehabilitation.

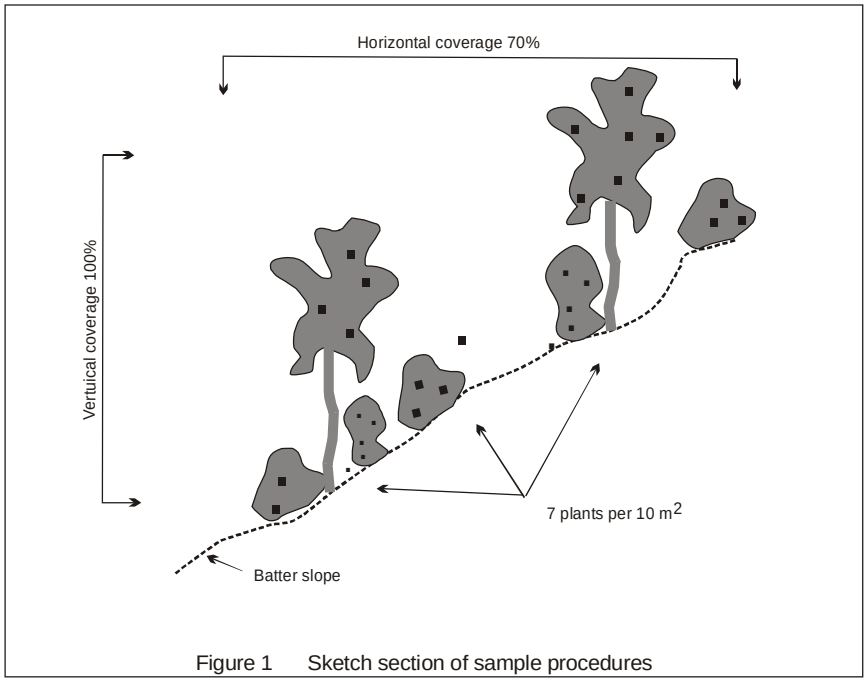


Figure 1 Sketch section of sample procedures

The average for all plots in the 1996 – 1997 rehabilitation was 7.95 plants per $10m^2$ which equates to 0.8 plants per m^2. The types of plant species are shrubs and trees and therefore the vegetation is providing significant and acceptable cover. When viewed from a distance it is not uncommon to glimpse small areas of soil through the trees and shrubs in natural communities, and this pattern is similar. Appendix 1.

When analysing the native plant communities, whilst the number of plants is much higher than 0.8 plants/m^2 the majority of the plants are small ground cover or ground hugging plants and herbs including annual species. The number of trees and taller shrubs is normally not dissimilar to that which is present in the rehabilitation.

The difference is that the rehabilitated areas have reduced numbers of small shrubs, herbs, ground covers and annual species.

Even with the low number of plants at 0.8 plants/m^2 the rehabilitation is achieving its function as shown in Figures 6 – 9D and Appendix 1.

As a result of the 2002 study the rehabilitation techniques and species lists were updated and outlined in the 2002 report *Overview of Rehabilitation Completed in 1996/1997*.

As a result of the 2002 studies, a number of recommendations were made.

Changes made as a result of the 2002 assessments of rehabilitation.

1. *In visually sensitive areas it is better to use restricted lists of local species that have proven to grow well in order to achieve better long term horizontal and vertical coverage. However, adjacent to remnant vegetation, an increased species richness is recommended.*

2. *Increased numbers of taller long lived tree species are to be included in the rehabilitation, particularly Eucalyptus wandoo, E. calophylla and E. accedens.*

3. *A total of 1 300 stems of trees per hectare, with some long lived taller shrubs, should be aimed for at establishment, together with a dense understorey and ground cover.*

4. *Both tube stock and seeding should be used.*

5. *Increased leguminous species should be introduced preferably within the seed mix.*

6. *The batter slopes and banks should be left rough to increase water collection and provide a good substrate for seed establishment.*

The above changes have been incorporated into the rehabilitation since 2003.

Another assessment of the rehabilitation was undertaken in November 2006 to determine the sustainability of the earliest rehabilitation. In addition some of the most recent rehabilitation, on the south western overburden dump, was also assessed to compare recent success rates to earlier success rates.

The vegetation coverage in the 1996 – 1997 rehabilitation was found to not have changed significantly between 2002 and 2006. The plant density was 7.3 whilst the lateral and vertical vegetation cover remained similar. See Appendix 1.

Some of the shorter lived species such as *Acacia saligna* have died but have been replaced by seedlings, ensuring that the rehabilitation is self sustaining.

However on the newer rehabilitation (2003 – 2005) on the overburden dump, where growth conditions were good, using the changed rehabilitation methods resulted in an average number of species of 2.5 per m^2 of shrubs and trees. See Appendix 1.

The improved rehabilitation is based on the updated species lists and techniques which are outlined in this document.

The species lists amended in 2002 have proven better, although there is room to increase the number of species used for the suggested lists. This can be achieved by ordering tube plants and seeds earlier to ensure their ready availability.

The key directions of rehabilitation remain valid and continue to be used. These are included in the following Completion Criteria.

Hanson has a good record in environmental management and rehabilitation. In 1992 the Herne Hill Quarry won the Greening Australia Award for Rehabilitation and in 1995 the Byford Quarry was a Finalist in the Greening Australia Awards.

8.0 COMPLETION CRITERIA FOR FINAL LAND SURFACE

Completion Criteria have been developed based on past experience/research, the approvals, and need to satisfy the Key Directions of rehabilitation. The completion criteria applies to the final land surface.

There are some areas that will be rehabilitated on an interim basis to provide visual enhancement, soil stabilisation or for some other purpose which may not meet the criteria. These areas will be rehabilitated to the criteria on completion of quarry or ancillary activities on that site; for example when static plant is decommissioned and removed or when temporary bunds and access features are removed.

Completion Criteria

- *The land surface is to be non eroding and stable in compliance with the Mines Safety and Inspection Act 1994 and Department of Industry and Resources Guidelines for the Abandonment of Excavations.*
- *The land surface is to be consistent with the concept final contour plans.*
- *Rehabilitation follows the Key Directions of Rehabilitation wherever possible.*
- *Rehabilitation is to provide satisfactory visual screening and be self sustaining to the number of plant stems and species.*
- *Weed incidence and coverage of nil or at minimal levels which does not compromise the long term effectiveness of rehabilitation.*
- *A total of 1 native shrub or tree is to be present per 1 m^2 at 3 years, averaged over each rehabilitation area.*
- *A minimum of 600 trees per hectare.*

- *Ten local species per 100 m^2*

Key Directions for Rehabilitation.

- *Local species are to be used to maximise the habitats available.*
- *Species should be matched to the microhabitat of each site.*
- *Rarer species are to be used to increase their numbers and compensate for any that had to be cleared.*
- *There is a need to consider fauna habitats and use species that are capable of supplying nectar breeding sites and other resources.*
- *Vegetation should become self sustaining and maintenance free.*
- *Areas of rehabilitation should not add to the fire risk of the site.*
- *The provision of a weed management program.*
- *The use of a dieback prevention program.*
- *The awareness of the work force is to be encouraged to foster "ownership of the program.*
- *Local people and groups are to be involved as appropriate.*
- *Establishment of a seed orchard of on site species. (This is less appropriate now because of the availability of local provenance seed stocks).*
- *Rehabilitation must not compromise the safety of the site.*
- *Bushland conservation has a high priority.*
- *Fast growing local species are to be used in areas where visual management is a priority.*
- *Vegetation linkages and fauna corridors will be maintained and enhanced where suitable situations exist or where the exchange of fauna may be restricted.*

9.0 REHABILITATION PROGRAM

9.1 Vegetation Clearing

Vegetation present on the excavation site must be cleared to enable quarrying to proceed.

Vegetation clearing may have a number of localised impacts. Some of these impacts are temporary such as dust, whilst others such as visual impact may take longer to reduce.

Whilst vegetation must be cleared, it is a valuable source of local provenance seeds for rehabilitation. When spread on rehabilitation areas it is a source of soil organic matter.

In many parts of the site the vegetation is low shrubs with reduced numbers of trees. There is also reduced vegetation associated with granite outcrops.

Therefore in some locations the vegetation can be cleared separately from topsoil, but in other situations with less shrubs and groundcover it is preferable to take the vegetation as part of the clearing of topsoil.

The number of trees also varies and in some areas trees are to be taken separately and the timber utilised offsite or used for habitat creation.

As the amount of vegetation to be cleared is predominantly shrubs and understorey, there is unlikely to be any requirement for mulching. However if the vegetation is significant, for example trees that cannot be utilised offsite or for habitat creation, mulching will be used and the mulch spread on rehabilitation areas. Burning is not used or proposed in the future, although burning has been found to be beneficial at Pickering Brook in rehabilitation conducted by Landform Research. There the ash, charcoal and charred fragments is mixed with topsoil and has led to significantly better germination of seed stored in topsoil and to the germination of some species which often do not return from direct return of topsoil.

Potential Impacts of clearing could be;

- removal of excessive vegetation
- increased noise by working on the land surface rather than within the pit shielded by bunds and the form of the quarry
- potential generation of additional dust when moving dry topsoil and overburden
- potential for additional sediment to be dislodged and moved by precipitation or surface water
- introduction of weeds
- introduction of plant pathogens
- visual impacts

A number of measures can be used to minimise the impacts of clearing on the immediate environment and local habitats. These are described in detail in this rehabilitation plan, and include;

1. Careful quarry planning to match the short term resource requirements to the configuration of the pit.

2. Provide excavation to as great a depth as possible to maximise the resource available and minimise the progression of clearing.

3. Using a staged progress of excavation wherever possible to reduce the area of clearing required having regard to safety and future pit operational issues.

4. Only clearing the minimum vegetation required for each particular stage.

5. Selecting an appropriate time of year and local weather conditions for clearing, to avoid mid or late summer when increased dust is more likely; and avoiding very wet conditions when the risk of surface water runoff is likely to be increased reducing the safety for mobile plant.

6. Marking out the area to be cleared and quarantining vehicles and access to that area to minimise the disturbance to adjoining land and minimise the introduction of weeds or plant pathogens.

7. Ensuring that equipment brought to the site for clearing is free from soil and plant material in compliance with the Dieback and Weed Management Plans.

8. Clearing from vegetation of high quality towards areas of disturbed vegetation.

9. Operating and clearing behind vegetation or constructed bunds and working from “inside – out” wherever possible, taking into account the local landform and location of sensitive premises.

10. Larger timber from the scattered large trees is recovered and used for millable products where possible and safe to do so. Smaller stems are used for fence posts and similar products. This helps in a small way to take pressure from other areas for such products.

11. Other timber is made available to a local contractor for firewood provided safety and dieback issues are managed and subject to the suitability of the timber.

12. Remaining vegetation fragments/timber is retained on site and placed on rehabilitation areas. This assists with habitat creation and serves as a seed source and source of soil microbial material.

9.2 Topsoil and Overburden Removal - Treatment

Topsoil refers to the top 100 mm of the soil profile and consists of the darker, more brown material to which organic matter has been added. Above the topsoil is the leaf litter that is normally thin and only exceeds 10 mm in small depressions and sheltered areas.

On this site it is not practical to clear the leaf litter separately. With the shallow topsoil on the rocky soils it is often not possible to only strip 100 mm of topsoil because of the rock outcrops, and changeable nature of the soil profile. In this case the topsoil will be stripped with the shrub vegetation, which will be flattened and broken up in the process making it suitable for direct transfer to a rehabilitation area.

Topsoil is a valuable source of local provenance seeds and soil micro-organisms. Rehabilitation often develops better if topsoil is available and it is thought that this may be due to mulching effects and soil microbial inoculation.

Topsoil is also a source of soil organic matter and as such contains nutrients. The microorganisms in soil are capable of interacting with the organic matter and clay particles to release and store nutrients.

A bulldozer will normally be used for topsoil stripping, with a loader tidying up and loading materials for transport to a rehabilitation area.

Topsoil management also relies on managing the issues identified in 9.2 Vegetation Clearing The same potential problems occur and the topsoil will be cleared at the same time as the vegetation is stripped.

This includes;

- considered quarry planning,
- staging,
- stripping only the minimum area required for each particular stage,
- selecting an appropriate time of year and local weather conditions,

- quarantining vegetation to be impacted on,
- ensuring than equipment brought to the site for clearing is free from soil and plant material in compliance with the Dieback and Weed Management Plans,
- clearing topsoil/vegetation areas of high quality towards areas of disturbed vegetation, operating behind vegetation or constructed bunds taking into account the local landform and the adjoining community.

The following additional measures will be used in addition to the above;

1. Assess the site and construct bunds and water management features as required to minimise sediment runoff. In many cases the surface will be configured to allow stormwater to run back into the pit during clearing.

2. Where possible topsoil is directly transferred from an area being cleared to an area being rehabilitated. Where this is not possible the topsoil is stored in low dumps (0.5 m high for topsoil) for future use in rehabilitation.

3. Following topsoil removal overburden will be stripped by a variety of plant, such as a bulldozer, loader, scraper or excavator, depending on the local site conditions.

4. Overburden is directly transferred from an area being cleared to an area being rehabilitated. Where this is not possible the topsoil is stored in dumps in locations from which it can be recovered for use in future land restoration.

5. Where possible top soil clearing and removal of overburden is undertaken in wetter months to minimise the risk of dust generation. For dieback management clearing is preferred in summer, at which time the blowing of spores could be a means of dieback spread.

9.3 Landform Reconstruction and Contouring

Quarrying in hard rock produces rows of narrow benches with steep faces of rock separating them. Production faces normally have a slope of near 15^{o} from the vertical, laid back towards to the upslope side.

In softer weathered rock the slopes must be laid back even more to ensure slope stability. Slopes need to comply with *Mines Safety and Inspection Act 1994* and Department of Industry and Resources *Guidelines for the Abandonment of Excavations*. These slopes are taken as the angle of the whole slope including the steps cut, to form the working benches.

The slopes are in most cases interim and are likely to be modified in the final stages of excavation. In the interim the slopes are steeper in order to maximise the resource and reduce the need for additional clearing whilst taking into account operational safety.

Slopes left as a final sloping surface suitable for abandonment of the quarry will have reduced angles as noted below.

Description using AS 1726	Interim slopes and faces during operations.	Final slopes and faces at abandonment. (DOIR Guidelines)
Extremely weathered rock, including topsoil and overburden	30 degrees	25 degrees
Distinctly weathered rock or saprolite	50 degrees	
Slightly weathered rock or saprock	70 degrees	45 degrees
Fresh rock	70 degrees	

To achieve DOIR *Guidelines for the Abandonment of Excavations* the slopes will have the faces laid back or be backfilled to reduce the angles of slope. This will normally only be completed in the final stages of excavation or slopes for which the final land use is well defined.

For interim rehabilitation of faces and benches the steeper angles will enable overburden to be placed along the completed quarry benches and the growth of trees for visual screening as is currently used on site. See Figure 8.

The stability of slopes also depends on their composition, with dumps having greater stability if they contain a proportion of large rock and stone. The water loading on slopes and dumps is also important. Surface water should be gently shed to prevent saturation of the weathered materials and overburden which could decrease the slope stability. On the other hand drainage will be designed in a manner that will not lead to uncontrolled sediment loss.

1. The land surface is re-contoured to match the post excavation concept plans for the pit. Interim land surfaces and batter slopes are used where appropriate. The Concept Post Excavation Contour Plans are subject to ongoing changes as the quarry develops based on resource management, safety, visual management and long term requirements.

2. Steep slopes and dumps are pushed down and smoothed wherever possible.

3. Final slopes will comply with *Mines Safety and Inspection Act 1994* and Department of Industry and Resources Guidelines for the Abandonment of Excavations.

4. Where safe to do so, compacted soils, gravels and clay are deep ripped in two directions at intervals of approximately one metre. Overburden is spread over the surface to a minimum depth of 500 mm where available. Along contour furrows and undulations are used on slopes to assist water penetration and minimise surface water run off, where safe to do so.

5. Topsoil from the clearing operations is spread directly onto the overburden to maintain seed viability when available. Storage of topsoil leads to a reduction of seed viability over time. When topsoil is not available good growth rates from seed and tube plants are obtained by planting into dumped but uncompacted overburden.

6. It should be noted that for dumps and batters, some of the ground preparation is not possible for certain safety reasons such as backfilling benches. See Figure 8.

7. Dump and batter slopes are constructed with a mixture of rock in the core, to assist slope stability, with a covering of overburden.

8. Slopes should be left rough and not smoothed or compacted, both of which increase surface water runoff. Batter slopes left rough enable easy access for rehabilitation and provide sufficient undulations and depressions to catch seeds and assist in water penetration.

9.4 Soil Reconstruction

The reconstructed soils on rehabilitation areas are formed from overburden with, where available, a layer of topsoil. The overburden is generally light coloured and can be highly visible until plant growth has established.

In order to minimise any visual impact top soil taken during clearing is placed across the top to provide a dark brown cover which resembles natural soils. The topsoil and any plant fragments contained within it carry microorganisms which in turn assist in the health of the soil.

Even though topsoil is advantageous, it has been shown on site and at Hanson Byford Quarry that high quality revegetation can result from planting directly into overburden which has not had time to compact significantly.

Additional information is included in 9.3 Landform Reconstruction and Contouring.

9.5 Erosion Control

Wind erosion is not normally a problem on the finished surface because of the loamy – gravelly nature of the reconstructed soils.

Uncontrolled surface water has the greatest potential to impact on slope stability. Drainage design and management is incorporated into the design of pit configuration, interim slope management and final land surface reconstruction.

It is also important that wet areas are not created in remnant vegetation or rehabilitation because this can lead to growth of pathogens as described in 10.0 Dieback Management Plan.

The erosion control methods used include;

1. Cut off drains are provided upslope of any batter slope.

2. Benches of fresh hard rock and grade, slightly back towards the face to minimise surface water loss. When filled with overburden and rehabilitated on an interim or final basis, the slope of the fresh rock base helps reduce surface water flowing from the site.

3. Prior to areas being stripped of topsoil and overburden drainage is installed to minimise sediment loss. This normally directs surface water back into the pit where sediment settlement can occur. Where this is not possible surface water is directed into detention basins that can be cleaned out, or sediment settlement dams.

4. Flows of water will be treated by flowing across bare fresh rock, riprap, energy dissipators, and rock lined drains. Sediment traps, detention basins and silt fences will be used to capture sediment.

5. Surface water flows are sampled monthly for quality when flowing.

9.6 Vegetation Establishment

Establishment of rehabilitation is completed as soon as possible following placement of the substrate. Leaving the completed earth works for one season reduces the success of rehabilitation by at least 50%, due to compaction effects.

Therefore rehabilitation is carried out after the first available winter months following the restoration earth works.

The methods used in the establishment of vegetation are;

1. Topsoil is directly spread where available.

2. Local provenance species from the attached lists are used for rehabilitation. These are ordered in sufficient time to ensure suitable numbers of species are available for use in rehabilitation.

3. The preferred method of revegetation is to use the seed from existing topsoil combined with tube plants and additional local provenance seed. Topsoil is not always available.

4. Scarified seed is spread in the first late summer/autumn following placement. If seeding is conducted in spring the seeds are heat treated/scarified and spread in July – August. Seeds are spread by hand, or mechanical means, and bulked using vermiculite, sawdust or sand. Hydro seeding or hydro mulching may also be appropriate in some situations.

5. Seeding should be treated with smoke water. This is normally achieved by soaking the seeds in the diluted smoke water for 12 to 24 hours prior to seeding. It should be noted that increased germination from topsoil can be obtained by mixing the topsoil with ash, charcoal or charred vegetation fragments

6. Trees are planted as tube plants in winter, (June to August) and installed with a 10 g fertiliser tree tablet next to each plant. Tube plants are established in low undulations and not on the high points of furrowed soil. The planting rate is normally 500 – 1000 stems per hectare when combined with seeding. With no seeding, planting rates are significantly higher to achieve the completion criteria.

7. Broadscale pelleted fertiliser is not normally used because of its tendency to advantage annual and weed species if present. When done well, and the species selected appropriately additional fertiliser is not required, even though it

is used at some other mining ventures. For example the rehabilitation completed in 2003 – 2005 was not provided with additional fertiliser. See Appendix 1. Bulk fertiliser to be used will be a general NPK garden fertiliser containing trace elements.

8. The seeding program is co-ordinated with the local weather. For example heat and smoke treated seeds that are moist may be already germinating when spread. Prior to seeding a suitable day is selected on which it is likely to be raining or will rain immediately following seeding. It is less successful to spread seeds that may be germinating in a spell of warm dry weather as this may lead to increased losses.

9. Weeds have not been significant because only on site materials are used for soil restoration. Weeds are treated according to the attached Weed Management Plan. Any weeds likely to significantly impact on the rehabilitation are sprayed with Roundup or similar herbicide or grubbed out, depending on the species involved, prior to seeding or tube planting. This has not been required in the past because the weed load is low.

10. Rehabilitation is progressive with completed disturbed areas revegetated as soon as practicable on a progressive basis.

9.7 Local Species Suitable for Rehabilitation

In all situations the species should be matched to the site conditions. For example on dry north facing slopes species better suited to lower rainfall are selected at higher rates. On the other hand in moist areas species from riparian situations or those that normally grow in damp soils are included at higher rates.

On clay soils species known to grow well in clay are included in the species lists at increased numbers.

Better matching to the microclimates and soil conditions is one reason why better rehabilitation has been achieved since 2002.

The species to be used in the next year's rehabilitation are selected each year to match the specific soils and growing conditions of the area to be rehabilitated.

The species mix therefore changes from year to year and within any year's rehabilitation several different species mixes are often used to reflect the soils and microclimate of each area to be rehabilitated.

9.7.1 Visual Management

There are some areas where fast growth and visual management is required. These areas are the screening bunds, and exposed soil areas or landscape banks.

From previous experience on site it has been found that some species are much better suited than others in providing fast cover. It is these species that have been used since 2002 and have resulted in plant densities of 2.5 per m^2 being achieved since that time on suitable areas.

For visual management it is also better to use less species , selecting for availability, local provenance, growth rates and capability of achieving good vertical and lateral coverage.

A list of suitable species is attached, together with suggested rates of tube stock and seeding rates per hectare.

Species to be used for maximum visual control (per hectare)

- *The numbers are to be adjusted to compensate for species not available.*
- *It is assumed that both tube plants and seeds are used.*
- *Tube plants to be used for maximum visual control and on batters where later infill may be difficult.*
- *Form T tree S shrub G ground cover*

Species	Form	Tube stock/hectare	
Acacia acuminata	ST	100	
Acacia microbotrya	ST	100	
Acacia saligna	ST	100	
Callistemon phoeniceus	S	50	
Calothamnus quadrifidus	S	50	
Calothamnus rupestris	S	50	
Calothamnus sanquineus	S	50	
Eucalyptus accedens	T	200	
Eucalyptus calophylla	T	250	
Eucalyptus laeliae	T	50	
Eucalyptus marginata	T	100	
Eucalyptus megacarpa	T	50	(southern slopes/ better soils)
Eucalyptus patens	T	50	(southern slopes/ better soils)
Eucalyptus wandoo	T	200	
Hakea petiolaris	T	50	
Leptospermum erubescens	S	50	

Plus the seeds listed below at the rate per hectare. Sowing can either be in summer or early autumn for seeds and scarified leguminous seeds, or July - August for seeds and heat treated leguminous seeds.

Species	Form	Grams of seed/hectare
Acacia celastrifolia	S	100 g
Acacia extensa	S	100 g
Acacia microbotrya	ST	200 g
Acacia pulchella	S	200 g
Acacia saligna	T	200 g
Allocasuarina fraseriana	T	50 g
Banksia grandis	T	200 seeds
Calothamnus quadrifidus	S	100 g
Clematis aristata	G	50 g
Dryandra armata	S	200 seeds
Dryandra sessilis	S	200 seeds
Eucalyptus accedens	T	100g
Eucalyptus calophylla	T	100 g
Eucalyptus marginata	T	100 g
Eucalyptus wandoo	T	100 g
Hardenbergia comptoniana	G	200 g
Kennedia coccinea	G	200 g
Kennedia prostrata	G	200 g

Kunzea recurva	S	50 g
Leptospermum erubescens	S	100 g
Melaleuca scabra	S	50 g
Mirbelia dilatata	S	50 g
Viminaria juncea	S	50 g

Table 7 Local species to be used for visual management

9.7.2 Local Community Restoration

Adjacent to remnant vegetation, where fast screening cover is not required, a greater species richness can be used because a number of species have relatively slow growth rates. A list of suitable species is attached.

These species are normally grown from seed by the commercial nurseries and seed suppliers, and are suitable for use on site either by direct seeding or through the use of tube plants.

Species to be used adjacent to existing remnant vegetation (per hectare)

Species	**Form**
Acacia alata	S
Acacia extensa	S
Acacia pulchella	S
Acacia saligna	T
Agonis linearifolia	S
Allocasuarina fraseriana	T
Allocasuarina humilis	S
Baeckea camphorosmae	S
Banksia grandis	T
Beaufortia purpurea	S
Bossiaea eriocarpa	S
Callistemon phoeniceus	S
Calothamnus quadrifidus	S
Calothamnus rupestris	S
Calothamnus sanquineus	S
Clematis aristata	G
Darwinea citriodora	S
Darwinea pimeloides	S
Dryandra armata	S
Dryandra sessilis	S
Eucalyptus accedens	T
Eucalyptus calophylla	T
Eucalyptus laeliae	T
Eucalyptus marginata	T
Eucalyptus patens	T
Eucalyptus rudis	T
Eucalyptus wandoo	T
Grevillea bipinnatifida	S
Grevillea endlicheriana	S
Hakea cristata	S
Hakea lissocarpha	S
Hakea petiolaris	T
Hakea prostrata	S

Hakea stenoptera	S
Hakea trifurcata	S
Hakea undalata	S
Hardenbergia comptoniana	G
Hypocalymma angustifolium	S
Kennedia coccinea	G
Kennedia prostrata	G
Kennedia stirlingii	G
Leptospermum erubescens	S
Melaleuca radula	S
Melaleuca scabra	S
Petrophile biloba	S
Trymalium ledifolium	S

Table 8 Local species to be used for habitat creation

9.8 Monitoring

Monitoring of the rehabilitation is essential to determine the success, and to direct any steps that need to be taken to restore the vegetation or prevent it being impacted on by a variety of scenarios, such as weeds, dieback, fauna including rabbits and unacceptable loss of plants.

Monitoring of the visual management is conducted at the same time.

The monitoring is normally visual on a frequent and ongoing basis such as from time to time when the nominated person drives past.

From time to time monitoring against the completion criteria is undertaken. A consultant is used to annually review the rehabilitation. This occurs at least annually as part of the annual assessment and reporting for the Annual Environmental Summary Report or more frequently as required. Assessments of the visual management are completed at the same time or more frequently where specific issues warrant further consideration.

It is, however, the aim that all rehabilitation will achieve the Completion Criteria and the stated Key Directions. The monitoring program covers the following points.

1. Monitor the rehabilitation with respect to the Key Directions and the Completion Criteria.

2. During late summer an assessment of the success of the rehabilitation is made to determine the rehabilitation requirements for the following winter. This is normally completed visually at the time of the site assessment for the annual reporting.

3. Counts of the species diversity, richness and visual coverage are made to check that each area of rehabilitation meets the Completion Criteria, using sample plots of 10 m^2 as described in Appendix 1. This occurs during or at the end of three year's growth for each area of rehabilitation. At least three sample plots per area of rehabilitation will be used and the results averaged.

4. Follow up counts using 10 m^2 sample plots are conducted every five years or as required to ensure that the rehabilitation continues to meet the Completion Criteria during operation.

5. On closure monitoring detailed in steps one to four will continue annually until the completion criteria is achieved.

6. The results of the monitoring are reported annually to the City of Swan, EPA and Department of Environment and Conservation in the Annual Summary Report, which includes a "Rolling Rehabilitation Plan".

7. As necessary steps are taken to correct any deficiencies in the vegetation.

8. Rehabilitation of each stage is monitored annually. On site completed rehabilitation will continue to be monitored for a period of at least three years to ensure that the revegetation meets the completion criteria of providing self sustaining indigenous shrub vegetation.

9. Monitoring includes consideration of;

    - visual protection
    - plant density
    - growth rates
    - species richness
    - plant deaths
    - weed infestation
    - animal damage
    - fire impact and sustainability

9.9 Review of the Rehabilitation Procedures

The rehabilitation procedures are assessed, as a minimum, annually and the results matched against the Completion Criteria and the stated Key Directions. Where changes are required to improve rehabilitation or screening the rehabilitation program is updated.

This has occurred a number of times during the operation of the current pit.

Improving Rehabilitation

Areas not meeting or likely not to meet the Rehabilitation Criteria, will be replanted and/or seeded during the next winter to increase species richness and plant density as required, using the methods outlined above.

Fertiliser will be used as necessary on areas that are already achieving satisfactory plant density and species richness but not achieving satisfactory visual coverage.

Fertiliser to be used for this purpose will be a general NPK garden fertiliser containing trace elements.

In some situations to improve visual management may require the additional planting of taller or more suitable species.

10.0 DIEBACK MANAGEMENT PLAN

Land near Toodyay Road on which the processing plant, stockpiles and site office was subjected to past gravel excavation prior to Hanson acquiring the site. Although the PER did not list the presence of dieback on site, it is possible that it was originally associated with the old gravel pits, as it is recorded from other old pits in the local Red Hill Area.

Excavation is undertaken using practices recommended by Department of Environment and Conservation. See *CALM Dieback Hygiene Manual 1992* which is more practical and *CALM Best Practice Guidelines for the Management of Phytophthora cinamomi, draft 2004.* See also *Dieback Working Group 2005, Management of Phytophthora Dieback in Extractive Industries.*

The aim of any *Phytophthora* management program is to manage excavation to reduce the risk of dieback introduction and local spread. This involves water management, vehicle hygiene and the management of access.

In many ways the management of the site for dieback is similar to that for the management of weeds and the two management practices should be considered together.

Apart from the void, the remainder of the land surface remains free draining to discourage the pooling of water and reduce the potential for damp spots which might encourage dieback disease. Drainage of disturbed areas is into the pit or to detention basins and dams. All native vegetation is quarantined and vehicles are only permitted along designated tracks.

The operation is effectively worked as a "split operation". Site vehicles such as loaders and light vehicles travel on formed roads or sealed and aggregate based areas such as the stockpile area. Excavation vehicles are restricted to the pit, but do travel to service areas for maintenance.

Road trucks and external traffic only access the stockpile area and entrance access road. Light traffic accesses the site office. External maintenance vehicles do access the site but are also restricted to formed roads.

Granite hard rock and aggregate products carry minimal to nil risk of dieback spread. This is confirmed in *CALM Best Practice Guidelines for the Management of Phytophthora cinamomi, draft 2004,* Section 3.6 page 8 for deep quarries.

The main risk comes from vehicles being used on site for land clearing and inappropriate soil treatment. All excavation equipment and road transport vehicles are required to be clean and free from soil and vegetable matter prior to entering the operations.

Dieback Management Program

1. The site is maintained to minimise the spread or introduction of Dieback Diseases according to the above points.

2. Excavation of the site has been designed to comply with *CALM Best Practice Guidelines for the Management of Phytophthora cinamomi, draft 2004 and*

Dieback Working Group 2005, Management of Phytophthora Dieback in Extractive Industries.

3. The pit and operations are designed to minimise water from leaving the pit and entering remnant vegetation without passing through detention and sediment settlement basins.

4. The quarry activities operate separately from the stockpile and loading areas and are effectively a "split" operation. A dedicated wash down bay is not required for an operation such as this.
5. The site is secured from unwanted access by locked gates, barricades and fences.

6. Excavation vehicles are restricted to the excavation area, stockpiles and access roads.

7. Road transport vehicles are restricted to the stockpile, loading and access areas.

8. Remnant vegetation is quarantined from all vehicles.

9. Firebreaks are maintained and are tidied each year, but not extended into remnant vegetation.

10. If any clearing is proposed, vegetation and soil material is pushed from “dieback free” areas towards” at risk” areas.

11. All quarrying, excavation and transport vehicles are required to be cleaned when coming from a dieback affected area, prior to leaving their source.

12. A hygienic site is maintained through a policy of not bringing any soil or plant material onto the site except for rehabilitation purposes.

13. Prompt removal of any rubbish or dumped materials is practised.

14. Stockpiles are contained on the dedicated stockpile area or pit floor.

15. Water from excavations is contained and directed to settlement dams. The dams do not generally overflow apart from during exceptionally wet conditions.

16. Ponding of surface water on rehabilitation areas and natural vegetation is avoided.

17. The Weed Management Plan is implemented.

11.0 WEED MANAGEMENT PLAN

Weeds are plants that are in the wrong place and have the potential to impact on vegetation, whether it be remnant native vegetation or rehabilitation.

- **Declared Weeds** are listed under Section 37 of *the Agriculture and Related Resources Protection Act 1976*, and there is a legal obligation to control these weeds.

- Other weeds can be **Environmental Weeds** whereby they can significantly impact on vegetation. These should be controlled because they could cause major impacts on revegetation or native vegetation communities.

- There are also **Non Invasive Weeds** that are not invasive but are none the less not in their correct location. These are often exotic and they should also be prevented from entering the site. If they occur they should be monitored to ensure they do not create unacceptable impacts on vegetation or habitat.

The management of weeds is essentially similar to that for plant diseases. The impact of weeds is really the impact within the local area and the more they are controlled the better. It is desirable that the site does not become a haven for environmental weeds and therefore a management and control program is warranted.

Currently the amount of weed species is minimal and restricted to near the site office, Toodyay Road, and in areas previously used for gravel extraction prior to Hanson acquiring the site.

Minor Paterson's Curse occurs on site. Watsonia has been present along Susannah Brook for many years.

A weed spraying program is in place and in recent years has dealt with the few weeds around the site office. The weeds targeted were Paterson's Curse and a small outbreak of Blackberries.

Watsonia sp. forms a monoculture along Susannah Brook. Watsonia is a community problem of the whole Susannah Brook catchment and needs to be tackled as part of catchment management. A request was received from CALM in 2001 to survey the Watsonia along Susannah Brook, with a view to control. Hanson supports this program and liaison continues.

Weeds such as Paterson's Curse, west of Herne Hill, and Watsonia, along Susannah Brook, require a coordinated program to be carried out by adjoining land holders, to be effective.

Paterson's Curse has been targeted by the crown weevil and a root weevil which have been released by the Department of Agriculture and Food in recent years. The biological control could take up to five years before noticeable affects become obvious.

Hanson has a policy that no soil or vegetation matter that has the capability of introducing weeds will be brought onto the Red Hill site.

Incursions by horses from the west along Padbury Avenue and Loton Road are sometimes an issue although these have reduced in recent years. Droppings from the horses are a major potential source of weeds as they contain large amounts of seed of pasture species that are particularly effective at colonising the cleared edges of roads and firebreaks.

Hanson has a policy of discouraging or prohibiting horses on their sites, from both a safety and weed point of view. Fences are inspected regularly and repaired as necessary.

Monitoring and control of weeds continues and includes edge effects along tracks and fire breaks.

Two local publications on weed control will be used as a reference to the management of weeds on site;

> Brown K and K Brooks, 2002, *Bushland Weeds*, Environmental Weeds Action Network Perth WA.
>
> Scheltema M and J Harris eds, 1995, *Managing Perth's Bushlands*, Greening Australia.

Weed Management Program

1. No plant, soil or fill material will be brought onto the site apart from that known to be weed free.

2. The site is secured against illegal entry and to prevent illegal dumping of rubbish.

3. All rubbish is removed promptly.

4. When observed, weeds are treated promptly. Several weeds pulled out by hand and destroyed, may save many dollars in spraying at a later stage.

5. Weed control is from the least weed affected areas to the most weed affected, which therefore gives a smaller area to treat with spray or earthworks.

6. Weed affected soils are not used for rehabilitation, but buried at least 500 mm below the surface.

7. The site is regularly monitored for the introduction of Declared weeds and those that have the potential to become a local pest.

8. Follow up monitoring and spraying is conducted.

9. Liaison is maintained with Government authorities with respect to control of significant weeds such as Watsonia along Susannah Brook.

10. Awareness of the latest control programs is sought through contact with Government Agencies and published information.

11. The Dieback Management Plan is implemented.

12.0 COMMUNITY CONSULTATION

12.1 Public Quarry Visits

Community open days were held at the quarry on 11 March and 18 November 2006. These events enabled local residents to discuss issues and provided a forum for the exchange of information on the progress and future plans for the quarry.

Although these open days did not specifically address the Screening and Rehabilitation Plan they did provide a forum for the exchange of information and concerns.

The “Updated Screening and Rehabilitation Program” dated November 2006 was subsequently prepared and widely circulated.

A copy of the “Updated Screening and Rehabilitation Program” was sent to local residents that it had been determined may be affectedby views to Hanson’s Red Hill Quarry pit. This documentation was provided in December 2006 and a total of 22 copies were sent to residents in the area.

Potentially affected households were identified from past discussions and contacts between the landholders and Hanson and from an examination of aerial photography and field observations.

In addition the document was provided in CD format and distributed to a number of other residents and local groups.

A meeting was arranged for 7.00 pm on 6 February 2007 specifically to discuss the screening and rehabilitation of the existing quarry and the 5.6 hectares of the quarry footprint in the west as approved by the Minister for the Environment on 22 September 2006.

A total of nine residents attended the meeting of 6 February 2007. Not all were from the mailing list. Two apologies were received from those that had received a copy of the document .

The proposed long term quarry progression, which is currently being investigated is the subject of separate meetings and community consultation.

On Saturday 17 February 2007 a public meeting was arranged by Hanson to provide an update of the various environmental studies that Hanson had commissioned for the land to the west and north west of the existing pit. This meeting is part of the community consultation program for the long term quarry progression.

Whilst the purpose of the meeting was not the “Updated Screening and Rehabilitation Program”, the potentially affected residents were invited and the meeting provided an information gathering opportunity. It also provided both a formal and informal forum for discussion of all the issues; something that was taken up by most attendees.

As a result of the meeting and correspondence received by Hanson with respect to the “Updated Screening and Rehabilitation Program”, the following points were raised.

12.2 Comments received from the public with respect to community consultation on the Updated Screening and Rehabilitation Program

It appeared that the main community concerns related to the management of the rehabilitation and visual impacts rather than the footprint itself. Most of the discussion appeared to relate to information rather than specific concerns.

The following comments were received.

ITEM	PUBLIC COMMENT	COMMENT BY HANSON
1	A question was asked in relation to the glow of light that could be seen from behind the ridge, and whether this will expand in the future.	• The glow relates to the processing plant lights only. This plant will not be moved nor expanded in the foreseeable future. The glow relates to lighting used for maintenance that is undertaken during the evening and will not be expanded.
2	Both Swan Valley community groups wish to be kept informed	• The two community groups of Swan Valley Residents and Ratepayers Association and the Swan Valley Progress Association will be added to the mailing list as a matter of courtesy
3	The reference in the rehabilitation program to the open day on 18 November 2006 as being related to the rehabilitation program is incorrect.	• The open day of the 18 November 2006 was an opportunity for local residents to visit the quarry, view the operations and an opportunity for discussion. Aspects of Hanson's rehabilitation to date were viewed. Whilst the open day was not specifically aimed at the "Updated Screening and Rehabilitation Program", all local residents, including those who can view the quarry were invited, with a letter drop to all nearby residents and local press advertising. • The open day was another opportunity for community consultation. • The same can be said for the information forum held on 17 February 2007 which also provided a forum for informal discussions and community contact.
4	Some people felt that over the years there has been insufficient communication between Hanson and the most affected residents	• Over the years there have been open days and standing open invitations to the local community groups. Only limited applications have been forthcoming. • It is only in the latter part of 2006, with the latest Ministerial Statement relating to the delineation of the 5.6 hectare area to the North West and the current planning for a long term resource application, that additional community consultation is required and this is being undertaken. • Annual Environmental Summary reports are produced and sent to all relevant authorities. These reports outline the progress of the quarry, the environmental management and regularly updated visual management and rehabilitation techniques.
5	A comment was made that the stockpiles had been increased in elevation and the tops were now visible from Toodyay Road.	• A large order for quarry fines was anticipated and the material stockpiled. This necessitated a temporary elevation of the stockpile. The order did not ultimately eventuate and now a proportion of the material will be removed and tipped into the base of the pit, to continue the backfill of the early part of the pit (southern face). • This material has been used to increase the backfill in the south eastern corner of the quarry as shown on Figure 10.

6	Some residents suggested that photographic points be established at the boundaries of Hanson land.	• A photographic record has always been kept. This has normally been from Hanson land north of Susannah Brook and this photography is included in the Updated Screening and Rehabilitation Program (Figures 6 and 7). • For the progress to date this has been a very good location for photographic recording. Yearly photographs are provided in the Annual Environmental Summary reports. • Other photographic points have been used over the years but have now been excavated. Photographs have been regularly taken from Joshua Mews but have not normally been included in the reports as the view is much further away than that from Hanson land and is essentially similar. • Additional photographic points will be created from alternative locations on Hanson and Public land, particularly in the North West. • The use of photography from private property will be investigated through discussions with the relevant residents.
7	A suggestion was made that computer generated images be used to show the likely future impacts.	• This was done in the original PER of 1991. • It was also completed in 2000 and included in the Year 2000 annual Summary Report for the photographic monitoring point on Hanson land. • The predicted image is similar to the current view from the monitoring point but the dam wall has not been revegetated because of the risk of tree roots compromising the structure. • Shallow fibrous rooted plants will be tried on the wall to try and remedy this. • The batter of the haul road will also have added vegetation when it reaches its final form. • Computer modelling of visual potential mpacts will be considered for any future applications for expansion.
8	The publication of a printed “Updated Screening and Rehabilitation Program” is not community consultation.	• Hanson has found that it is generally more productive to produce a document with all the background information that provides the discussion points and can be adjusted as necessary. • The document formed the basis of community consultation, which is the aim of community meetings.

9	A comment was made that time frames should be included for the various areas of rehabilitation, particularly the southern face.	• Time frames are worthwhile but are dependant on market conditions, for example see Point 5 above. • Unfortunately if a time frame is placed on an activity, for example the rehabilitation of the southern face, and it cannot be completed on time, it may become a target for community and authority action. The inability to meet timeframes through unforeseen circumstances may lead to a loss of community trust, which is something Hanson is anxious to avoid. • Rehabilitation of terminal benches such as the southern face is dependant on the availability of overburden which is often quite variable when opening new ground. • The use of flexible timeframes with indicative targets will be considered. • Backfill of the south eastern corner has continued. Photographs and concept time frames are included in Figure 10.
10	Letters should be addressed to the residents name and not generally to the "landowner / resident".	• This is an ideal situation, but it is difficult to determine everyone's name without breaching privacy, and most authorities are reluctant to provide the information. • A database of names and addresses is being compiled, for the dissemination of information. Even so this is still unlikely to negate the use of "landowner" or "resident".
11	Some people do not get the local non posted mail such as the community newspaper.	• Hanson has no control over which local residents receive the local community newspaper. • Hanson will continue to strive to inform all potentially affected residents.
12	A suggestion was made that Hanson should offer to plant trees along private boundaries to minimise visual impact.	• This has been considered on a number of occasions but in most situations the trees will not provide the required screening because houses are built on a higher level and will not mitigate the visual aspects. • Trees will increase the risk of fire on the boundary. • Local residents may not wish to have the trees planted and will have to be consulted. • The offer of trees in the past has been refused by at least one property owner. • Hanson will consider this option in line with the above limitations.
13	A question was raised in regards to the need to open more ground rather than deepen the pit.	• The pit footprint must be enlarged to enable the haul roads to be extended downwards as there is a limit on the safe gradient of the haul roads. • Deeper benches can be created as the pit footprint is enlarged.
14	A question was asked relating to why the pit was trending to the west rather than the south west on top of the Scarp	• The top of the scarp has excessive overburden, which must be placed somewhere. This require very large dumps of overburden to be placed on indigenous vegetation, because there would be excess material for backfill or rehabilitation of the quarry faces.
15	Some discussions were raised in relation to the original footprint of the quarry.	• The original east pit was not opened because of greater visual impact to the North West. Only the west pit from the original PER has been quarried.

16	A comment was made on the vigour of growth of the trees along the benches	• The trees on the southern benches were used to modify the visual impact in the short term. • In the long term the southern face will be backfilled with waste quarry material and overburden, as it becomes available, and will be revegetated in line with the "Updated Screening and Rehabilitation Program".

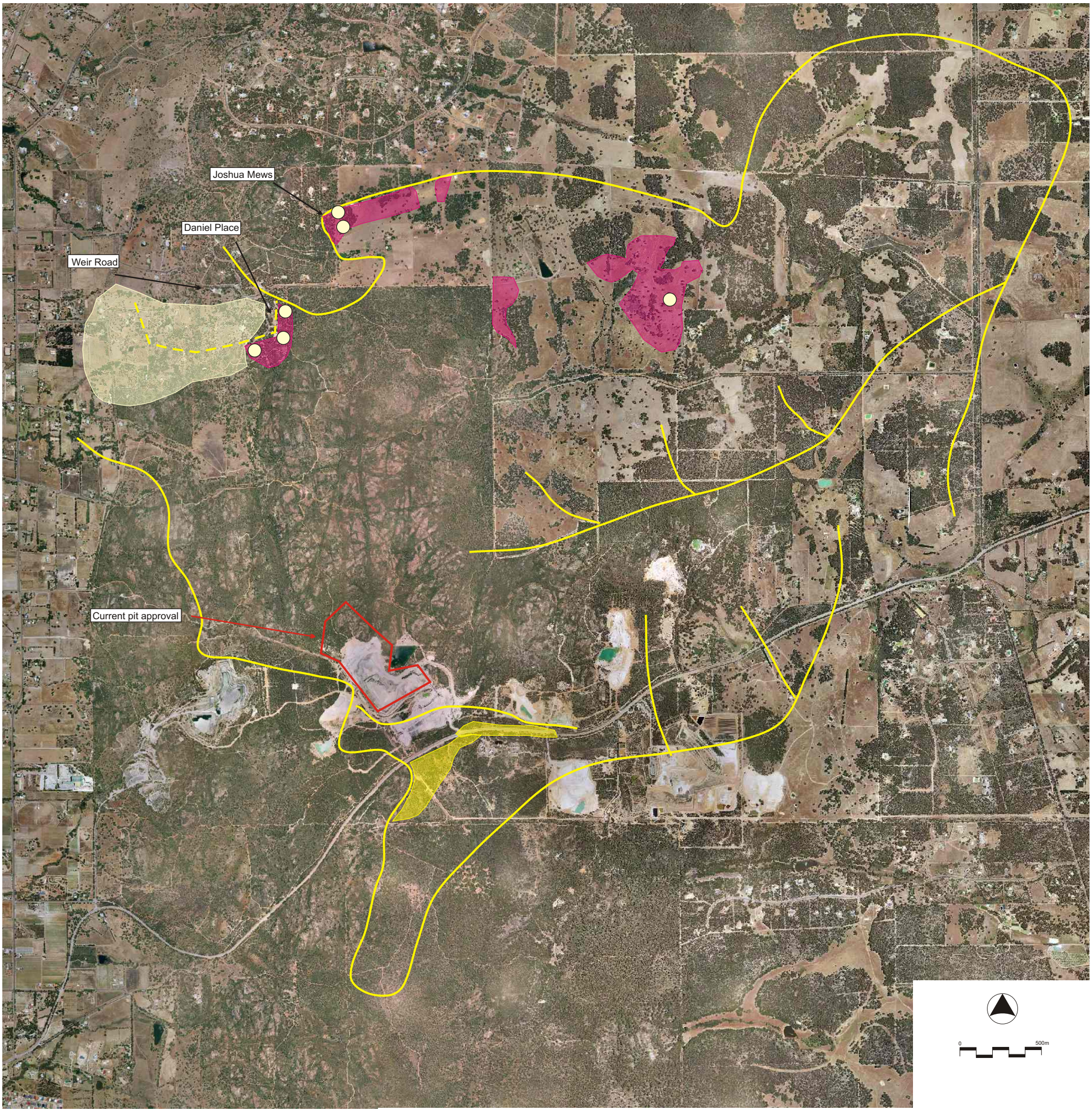
AERIAL PHOTOGRAPH - REHABILITATION

RED HILL QUARRY

HANSON CONSTRUCTION MATERIALS

Source	Landform Research
DLI January 2006	Nov 2006

Figure 1



KEY	COMMENT
▬	Crests of ridges, which mark the visual divide. Potential area from which the pit may be visible if there was no remnant vegetation. Not all locations will be able to see the pit because of irregularities in the landform
▬	Areas from which the pit has been visible. In many cases the existing vegetation provides screening NOTE - Some land is not accessible
▬	Area where there are dwellings which may be able to see the pit with future development.
▬	Area where rehabilitated bunds are visible, but the pit cannot be seen
○	Known dwelling from which the pit can be seen

NOTE Analysis is based on contour interpretation, aerial photography and site inspections

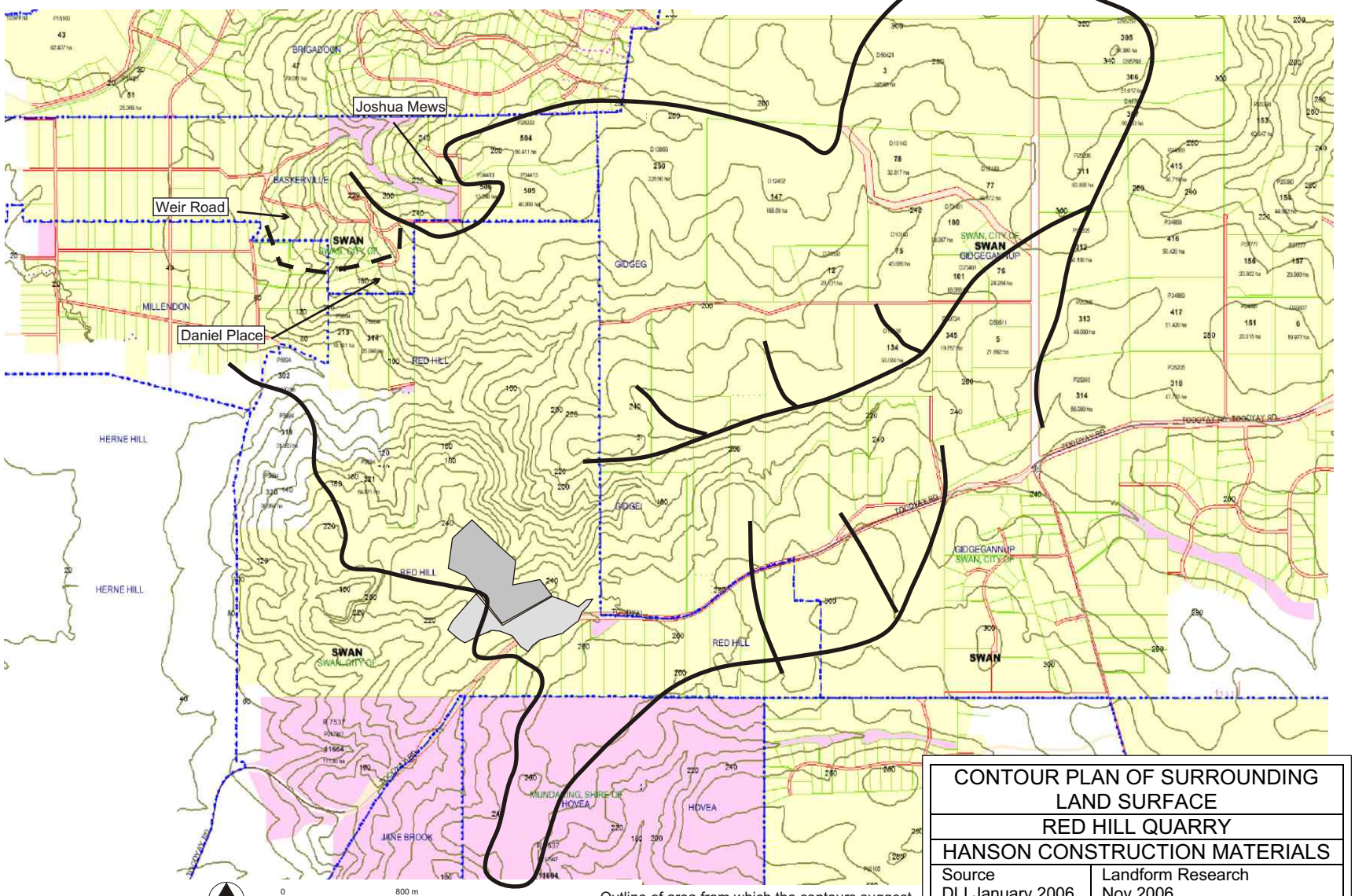
See Figures 3, 4 and 5

Hanson

Landform Research

Figure 2

VISUAL ANALYSIS	
RED HILL QUARRY	
HANSON CONSTRUCTION MATERIALS	
Source DLI January 2006	Landform Research Nov 2006



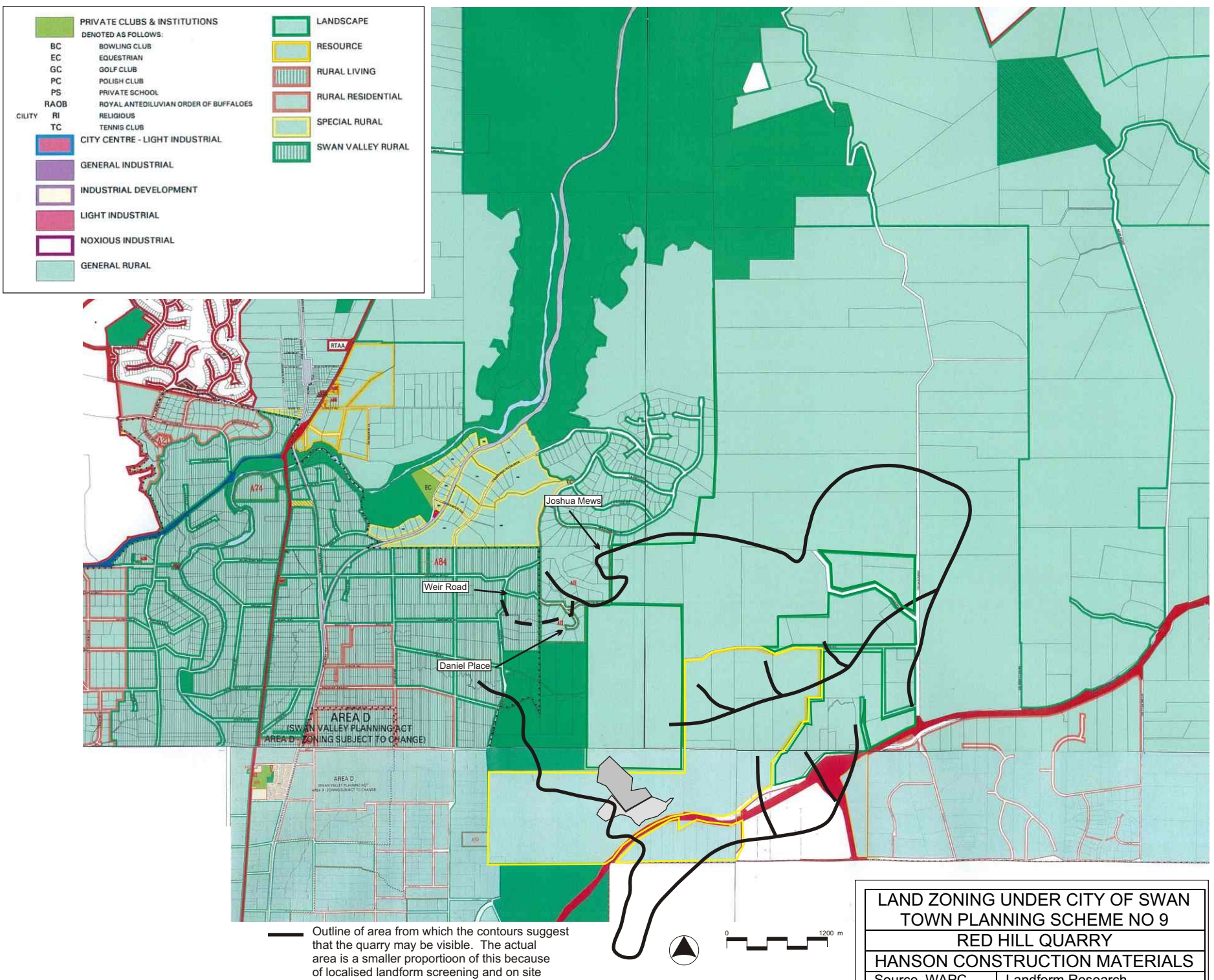
Outline of area from which the contours suggest that the quarry may be visible. The actual area is a smaller proportioon of this because of localised landform screening and on site screening vegetation.

CONTOUR PLAN OF SURROUNDING LAND SURFACE	
RED HILL QUARRY	
HANSON CONSTRUCTION MATERIALS	
Source DLI January 2006	Landform Research Nov 2006

Hanson

andform Research

Figure 3



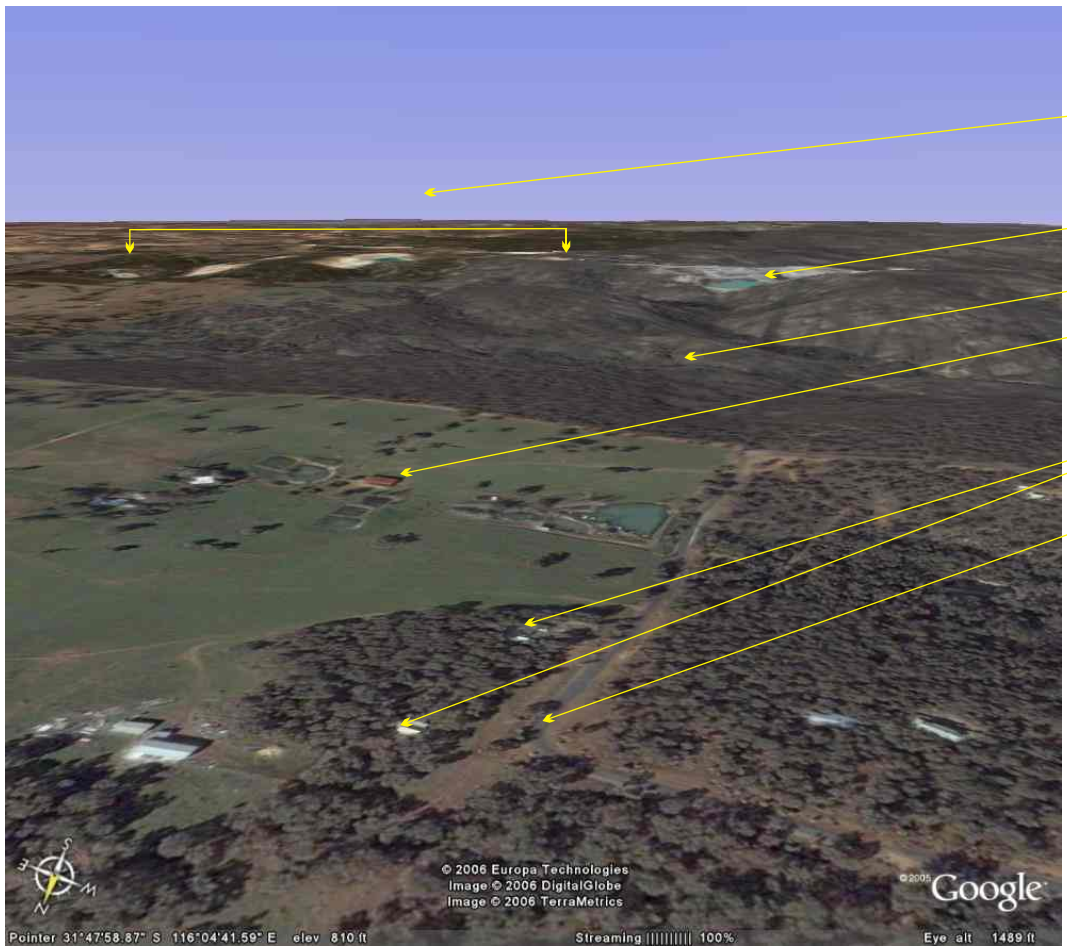
Outline of area from which the contours suggest that the quarry may be visible. The actual area is a smaller proportioon of this because of localised landform screening and on site screening vegetation.

LAND ZONING UNDER CITY OF SWAN TOWN PLANNING SCHEME NO 9	
RED HILL QUARRY	
HANSON CONSTRUCTION MATERIALS	
Source WAPC	Landform Research Nov 2006

Hanson

Landform Research

Figure 4



Midland Brick pits

Red Hill pit

Buffer owned by Hanson Construction Materials

Dwelling in the valley

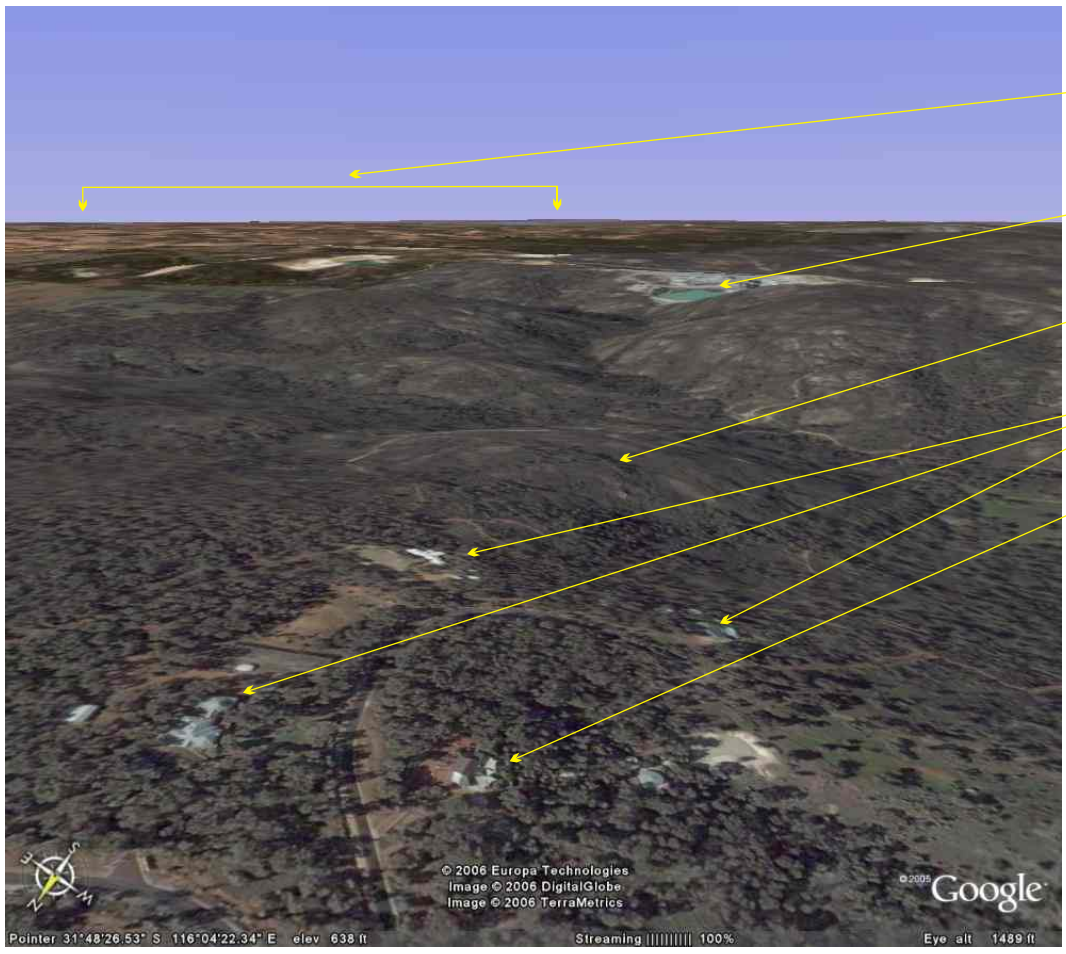
Dwellings protected by trees

Joshua Mews

VIEW FROM J OSHUA MEWS

Note that the image is a satellite image generate from well above ground level. The pit is visible from part of the road, and may be visible from the two dwellings through trees. The third dwelling is located in a valley which probably visually protects the pit from view.

GENERATED FROM SATELLITE , AT A MUCH HIGHER ELEVATION THAN THE NATURAL LAND SURFACE



Midland Brick pits

Red Hill pit

Buffer owned by Hanson Construction Materials

The pit can be viewed through trees from dwellings

Currently unlikely to see the quarry

VIEW FROM DANIEL PLACE

Note that the image is a satellite image generate from well above ground level. The pit is not readily visible from the road, but is likely to be visible from the three dwellings through trees. With the western progress of the pit, the pit may become visible from additional dwellings. The landform will continue to provide protection.

GENERATED FROM SATELLITE , AT A MUCH HIGHER ELEVATION THAN THE NATURAL LAND SURFACE

Midland Brick pits

Red Hill pit

Buffer owned by Hanson Construction Materials

The pit is not visible from this dwelling

VIEW FROM LOT 250

Note that the image is a satellite image generate from well above ground level. The pit is not visible from the dwelling but is visible from pasture to the west. It is also visible from another dwelling on Lot 250.

GENERATED FROM SATELLITE , AT A MUCH HIGHER ELEVATION THAN THE NATURAL LAND SURFACE

OBLIQUE VIEWS FROM THE NORTH	
RED HILL QUARRY	
HANSON CONSTRUCTION MATERIALS	
Source Google Earth	Landform Research Nov 2006

Figure 5

Figure 6 View from northern side of Susannah Brook in late 1996. The photo is at the same scale as the one below taken in November 2006

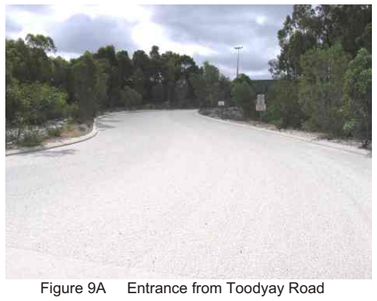


Figure 9A Entrance from Toodyay Road

Figure 9B Rehabilitation from Toodyay Road

Figure 9C Vew from east along Toodyay Road

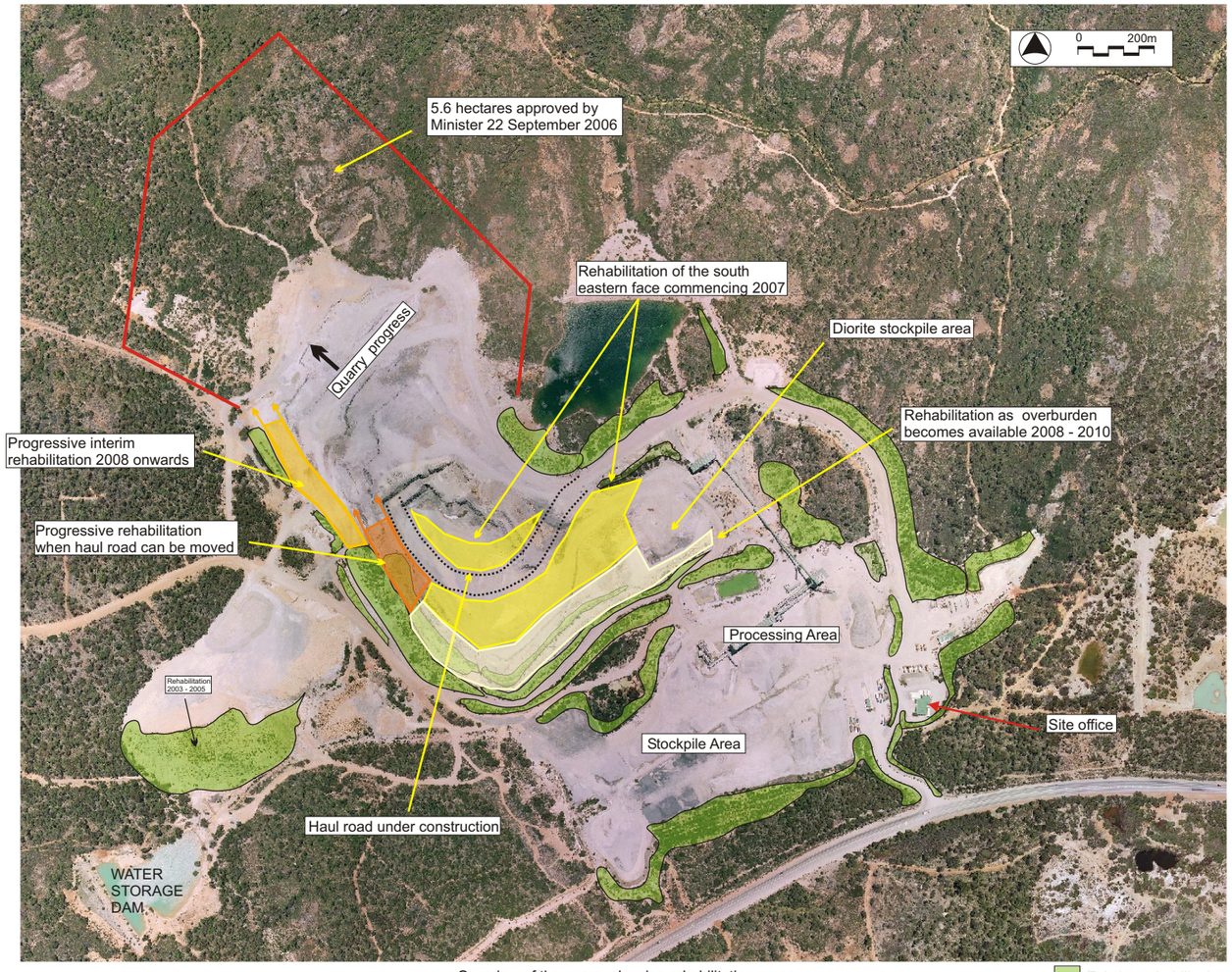
Figure 7 View from northern side of Susannah Brook in November 2006. The photo is at the same scale as the one above taken in December 2006

9D Year 2003 rehabilitation

Figure 8 Southern face of the pit showing rehabilitation of the upper benches

Landform Research

Hanson



Overview of the quarry showing rehabilitation areas

Existing rehabilitation

Construction of bench to enable backfill and vegetation

Interim revegetation of the south eastern face that will be backfilled and rehabilitated

To be vegetated in 2007

Construction of benches to enable backfill of the south eastern face

Construction of benches to enable backfill of the south eastern face
To be covered by overburden and vegetate, to screen the diorite stockpile.

BACKFILL OF THE SOUTH EASTERN FACE AND CONCEPT TIMING OF REHABILITATION	
HANSON CONSTRUCTION MATERIALS RED HILL QUARRY	
Landform Research	March 2007
Basemap DOLA Air Photo January 2006	Scale 1 : 10 000 approx

Hanson

Figure 10

View of existing pit from the north west

View south across the new area of backfill

APPENDIX 1

ASSESSMENT OF REHABILITATION

RED HILL QUARRY

HANSON CONSTRUCTION MATERIALS

NOVEMBER 2006

Landform Research

ASSESSMENT OF REHABILITATION

RED HILL QUARRY

HANSON CONSTRUCTION MATERIALS

Landform Research
Land Systems - Quarries - Environment
ABN 29 841 445 694

Lindsay Stephens Bsc (Geology), Msc (Botany) MEIANZ

25 Heather Road, Roleystone WA 6111

CONTENTS

ASSESSMENT OF REHABILITATION

FIGURES

TABLES LOCATED IN ASSESSMENT OF REHABILITATION

1.0 BACKGROUND

The Red Hill quarry lies within an area of the Darling Scarp covered by remnant vegetation that provides a buffer for the quarry. The quarry and associated infrastructure lie on the southern side of Susannah Brook, extending to Toodyay Road.

Rehabilitation plans have been prepared for the Red Hill Quarry and Herne Hill Quarry as part of the ongoing management of environmental issues associated with the start of development of the Red Hill Quarry in 1996 and placing the Herne Hill Quarry into "care and maintenance" pending decisions on its future use.

A number of Rehabilitation Plans have been prepared for the operations and this report seeks to update those reports and combine them into one document.

The Red Hill Quarry was opened and brought into production in 1998. This involved clearing for both the quarry site and the infrastructure associated with the quarry. In the early years the only land available to be restored was the batters and bunds surrounding the development areas. These were landscaped and revegetated as part of the landscaping of the site.

The sites rehabilitated during construction in 1996 and 1997 included the batters of the dams, around the site office, access roads, stockpiles and entrance statement. Since 1996/1997 revegetation has concentrated on infill planting and revegetation of the rear of some completed benches, and extension of the batter slopes to the south of the stockpile areas and an overburden dump.

Re-establishment of the local flora was deemed a key principle in the rehabilitation to be used on site and this was picked up in the Rehabilitation Plan developed and approved for the Red Hill Quarry in 1996.

2.0 VEGETATION ON SITE

The 1989 vegetation study identified the following communities. During 2006 an additional study of the flora is being undertaken to reassess the vegetation in the light of more recent environmental expectations.

VEGETATION COMMUNITIES (Identified in earlier studies and currently under review)	**HABITAT AND SOIL**
Open Forest of Jarrah - Marri	Lateritic gravels of the ridge tops
Woodland of Wandoo - Marri	Deeper younger red clayey soils of the upper slopes and developed on dolerite dykes.
Low Woodland of Rock Sheoak	Skeletal soils associated with granite outcrops.
Open to closed Heath	Granite outcrops
Herblands or Lithic Complex	Granite outcrops
Rehabilitation Areas	Rehabilitation of old gravel and clay pits

Table 1 Vegetation communities identified in 1989.

Some significant flora were identified in the 1989 studies. These flora were identified as Declared Rare or Priority Flora.

The species recorded were *Beaufortia purpurea, Calothamnus rupestris, Darwinea pimelioides, Hakea cristata, Synaphea acutiloba, Synaphea pinnata* and *Tetratheca pilifera*.

Both *Beaufortia purpurea* and *Hakea cristata* have now been removed from the Rare or Priority Lists of flora. The others are listed as either Priority 3 or Priority 4 which are shown as either Poorly Known or Flora in need of further study to assess their true position. Currently (2006) the vegetation on site is being reviewed and any changes to the lists of significant flora will be made as a result of those studies.

Details of the plant communities listed in the 1989 studies are included in the Public Environmental Review Document, 1990.

It should, however, be noted that much of the vegetation of the ridge where the infrastructure, site office and stockpiles are located was already disturbed and degraded as a result of earlier gravel and clay excavation.

The species on these disturbed sites, prior to construction, were generally non local Eucalypts and *Acacias.* Some were eastern state's varieties and out of character with the area. The remainder of the site, including the pit footprint, was indigenous vegetation from a range of the plant communities listed above.

In April 2006, Mattiske Consulting Pty Ltd was commissioned to again survey the vegetation ahead of excavation. Additional studies are currently underway to assess the vegetation through spring surveys and to extend the vegetation survey across the whole of the proposed area of clearing.

Four vegetation types were defined and mapped for the survey area, shown in Figure 7 of the Flora report (Appendix 2). These vegetation types are a combination of Havel's (1975a and 1975b) site-vegetation types, for the Darling Ranges forest region.

Vegetation Type H -

Woodland to Open Woodland of *Eucalyptus marginata* subsp. *thalassica – Corymbia calophylla* with scattered understorey, including *Dryandra lindleyana*, *Xanthorrhoea gracilis, Calothamnus sanguineus* and *Lepidosperma squamatum*.

This site-vegetation type occurs on low undulating sandier soils, although the soils can range from grey leached surface sands to sandy-gravels.

Vegetation Type HG-

Woodland to Open Woodland of *Eucalyptus marginata* subsp. *thalassica - Corymbia calophylla* with low dense understorey, including *Dryandra armata* var. *armata, Hakea undulata, Hakea stenocarpa, Hakea trifurcata* and *Lepidosperma squamatum*.

This site-vegetation type occurs on low undulating sandy gravel to gravel soils over shallow soils.

Vegetation Type MG-

Open Woodland of *Eucalyptus wandoo* subsp. *wandoo* and *Eucalyptus accedens* with dense understorey, including *Hakea incrassata, Allocasuarina humilis, Dryandra armata* var. *armata, Hakea undulata* and *Hakea trifurcata.*

This site-vegetation type occurs on the upper slopes of the undulating hills with clay-loams on shallow soils.

Vegetation Type G-

> Open to Closed Heath of Proteaceae - Myrtaceae species, including *Hakea incrassata, Hakea stenocarpa, Dryandra armata* var *armata, Hakea undulata, Melaleuca trichophylla*, *Calothamnus rupestris* (Priority 4), *Allocasuarina humilis* and *Hypocalymma angustifolium*.
>
> This site-vegetation type occurs on the shallow soils on or surrounding outcrops on the upland and valley systems on the Darling Ranges.

Mattiske 2006 notes that the vegetation is dominated by specific herb and shrub species, which reflect the soils and moisture associated with granite outcrops on the Darling Ranges.

A total of 68 taxa (species, subspecies and varieties) from 22 families and 39 genera were recorded at the proposed clearing site.

Only One Priority species, *Calothamnus rupestris* (P4), as listed by the Department of Environment and Conservation, was located throughout the survey area.

A rehabilitation program was initially developed in the Public Environmental Review and updated into the 1997 Rehabilitation Management Plan which expanded the original program to show in greater detail the revegetation techniques that would be used in rehabilitation.

3.0 AIMS OF THE REHABILITATION PROGRAM

3.1 Aims of the Rehabilitation Listed in the PER

In the 1990 PER, rehabilitation was treated in more general terms but the aims can be summarised as;

- reducing the visual impact
- restoring soil and soil based organisms
- restoring vegetation cover
- reducing erosion
- restoring habitat for fauna
- reducing noise and dust arising from the quarry operation

In 1997 those aims were expanded to try and achieve a higher standard of rehabilitation in line with community expectations. This resulted in the 1997 Rehabilitation Plan.

Some of the methods described in the PER were not used. For example cover crops were not to be planted even as interim soil cover because of the risk of introducing weed problems. Rather the aim in the 1997 Rehabilitation Plan was to return each completed area to a self sustaining planting of local indigenous species suited to each microhabitat.

Whilst the original (1990) aims generally remained the same, the rehabilitation methods were expanded and slightly varied. These were summarised into the key points, in the 1997 Rehabilitation Plan.

3.2 Key Directions to the Rehabilitation Program in the 1997 Rehabilitation Plan:

The 1997 Rehabilitation Plan expanded on the aims of the PER and developed the following key directions, which were to direct the rehabilitation program.

- The use of local species to maximise the habitats available.
- The matching of the species to the microhabitat of each site.
- The use of the rarer species to increase their numbers and compensate for any that had to be cleared.

- The need to consider fauna habitats and use species that are capable of supplying nectar breeding sites and other resources.
- Vegetation should become self sustaining and maintenance free.
- Areas of rehabilitation should not add to the fire risk of the site.
- The provision of a weed management program.
- The use of a dieback prevention program.
- Raising the awareness of the work force to encourage "ownership of the program.
- Involvement of local people and groups.
- Establishment of a seed orchard of on site species.
- Rehabilitation must not compromise the safety of the site.
- Bushland conservation has a high priority.

However, once site works and initial rehabilitation of non essential areas commenced it quickly became obvious that the protection of the visual landscape was a very important focus, and significant rehabilitation effort was directed towards this goal.

The use of rehabilitation to manage visual issues was also included in the 1996 Visual Management Plan and was expanded upon in the 2000 Visual Management – Proposed Quarry Extension, Red Hill Quarry that was included in the Year 2000 Annual Environmental Summary Report.

The 2000 Visual Management Plan, on page 5 of that report, added another key direction to the above list ;

- The use of fast growing local species in areas where visual management is a priority.

4.0 SUMMARY OF THE REHABILITATION TO 2006

The key directions of the rehabilitation of the site, up to this point, are listed with a comment on each as described in the table below.

Rehabilitation through tube planting has been conducted during winter each year, generally June to August. The species used have been local provenance. Leguminous seed, which has been scarified, has often been spread in late summer.

Since 1996 nearly 45 000 tube plants have been planted at the Red Hill site in addition to over 100 kg native seed (25 kg in 1997 alone). This included a further 4 000 tube plants in 2002. No seed was spread in 2002.

5.0 SUCCESS OF THE REHABILITATION PROGRAM

An overview of the rehabilitation was conducted in 2002. This consisted of examining rehabilitation undertaken during the 1996 – 1997 planting years. At that time a large number of species were used in the seed and tube plant mixes. However no data other than visual information had been gathered on the success of particular species.

Aims of the 2002 Study of Rehabilitation were to;

- Assess the species richness of the rehabilitation by comparing what is growing to the lists of species used.
- Provide comment on the suitability of particular species for rehabilitation.
- Assess the density of the vegetation.
- Assess the effectiveness of the vegetation in providing cover of disturbed ground.
- Assess the sustainability of the vegetation.
- Assess the batters and slopes for signs of surface erosion.
- Suggest changes that might contribute to the effectiveness of the rehabilitation methods and program.

Eight batter slopes were assessed. Following the 2002 assessment no infill rehabilitation of the assessed areas was carried out. See Figure 2.

As a result of the study the rehabilitation methods were changed slightly in terms of the species used. Less species have been used in recent rehabilitation, with the species being selected because of their fast growing ability, local provenance and known success.

The study was repeated in November 2006 to determine the sustainability of the earliest rehabilitation. In addition some of the most recent rehabilitation, on the south western overburden dump, was also assessed to compare recent success rates to earlier success rates.

Aims of the 2006 Study of Rehabilitation were to;

- Re-assess the areas sampled in 2002 to determine whether the vegetation is sustainable.
- Assess the continued ability of the 1996 –1997 rehabilitation to meet the aims of rehabilitation particularly with respect to visual management.
- Compare rehabilitation completed in 2003 – 2005 to see if the changes recommended in 2002 have provided improvements.

5.1 Assessment Methods Used

There are difficulties in assessing the vegetation on the batters and slopes. These are at angle of repose for the dumped materials such as overburden. As such the hardened surface can be slippery and present a hazard to walking on the slopes in a number of locations, but particularly where the slopes are high or are above drops of the face of the quarry.

High slippery slopes were not walked on, on safety grounds. In such cases the vegetation was assessed by walking along the upper or lower edge of the rehabilitation.

- In each assessment 10m^2 plots (3 metres x 3.3 metres) were measured using a small tape, or where too dangerous to do so, the sides of the plots were visually estimated.

- As there were relatively low numbers of stems in each sample, measurements were necessary only to determine whether a particular stem lay in or out of the sample. The sample areas are shown in Figure 2.

- The plots were determined to provide an unbiased average of the rehabilitation of the slope by placing samples in the best, worst and average vegetation coverage areas, in a proportion that visually matched the overall coverage of that slope.

- All stems were counted, and in some cases in 2002 a separation between seedlings (1 - 2 years old) and older plants was made. No such distinctions were made in November 2006.

- All species observed were recorded in 2002. However the species richness within each plot was not recorded because of the obvious proportion of certain species which are discussed later in this report. In 2006 the only species recorded were on the most recent rehabilitation on the overburden dump.

- A visual estimate of the percentage of vertical ground cover was recorded.

- A visual estimate of the horizontal coverage of the slope was also recorded. This provides an effectiveness of the vegetation for visual/landscape protection. For example a thin tree may provide low levels of vertical ground cover but higher levels of visual ground coverage when viewed from the side. A tall tree with a long trunk may provide good vertical coverage of the ground but it may be possible to see the slope past the trunk when viewed laterally. For slopes viewed from above it was not possible to assess the lateral coverage.

- For each area of rehabilitation an average for all parameters was calculated.

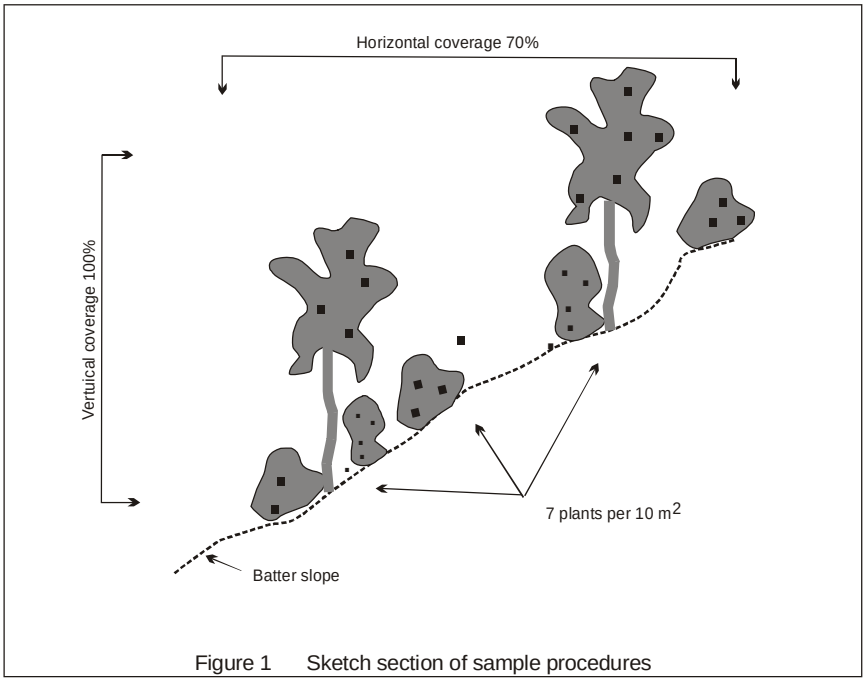


Figure 1 Sketch section of sample procedures

5.2 Plant Density in Rehabilitation

See Figure 2 for the location of the sample Areas.

SAMPLE AREA 1 – Rehabilitated 1996/97

2002 Sample Data

AREA 1 2002 Sample number	Total number of all stems in 10m² sample (includes seedlings)	Vertical ground cover afforded by 10m² sample	Lateral visual cover afforded by 10m² sample
1	8	30%	90%
2	11	90%	90%
3	2	20%	80%
4	7	20%	70%
5	8	70%	70%
6	11	90%	90%
7	5	20%	80%
8	14	60%	100%
9	6	5%	100%
10	6	130%	90%
Average	**7.8**	**53%**	**86%**

2006 Sample Data

AREA 1 2006 Sample number	Total number of all stems in 10m² sample (includes seedlings)	Vertical ground cover afforded by 10m² sample	Lateral visual cover afforded by 10m² sample
1	5	100%	90%
2	4	90%	30%
3	3	60%	100%
4	4	10%	20%
5	5	40%	70%
6	28	30%	80%
Average	**8.1**	**55%**	**65%**

AREA 2

2002 Sample

AREA 2 2002 Sample number	Total number of all stems in 10m² sample (includes seedlings)	Vertical ground cover afforded by 10m² sample	Lateral visual cover afforded by 10m² sample
1	9	20%	not recorded
2	10	20%	not recorded
3	10	10%	not recorded
4	7	80%	not recorded
5	6	70%	not recorded
Average	**8.4**	**40%**	

2006 Sample

AREA 2 2006 Sample number	Total number of all stems in 10m² sample (includes seedlings)	Vertical ground cover afforded by 10m² sample	Lateral visual cover afforded by 10m² sample (estimated)
1	5	110%	100%
2	16	20%	30%
3	5	90%	100%
4	4	100%	100%
5	4	60%	100%
6	14	40%	40%
Average	**8.0**	**70%**	**78%**

AREA 3

2002 Sample

AREA 3 2002 Sample number	Total number of all stems in 10m² sample (includes seedlings)	Vertical ground cover afforded by 10m² sample	Lateral visual cover afforded by 10m² sample (estimated)
Average	not recorded	not recorded	**50 - 90%**

2006 Sample

AREA 3 2006 Sample number	Total number of all stems in 10m² sample (includes seedlings)	Vertical ground cover afforded by 10m² sample	Lateral visual cover afforded by 10m² sample (estimated)
1	9	20%	30%
2	11	100%	100%
3	10	100%	100%
4	8	40%	100%
5	6	140%	100%
Average	**8.8**	**80%**	**86%**

AREA 4

2002 Sample

AREA 4 2002 Sample Number	Total number of all stems in 10m² sample (includes seedlings)	Vertical ground cover afforded by 10m² sample	Lateral visual cover afforded by 10m² sample (estimated)
1	26	70%	Visually assessed as 90% dropping to 70% but will increase as the many seedlings grow.
2	41	80%	
3	12	60%	
4	7	60%	
5	7	30%	
Average	**18.6**	**60%**	**86%**

2006 Sample

AREA 4 2006 Sample number	Total number of all stems in 10m² sample (includes seedlings)	Vertical ground cover afforded by 10m² sample	Lateral visual cover afforded by 10m² sample (estimated)
1	13	60%	90%
2	4	100%	100%
3	9	80%	80%
4	12	60%	60%
Average	**9.5**	**75%**	**83%**

AREA 5

2002 Sample

AREA 5 2002 Sample number	Total number of all stems in 10m² sample (includes seedlings)	Vertical ground cover afforded by 10m² sample	Lateral visual cover afforded by 10m² sample
1	6	30%	50%
2	12	20%	70%
3	14	40%	60%
4	17	80%	90%
5	11	90%	100%
6	9	70%	100%
7			100%
8			90%
9			100%
10			80%
11			70%
Average	**13.8**	**66%**	**91%**

2006 Sample

AREA 5 2006 Sample number	Total number of all stems in 10m² sample (includes seedlings)	Vertical ground cover afforded by 10m² sample	Lateral visual cover afforded by 10m² sample (estimated)
1	21	70%	60%
2	12	90%	90%
3	17	80%	70%
4	19	100%	80%
5	4		
Average	**14.6**	**85%**	**75%**

AREA 6

2002 Sample

AREA 6 2002 Sample number	Total number of all stems in 10m² sample (includes seedlings)	Vertical ground cover afforded by 10m² sample	Lateral visual cover afforded by 10m² sample
1	6	70%	100%
2	5	100%	80%
3	4	100%	100%
4	6	60%	90%
5	5	90%	100%
6			60%
7			40%
8			80%
9			100%
10			90%
Average	**5.0**	**84%**	**84%**

2006 Sample

AREA 6 2006 Sample number	Total number of all stems in 10m² sample (includes seedlings)	Vertical ground cover afforded by 10m² sample	Lateral visual cover afforded by 10m² sample (estimated)
1	4	140%	100%
2	4	100%	70%
3	3	50%	70%
4	4	70%	100%
5	4	120%	50%
Average	**3.8**	**96%**	**78%**

AREA 7

2002 Sample

AREA 7 2002 Sample number	Total number of all stems in 10m² sample (includes seedlings)	Vertical ground cover afforded by 10m² sample	Lateral visual cover afforded by 10m² sample
1	6	50%	90%
2	7	80%	100%
3	4	90%	100%
45	8	90%	100%
	5	90%	100%
Average	**6.0**	**80%**	**98%**

2006 Sample

AREA 7 2006 Sample number	Total number of all stems in 10m² sample (includes seedlings)	Vertical ground cover afforded by 10m² sample	Lateral visual cover afforded by 10m² sample (estimated)
1	4	60%	90%
2	5	80%	100%
3	2	30%	20%
4	6	50%	80%
5	10	80%	100%
Average	**5.4**	**60%**	**78%**

AREA 8

2002 Sample

AREA 8 2002 Sample number	Total number of all stems in 10m² sample (includes seedlings)	Vertical ground cover afforded by 10m² sample	Lateral visual cover afforded by 10m² sample
1	6	10%	20%
2	8	30%	50%
3	10	80%	70%
4	5	30%	30%
5	8	60%	60%
Average	**7.4**	**42%**	**46%**

2006 Sample

AREA 8 2006 Sample number	Total number of all stems in 10m² sample (includes seedlings)	Vertical ground cover afforded by 10m² sample	Lateral visual cover afforded by 10m² sample (estimated)
1	4	60%	90%
2	5	80%	100%
3	2	30%	20%
4	6	50%	80%
5	10	80%	100%
Average	**5.4**	**72%**	**78%**

Table 2 Counts of plant density and coverage

The number of plant stems per 10m² in 2002 varies from 3.8 in Area 6 to 14.6 in Area 5.

The average for all plots is 7.95 plants per 10m² which equates to 0.8 plants per m². The types of plant species are shrubs and trees and therefore the vegetation is providing significant and acceptable cover. When viewed from a distance it is not uncommon to glimpse small areas of soil through the trees and shrubs in natural communities and this pattern is similar.

When analysing the native plant communities, whilst the number of plants is much higher than 0.8 plants/m² the majority of the plants are small ground cover or ground hugging plants and

herbs including annual species. The number of trees and taller shrubs is normally not dissimilar to that which is present in the rehabilitation.

The difference is that the rehabilitated areas have reduced numbers of small shrubs, herbs, ground covers and annual species.

Even with the low number of plants at 0.8 plants/m^2 the rehabilitation is achieving its function as shown in Figures 9 and 14. The vegetation coverage has also not changed significantly between 2002 and 2006. Some of the shorter lived species such as *Acacia saligna* have died but have been replaced by seedlings, ensuring that the rehabilitation is self sustaining. See Figures 11, 12 and 13.

5.3 Species Present in Rehabilitation

1996 – 1997 Rehabilitation

The species listed below are those identified from the 1996 – 1997 rehabilitation areas in 2002. The identification included all species that were observed. The common species, as marked are those that probably originated from natural topsoil or seeding rather than rehabilitation.

SPECIES PRESENT IN 2002 IN REHABILITATION PLANTED IN 1996 – 1997	Occurrence C - common M - frequent U - uncommon	Sourced as a natural seedlings	Self seeding in rehabilitation	T - tree S - shrub G - ground cover
Acacia celastrifolia	U			S
Acacia extensa	C			S
Acacia pulchella	C		#	S
Acacia saligna	C		#	S/T
Acacia sp	U			S
Allocasuarina fraseriana	C			S/T
Banksia grandis	U			S/T
Calothamnus rupestris	M			S
Calothamnus quadrifidus	C		#	S
Calothamnus sanguineus	C			S
Calystachys lanceolata	U			S
Daviesia decurrens	U	#		S
Eucalyptus accedens	U			T
Eucalyptus calophylla	C			T
Eucalyptus marginata	U			T
Eucalyptus wandoo	C			T
Gastrolobium bilobium	C	#		S
Gastrolobium calycinum	U	#		S
Hakea petiolaris	U			S/T
Hakea prostrata	U			S
Hakea trifurcata	U			S
Hakea undulata	U			S
Hardenbergia comptoniana	U			G
Hibbertia hypericoides	U	#		S
Hovea chorizemifolia	U			S
Kennedia coccinea	U			G
Melaleuca scabra	U			S
Mirbelia dilatata	U			S
Paplionaceae sp	U			S
Viminea juncea	M			S
				S
Acacia dealbata* (exotic)	U	#		T

Acacia decurrens* (exotic)	U	#		T

Table 3 Species recorded in 1996 - 1997 rehabilitation

From the above species list there were only 29 species recorded in the 1996 - 1997 rehabilitation. Of these nine species were common. This data could be due to a reduced species list being used in the early years or some species that were used in rehabilitation not surviving. Tube stock lists for 1996, for plants supplied by Thompson Palmer, suggest a reduced species list with only 17 species being listed for 20 000 plants supplied in 1996, which may account for the number of species recorded.

A recommendation from 2002 was to change the species lists and these remain recommended as shown in 4.0 Local Species Suitable for Rehabilitation.

As a result of the 2002 studies, a number of recommendations were made.

Changes made as a result of the 2002 assessments of rehabilitation.

1. *In visually sensitive areas it is better to use restricted lists of local species that have proven to grow well in order to achieve better long term horizontal and vertical coverage. However adjacent to remnant vegetation, an increased species richness is recommended.*

2. *Increased numbers of taller long lived tree species are to be included in the rehabilitation, particularly Eucalyptus wandoo, E. calophylla and E. accedens.*

3. *A total of 1 300 stems of trees per hectare with some long lived taller shrubs should be aimed for at establishment, together with a dense understorey and ground cover.*

4. *Both tube stock and seeding should be used.*

5. *Increased leguminous species should be introduced preferably within the seed mix.*

6. *The batter slopes and banks should be left rough to increase water collection and provide a good substrate for seed establishment.*

The above changes have been incorporated into the rehabilitation since 2003.

5.4 Current rehabilitation 2003 - 2005

Species from the 2002 lists have been used for the rehabilitation since that time, including the overburden dump. At times some species were not available as it is not always possible to source local provenance of all required species.

The species on the overburden dump were identified in November 2006 to determine which species were most successful.

Counts and species assessment of the overburden dump which was rehabilitated in 2003 – 2005 reveal that species from the lists supplied in the 2002 report have been used. There are three other species present that were not listed and which are local. It is likely these have developed from seed occurring in the topsoil. The species developed from topsoil are *Pimelea suaveolens, Nemica dilatata* and *Hibbertia subvaginata.*

In all 19 species were observed on the overburden dump. There are additional species listed in the rehabilitation plan that should be included in future rehabilitation programs.

SPECIES RECORDED IN 2006 REHABILITATION (overburden dump planted in 2003 – 2005)	Species present from rehabilitation list	Species present not on list
Acacia celastrifolia	**x**	
Acacia extensa	**x**	
Acacia microbotrya	**x**	
Acacia pulchella	**x**	
Acacia saligna	**x**	
Banksia grandis	**x**	
Calothamnus quadrifidus	**x**	
Eucalyptus accedens	**x**	
Eucalyptus calophylla	**x**	
Eucalyptus wandoo	**x**	
Hakea trifurcata		**x**
Hibbertia subvaginata	**x**	
Kennedia coccinea	**x**	
Kennedia prostrata	**x**	
Leptospermum erubescens	**x**	
Mirbelia dilatata	**x**	
Nemica dilatata		**x**
Pimelea suaveolens		**x**
Viminaria juncea	**x**	

Sample number	**Total number of all stems in 10m^2 sample (includes seedlings)**	**Vertical ground cover afforded by 10m^2 sample**	**Lateral visual cover afforded by 10m^2 sample (estimated)**
1	27	90%	100%
2	20	80%	100%
3	29	100%	100%
4	22	90%	80%
5	28	100%	100%
Average	**25.2**	**92%**	**96%**

Table 4 Counts of species richness and plant density in 2003 – 2005 rehabilitation
Sample counts conducted in November 2006

The Average number of species is 2.5 per m^2 of shrubs and trees.

The plant density is much greater than in the 1996 – 1997 rehabilitation which contains 0.8 plants/m^2 and demonstrates the improvements to rehabilitation that have occurred on the Red Hill site in the last few years.

The improved rehabilitation is based on the updated species lists and techniques outlined in the 2002 report *Overview of Rehabilitation Completed in 1996/1997*.

The same rehabilitation techniques form the updated rehabilitation plan.

6.0 CONCLUSIONS

Further assessments of the older and new rehabilitation in November 2006 confirm that the early rehabilitation continues to be satisfactory and sustainable. It also confirms that the changes recommended in 2002 have lead to better, and more rapidly established rehabilitation with higher ground cover. Rehabilitation conducted on the south western overburden dump from 2003 – 2005 averages 2.5 plants/m^2 compared to 0.8 plants/m^2 in the 1996 – 1997 rehabilitation.

The species lists amended in 2002 have proven better, although there is room to increase the species used. This can be done by ordering tube plants and seeds earlier to ensure their ready availability.

RECOMMENDATIONS

The key directions of rehabilitation remain valid and continue to be recommended.

Key Directions for Rehabilitation.

- Local species are to be used to maximise the habitats available.
- Species should be matched to the microhabitat of each site.
- Rarer species are to be used to increase their numbers and compensate for any that had to be cleared.
- There is a need to consider fauna habitats and use species that are capable of supplying nectar breeding sites and other resources.
- Vegetation should become self sustaining and maintenance free.
- Areas of rehabilitation should not add to the fire risk of the site.
- The provision of a weed management program.
- The use of a dieback prevention program.
- The awareness of the work force is to be encouraged to foster "ownership of the program.
- Local people and groups are to be involved as appropriate.
- Establishment of a seed orchard of on site species. (This is less appropriate now because of the availability of local provenance seed stocks).
- Rehabilitation must not compromise the safety of the site.
- Bushland conservation has a high priority.
- Fast growing local species are to be used in areas where visual management is a priority.

LOCAL SPECIES SUITABLE FOR REHABILITATION

Species to be used for maximum visual control (per hectare)

- *The numbers are to be adjusted to compensate for species not available.*
- *It is assumed that both tube plants and seeds are used.*

Form T tree S shrub G ground cover

Tube Plants to be used for maximum visual control and on batters where later infill may be difficult.

Species	Form	Tube stock per hectare	
Acacia acuminata	ST	100	
Acacia microbotrya	ST	100	
Acacia saligna	ST	100	
Callistemon phoeniceus	S	50	
Calothamnus quadrifidus	S	50	
Calothamnus rupestris	S	50	
Calothamnus sanquineus	S	50	
Eucalyptus accedens	T	200	
Eucalyptus calophylla	T	250	
Eucalyptus laeliae	T	50	
Eucalyptus marginata	T	100	
Eucalyptus megacarpa	T	50	(southern slopes/ better soils)
Eucalyptus patens	T	50	(southern slopes/ better soils)
Eucalyptus wandoo	T	200	
Hakea petiolaris	T	50	
Leptospermum erubescens	S	50	

Plus the seeds listed below at the rate per hectare. Sowing can either be in summer or early autumn for seeds and scarified leguminous seeds, or July - August for seeds and heat treated leguminous seeds.

Species	Form	Grams of seed per hectare
Acacia celastrifolia	S	100 g
Acacia extensa	S	100 g
Acacia microbotrya	ST	200 g
Acacia pulchella	S	200 g
Acacia saligna	T	200 g
Allocasuarina fraseriana	T	50 g
Banksia grandis	T	200 seeds
Calothamnus quadrifidus	S	100 g
Clematis aristata	G	50 g
Dryandra armata	S	200 seeds
Dryandra sessilis	S	200 seeds
Eucalyptus accedens	T	100g
Eucalyptus calophylla	T	100 g
Eucalyptus marginata	T	100 g
Eucalyptus wandoo	T	100 g
Hardenbergia comptoniana	G	200 g
Kennedia coccinea	G	200 g
Kennedia prostrata	G	200 g
Kunzea recurva	S	50 g
Leptospermum erubescens	S	100 g
Melaleuca scabra	S	50 g
Mirbelia dilatata	S	50 g

Viminaria juncea	S	50 g

Table 6 Local species to be used for visual management

Species to be used adjacent to existing remnant vegetation (per hectare)

NOTE At least 1 300 stems of trees are to be aimed for at establishment from tube stock and seeds plus taller shrubs, understorey and groundcover

Species	Form
Acacia alata	S
Acacia extensa	S
Acacia pulchella	S
Acacia saligna	T
Agonis linearifolia	S
Allocasuarina fraseriana	T
Allocasuarina humilis	S
Baeckea camphorosmae	S
Banksia grandis	T
Beaufortia purpurea	S
Bossiaea eriocarpa	S
Callistemon phoeniceus	S
Calothamnus quadrifidus	S
Calothamnus rupestris	S
Calothamnus sanquineus	S
Clematis aristata	G
Darwinea citriodora	S
Darwinea pimeloides	S
Dryandra armata	S
Dryandra sessilis	S
Eucalyptus accedens	T
Eucalyptus calophylla	T
Eucalyptus laeliae	T
Eucalyptus marginata	T
Eucalyptus patens	T
Eucalyptus rudis	T
Eucalyptus wandoo	T
Grevillea bipinnatifida	S
Grevillea endlicheriana	S
Hakea cristata	S
Hakea lissocarpha	S
Hakea petiolaris	T
Hakea prostrata	S
Hakea stenoptera	S
Hakea trifurcata	S
Hakea undalata	S
Hardenbergia comptoniana	G
Hypocalymma angustifolium	S
Kennedia coccinea	G
Kennedia prostrata	G
Kennedia stirlingii	G
Leptospermum erubescens	S
Melaleuca radula	S
Melaleuca scabra	S
Petrophile biloba	S
Trymalium ledifolium	S

Table 7 Local species to be used for habitat creation.

Interim rehabilitation

Ramp to western part of quarry

Dust sample point

3

SEDIMENT
SETTLEMENT DAM

Western quarry extension

6

5

Infill planting 2004

2

1

4

3

Processing Area

2

1

Midland Brick clay pits

7

Rehabilitation
2003 - 2005

2003 2005

Site office

Stockpile Area

GOOLY ROAD

8

4

WATER
STORAGE
DAM

0 200m

9 Sample Area

Rehabilitation

AERIAL PHOTOGRAPH AND SAMPLE SITES	
HANSON CONSTRUCTION MATERIALS RED HILL QUARRY	
Landform Research	November 2006
Basemap DOLA Air Photo January 2006	Scale 1 : 10 000 approx

Figure 2

Landform Research

Figure 3 Year 2005 rehabilitation in hardened ground. Mainly tube plants

Figure 4 Year 2005 rehabilitation in softer ground. Tube plants and seed

Figure 5 2004 - 2005 rehabilitation on the overburden dump. Note high lateral cover.

Figure 6 Sample Area 4 vegetation. Whilst not thick, it provides good lateral screening

Figure 7 Sample Area 4

Figure 8 Sample Area 2, showing germination and regrowth of *Acacia saligna*

Figure 9 Self seeding and germination of *Calothamnus quadrifidus* in Sample Area 1
Note that whilst the vegetation is not dense lateral screening is provided in the distance

Figure 10 Self seeding and germination on bare area of Sample Area 3

Figure 11 Lateral view of Area 1 rehabilitation. Compare to Figure 12

Landform Research

APPENDIX 2

FLORA AND VEGETATION SURVEY OF

THE PROPOSED CLEARING AREA FOR

RED HILL QUARRY - HANSON

Prepared for:

Strategen

Prepared by:

Mattiske Consulting Pty Ltd

April 2006

MATTISKE CONSULTING PTY LTD

TABLE OF CONTENTS

TABLES

FIGURES

APPENDIX

1. SUMMARY

In April 2006, Mattiske Consulting Pty Ltd was commissioned by Strategen to define the botanical values and the condition of the vegetation of the proposed clearing area at Red Hill Quarry for Hanson Construction Materials Pty Ltd, Western Australia. The survey was carried out in April 2006.

A total of 68 taxa (species, subspecies and varieties) from 22 families and 39 genera were recorded at the proposed clearing area (Appendix A). Three introduced (weed) species were recorded during the survey, none of which are listed by the Department of Agriculture (2006) as a Declared Plant or a Pest Plant.

No Declared Rare species pursuant to Subsection 2 of Section 23F of the Wildlife Conservation Act (1950) and listed by the Department of Conservation and Land Management (2006a) were located during the survey. No endangered or vulnerable taxa, pursuant to s179 of the Environmental Protection and Biodiversity Conservation Act (1999) were located during the survey.

One Priority species, *Calothamnus rupestris* (P4), as listed by the Department of Conservation and Land Management (2006a) was located throughout the survey area.

The main structural formations within the survey area are:

- Woodland to Open Woodland of *Eucalyptus marginata* subsp. *thalassica* (Blue-leaf Jarrah) – *Corymbia calophylla* (Marri),
- Open Woodland of *Eucalyptus wandoo* (Wandoo) and Eucalyptus accedens (Powderbark Wandoo),
- Open to Closed Heath of Myrtaceae-Proteaceae species.

The underlying site conditions also have influenced the resulting site-vegetation types and the vegetation communities on the survey area. The soils are dominated by sandy or sandy-gravel soils (H) and relatively shallow granitic soils (see HG, MG and G site-vegetation types). The G code (either on its own or when added to another code) reflects the presence of species that indicate shallow soils such as *Dryandra armata* var. *armata, Allocasuarina huegeliana* (Rock Sheoak), *Hakea undulata* and *Borya sphaerocephala.* These site conditions (and, in particular, when combined with the climatic conditions) have also influenced the resulting structure and floristics of the vegetation in the survey area.

As a result of considering both structural and floristic compositions and the site conditions, some 4 site-vegetation types, based on the Havel's site-vegetation types for the northern Jarrah forest region (Havel 1975a, 1975b), were recorded in the survey area. All these site-vegetation types are well represented within the conservation estate (both on the Darling Scarp and in the northern and eastern sections of the Darling Ranges). Therefore the proposed quarry extensions should have minimal impact on the vegetation values within the southwest forest region.

The survey area is located on the Darling Scarp vegetation complex as defined by Heddle et al. (1980) and as updated by Mattiske and Havel (1998). This vegetation complex is restricted to the western fringes of the Darling Ranges and is less well represented in the conservation estate (with 7.86% represented in the formal and informal reserves, based on data in the Forest Management Plan (Conservation Commission 2004).

The condition of the vegetation varies from modified (some rehabilitation areas) to excellent. No plant communities listed as threatened under the Environmental Protection Biodiversity Conservation Act (1999) were located within the survey area. No plant communities listed as threatened ecological communities by the Department of Conservation and Land Management (2006d) were located within the survey area.

2. INTRODUCTION

Mattiske Consulting Pty Ltd was commissioned in April 2006 by Hanson Quarries to define the botanical values and the condition of the vegetation of the proposed clearing site in Hanson Red Hill Quarry, Toodyay Rd, Red Hill. The project area is adjacent to the active mining area (Figure 1).

2.1 Regional and Local Vegetation

The survey area occurs in the Darling Botanical District of the South-western Botanical Province as recognized by Diels (1906) and later developed by Gardner (1942) and Beard (1979, 1980).

Previous workers have stressed the significance of the climate, landforms and soils in determining the distribution of plant communities in this area (Diels 1906; Williams 1932, 1942; Speck 1952, 1958; Lange 1960; Churchill 1961, 1968; Smith 1974; Seddon 1972; Havel 1968, 1975a, 1975b; Heddle *et al.* 1980a; Beard 1981, Mattiske and Havel 1998, Havel 2000).

In vegetation mapping it is necessary to define and map the plant communities into groups with common characteristics in structure and floristics. This grouping and classification has been achieved by:

- Havel on the Swan Coastal Plain (1968) and in the Northern Jarrah Forest (1975a, 1975b),
- Beard (1979) in the Pinjarra area (1:250,000),
- Heddle *et al.* (1980a) in the System 6 area; Perth, Pinjarra and Collie areas (1:250,000), and
- Mattiske and Havel (1998) in the vegetation mapping for the Regional Forest Agreement.

The classification system of Heddle *et al.* (1980a), and as recently updated by Mattiske and Havel (1998) for the Regional Forest Agreement vegetation mapping, utilised the concept of vegetation complexes, emphasized the relationships between the underlying landforms, soils and the plant communities. This latter system incorporated linkages with the previous work by Havel (1975a and b) and extensive vegetation mapping on specific areas throughout the northern and central Jarrah forest by Mattiske.

The survey area occurs on the western fringes of the Darling Range and occurs in the Darling Scarp vegetation complex as defined by Heddle *et al.* (1980a), and as recently updated by Mattiske and Havel (1998):

The site-vegetation types defined by Havel (1975a, 1975b) for the northern Jarrah forest, covered the variation of plant communities on this section of the Darling Range. Although the plant communities in this area form a continuum, it is possible to classify the site-vegetation types by incorporating site descriptions (e.g. soils, topography, slope, aspect, soil moisture regimes), floristic information and structural information.

In the last twenty years, subsequent studies by Mattiske and Havel in the northern Jarrah forest have recognised a series of new vegetation types not covered previously by Havel (1975a, 1975b). These include variations on the previously defined site vegetation types (e.g. PG, HS) as well as site-vegetation types, which were not covered by Havel.

2.2 Rare and Priority Flora

Species of flora and fauna are defined as Rare or Priority conservation status where their populations are restricted geographically or threatened by local processes. The Department of Conservation and Land Management recognises these threats of extinction and consequently applies regulations towards population and species protection.

Rare Flora species are gazetted under subsection 2 of section 23F of the Wildlife Conservation Act (1950) and therefore it is an offence to "take" or damage rare flora without Ministerial approval. Section 23F of the Wildlife Conservation Act (1950) defines "to take" as "... to gather, pick, cut, pull up, destroy, dig up, remove or injure the flora to cause or permit the same to be done by any means.

Priority Flora are under consideration for declaration as 'rare flora', but are in urgent need of further survey (Priority One to Three) or require monitoring every 5-10 years (Priority Four). Table 1 presents the definitions of Declared Rare and the four Priority ratings under the Wildlife Conservation Act (1950) as extracted from Department of Conservation and Land Management (2006).

Table 1: Definition of Rare and Priority Flora Species (Department of Conservation and Land Management, 2006a)

Conservation Code	Category
R	**Declared Rare Flora – Extant Taxa** "Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection and have been gazetted as such."
P1	**Priority One – Poorly Known Taxa** "Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey."
P2	**Priority Two – Poorly Known Taxa** "Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but urgently need further survey."
P3	**Priority Three – Poorly Known Taxa** "Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but need further survey."
P4	**Priority Four – Rare Taxa** "Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years."

Listed threatened species are a matter of national environmental significance under the Environmental Protection and Biodiversity Conservation Act (1999). A person must not take an action that has, will have, or is likely to have a significant impact on a listed threatened species or ecological community, without approval from the Commonwealth Minister for the Environment and Heritage. Table 2 presents the definitions of the categories of threatened species under the EPBC Act (1999).

Table 2: Categories of Threatened Flora Species (Environmental Protection and Biodiversity Conservation Act, 1999)

Category Code	Category
Ex	**Extinct** Taxa for which there is no reasonable doubt that the last member of the species has died.
ExW	**Extinct in the Wild** Taxa which are known only to survive in cultivation, in captivity or as naturalised populations well outside past ranges; or have not been recorded in known and/or expected habitats, at appropriate seasons, anywhere in past ranges, despite exhaustive surveys over time frames appropriate to their life cycles and forms.
CE	**Critically Endangered** Taxa which face an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
E	**Endangered** Taxa which are not critically endangered and face a very high risk of extinction in the wild in the immediate or near future, as determined in accordance with the prescribed criteria.
V	**Vulnerable** Taxa which are not critically endangered or endangered and face a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
CD	**Conservation Dependent** Taxa which are the foci of specific conservation programs, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

2.3 Native Vegetation Clearing Permit

The Environmental Protection (Clearing of Native Vegetation) Regulations 2006 dictate that any clearing of native vegetation in Western Australia requires a permit to do so from the Department of Environment. Native vegetation includes aquatic and terrestrial vegetation indigenous to Western Australia, and intentionally planted vegetation declared by regulation to be native vegetation, but not vegetation planted in a plantation or planted with commercial intent. Clearing is defined as the: killing or destruction of; the removal of; the severing or ringbarking of trunks or stems of; or the doing of substantial damage to some or all of the native vegetation in an area, including the flooding of land, the burning of vegetation, the grazing of stock or an act or activity that results in the above.

Native Vegetation Clearing Principles:

a) Native vegetation should not be cleared if it comprises a high level of biodiversity.

b) Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of a significant habitat for fauna indigenous to Western Australia.

c) Native Vegetation should not be cleared if it includes, or is necessary, for the continued existence of rare flora.

d) Native vegetation should not be cleared if it compromises the the whole or part of, or is necessary for the maintenance of a threatened ecological community.

e) Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.

f) Native vegetation should not be cleared if it is growing in, or in association with, and environment associated with a watercourse or wetland.

g) Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.

h) Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.

i) Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.

j) Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence of flooding.

This report forms part of an application for a Native Vegetation Clearing Permit (to the Department of Environment), as it constitutes the recommended detailed flora and vegetation survey, and complies with EPA Guidance Statement No 51 (EPA 2004).

3. OBJECTIVES

The objectives were to survey and assess the botanical values and the condition of the vegetation of the proposed clearing area in Red Hill Quarry, Red Hill in accordance with current state and federal legislation, and to report on the resultant findings.

4. METHODS

The proposed clearing area in Hanson Red Hill Quarry, Red Hill was surveyed on the 4th April 2006.

All plant specimens collected during the field survey were handled and identified in accordance with the requirements of the Western Australian Herbarium. Where necessary, specimens were compared with pressed specimens housed at the Western Australian Herbarium, and plant taxonomists with specialist skills were consulted. Nomenclature of recorded species follows that recommended by the Western Australian Herbarium, Department of Conservation and Land Management (2006b and 2006c).

Some annual and geophytic weeds and native herbs may not been noted in this survey as it was carried out in autumn rather than spring.

5. RESULTS AND DISCUSSION

5.1 Flora

A total of 68 taxa (species, subspecies and varieties) from 22 families and 39 genera were recorded at the proposed clearing site (Appendix A). Three introduced (weed) species were recorded during the survey, none of which are listed by the Department of Agriculture (2006) as a Declared Plant or a Pest Plant.

No Declared Rare species pursuant to Subsection 2 of Section 23F of the Wildlife Conservation Act (1950) and listed by the Department of Conservation and Land Management (2006a) were located during the survey.

No endangered or vulnerable taxa, pursuant to s179 of the Environmental Protection and Biodiversity Conservation Act (1999) were located during the survey.

One Priority species, *Calothamnus rupestris* (P4), as listed by the Department of Conservation and Land Management (2006a) was located throughout the survey area. This species is known from 46 records at the State Herbarium and is relatively widespread on granitic soils on the Darling Scarp and the northern Jarrah forest (Department of Conservation and Land Management (2006a). This species has been used extensively in rehabilitation areas near the Darling Scarp and in gravel pits within the northern Jarrah forest.

5.2 Vegetation

A total of four site-vegetation types were defined and mapped for the survey area, Figure 2. These units were a combination of Havel's (1975a and 1975b) site-vegetation types, and are described in the following text.

H - Woodland to Open Woodland of *Eucalyptus marginata* subsp. *thalassica* - *Corymbia calophylla* with scattered understorey, including *Dryandra lindleyana, Xanthorrhoea gracilis, Calothamnus sanguineus* and *Lepidosperma squamatum.*

This site-vegetation type occurs on low undulating sandier soils, although the soils can range from grey leached surface sands to sandy-gravels. This site-vegetation type occurs in other conservation areas, both within the eastern and northern parts of the Jarrah forest and as such is not restricted (Heddle *et al.* 1980b; Department of Conservation and Environment 1980; Department of Conservation and Land Management 1987).

HG - Woodland to Open Woodland of *Eucalyptus marginata* subsp. *thalassica* - *Corymbia calophylla* with low dense understorey, including *Dryandra armata* var. *armata, Hakea undulata, Hakea stenocarpa, Hakea trifurcata* and *Lepidosperma squamatum.*

This site-vegetation type occurs on low undulating sandy gravel to gravel soils over shallow soils. This site-vegetation type occurs in other conservation areas, both within the eastern and northern parts of the Jarrah forest and as such is not restricted (Heddle *et al.* 1980b; Department of Conservation and Environment 1980; Department of Conservation and Land Management 1987).

MG - Open Woodland of *Eucalyptus wandoo* subsp. *wandoo* and *Eucalyptus accedens* with dense understorey, including *Hakea incrassata, Allocasuarina humilis, Dryandra armata* var. *armata, Hakea undulata* and *Hakea trifurcata.*

This site-vegetation type occurs on the upper slopes of the undulating hills with clay-loams on shallow soils. This site-vegetation type occurs in other conservation areas, both within the eastern, western escarpment and northern parts of the Jarrah forest and as such is not restricted (Heddle *et al.* 1980b; Department of Conservation and Environment 1980; Department of Conservation and Land Management 1987).

G - Open to Closed Heath of Proteaceae - Myrtaceae species, including *Hakea incrassata, Hakea stenocarpa, Dryandra armata* var. *armata, Hakea undulata, Melaleuca trichophylla, Calothamnus rupestris (Priority 4), Allocasuarina humilis* and *Hypocalymma angustifolium.*

This site-vegetation type occurs on the shallow soils on or surrounding outcrops on the upland and valley systems on the Darling Ranges. This type is restricted in distribution within the northern Jarrah forest, but is well represented in the conservation estate, e.g. near Mt Cooke and Mt Windsor (Heddle *et al.* 1980b; Department of Conservation and Environment 1980; Department of Conservation and Land Management 1987).

This site-vegetation type tends to be dominated by specific herb and shrub species, which reflect the soils and moisture associated with outcrops on the Darling Ranges.

All these site-vegetation types are well represented within the conservation estate (both on the Darling Scarp and in the northern and eastern sections of the Darling Ranges). Therefore the proposed quarry extensions should have minimal impact on the vegetation values within the southwest forest region.

The survey area is located on the Darling Scarp vegetation complex as defined by Heddle et al. (1980) and as updated by Mattiske and Havel (1998). This vegetation complex is restricted to the western fringes of the Darling Ranges and is less well represented in the conservation estate (with 7.86% represented in the formal and informal reserves, based on data in the Forest Management Plan (Conservation Commission 2004).

The condition of the vegetation varies from modified (some rehabilitation areas) to excellent. No plant communities listed as threatened under the Environmental Protection Biodiversity Conservation Act (1999) were located within the survey area. No plant communities listed as threatened ecological communities by the Department of Conservation and Land Management (2006d) were located within the survey area.

6. LIST OF PERSONNEL

The following personnel were involved in this project:

Principle Ecologist - Dr E.M. Mattiske

Botanists - Ms B. Koch
Ms S. Robinson
Ms B Taylor

7. REFERENCES

Beard, J.S. (1979)
The vegetation of the Pinjarra Area, Western Australia. Map and Explanatory Memoir, 1:250,000 Series, Vegmap Publications, Perth.

Beard, J.S. (1980)
A New Phytogeographic Map of Western Australia. Western Australian Herbarium Notes Number **3**: 37-58.

Beard, J.S. (1981)
Vegetation Survey of Western Australia. Swan. Map and Explanatory Notes, Sheet 7, 1:1,000,000 Series, University of Western Australia Press, Perth.

Beard, J.S. (1990)
Plant Life of Western Australia. Kangaroo Press Pty Ltd, N.S.W.

Churchill, D.M. (1961)
The Tertiary and Quaternary vegetation and climate in relation to the living flora in South Western Australia. Ph.D. thesis, University of Western Australia.

Churchill, D.M. (1968)
The distribution of and prehistory of Eucalyptus diversicolor F.Muell., E. marginata Donn ex Sm., and *E. calophylla* R.Br. in relation to rainfall. Aust. J. Bot. **16**: 125-151.

Churchward, H.M and W.M. McArthur (1980)
Landforms and Soils of the Darling System, Western Australia. In: Department of Conservation and Environment (1980) *Atlas of Natural Resources Darling System, Western Australia.* Published by the Department of Conservation and Environment, Perth, 1980.

Conservation Commission of Western Australia (2004)
Forest Management Plan for the South-west Forest Region. Prepared by the Conservation Commission of Western Australia, Perth.

Department of Agriculture (2006)
Declared Plants List.
http://agspsrv34.agric.wa.gov.au/programs/app/dec_pl/declaredplants.htm

Department of Conservation and Environment (1980)
Atlas of Natural Resources Darling System, Western Australia. Published by the Department of Conservation and Environment, Perth, 1980.

Department of Conservation and Land Management (1987)
Northern Forest Regional Plan 1987 - 1997. Published Plan prepared by the Department of Conservation and Land Management, Perth.

Department of Agriculture (2006)
Declared Plants List.
http://agspsrv34.agric.wa.gov.au/programs/app/dec_pl/declaredplants.htm

Department of Conservation and Land Management (2006a)
Florabase. Department of Conservation and Land Management.
http://www.calm.wa.gov.au/science/florabase.html

Department of Conservation and Land Management (2006b)
Western Australian Flora Conservation Codes. Department of Conservation and Land Management. http://florabase.calm.wa.gov.au/help/conscodes

Department of Conservation and Land Management (2006c)
Max Version 2.1.1.129. Department of Conservation and Land Management.

Department of Conservation and Land Management (2006d)
List of Threatened Ecological Communities on the (TEC) Database endorsed by the Minister for the Environment.
http://www.naturebase.net/plants_animals/watscu/pdf/tec/endorsed_tec_list_jan04.pdf

Department of the Environment and Heritage (2006a)
EPBC Act List of Threatened Flora
http://www.deh.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=flora

Department of the Environment and Heritage (2006b)
EPBC Act List of Threatened Ecological Communities.
http://www.deh.gov.au/cgi-bin/sprat/public/publiclookupcommunities.pl

Diels, L. (1906)
Die Pflanzenwelt von Western-Australien sudlich des Wendekreises. Vegn. Erde 7, Leipzig.

Environmental Protection and Biodiversity Conservation Act 1999
http://scaleplus.law.gov.au/html/pasteact/3/3295/top.htm

Environmental Protection Authority (2004)
Guidance for the Assessment of Environmental Factors (in accordance with the Environmental Protection Act 1986) Terrestrial flora and vegetation surveys for environmental impact assessment in Western Australia No 51. June 2004.

Heddle, E.M., Loneragan O.W. and Havel J.J. (1980)
Vegetation of the Darling System in *Atlas of Natural Resources, Darling System, Western Australia.* Department of Conservation and Environment, Perth, Western Australia.

Gardner, C.A. (1942)
The vegetation of Western Australia with special reference to climate and soils. J. Proc. R. Soc. West. Aust. **28**:11-87.

Havel, J.J. (1968)
The potential of the northern Swan Coastal Plain for Pinus pinaster Ait *plantations.* Bull. For. Dep. W. Aust. **76.**

Havel, J.J. (1975a)
Site-vegetation mapping in the northern jarrah forest (Darling Range). I. Definition of site-vegetation types. Bull. For. Dep. W. Aust. **86.**

Havel, J.J. (1975b)
Site-vegetation mapping in the northern jarrah forest (Darling Range). II. Location and mapping of site-vegetation types. Bull. For. Dep. W. Aust. **87.**

Havel, J.J. (2000)
Ecology of the forests of south western Australia in relation to climate and landforms. Ph.D. Thesis, Murdoch University, Western Australia.

Heddle, E.M., J.J. Havel, and O.W. Loneragan (1980a)
Vegetation Complexes of the Darling System, Western Australia. In: Department of Conservation and Environment (1980) *Atlas of Natural Resources Darling System, Western Australia.* Department of Conservation and Environment, Perth, 1980.

Heddle, E.M., J.J. Havel, and O.W. Loneragan (1980b)
Focus on Northern Jarrah Forest Conservation and Recreation Areas. Forest Focus Number **22.**

Hopper, S.D., van Leeuwen, S., Brown, A.P. and S.J. Patrick (1990).
Western Australia's Endangered Flora. Department of Conservation and Land Management, Wanneroo, Western Australia.

Lange, R.T. (1960)
Rainfall and soil control of tree species distribution around Narrogin, Western Australia. J. Roy. Soc. W. Aust. **43**:104-110.

Mattiske, E.M. and Havel, J.J. (1998)
Vegetation Complexes of the South-west Forest Region of Western Australia. Maps and report prepared as part of the Regional Forest Agreement, Western Australia for the Department of Conservation and Land Management and Environment Australia.

Speck, N.H. (1958)
The vegetation of the Darling-Irwin botanical districts and an investigation of the distribution of the family Proteaceae in south-western Western Australia. Ph.D. thesis, University of Western Australia.

Seddon, G. (1972)
Sense of Place. A Response to an Environment, the Swan Coastal Plain, Western Australia. University of Western Australia Press, Nedlands.

Smith, F.G. (1974)
Vegetation Survey of Western Australia. Vegetation Map of the Collie Sheet. 1:250 000. Department of Agriculture, Western Australia.

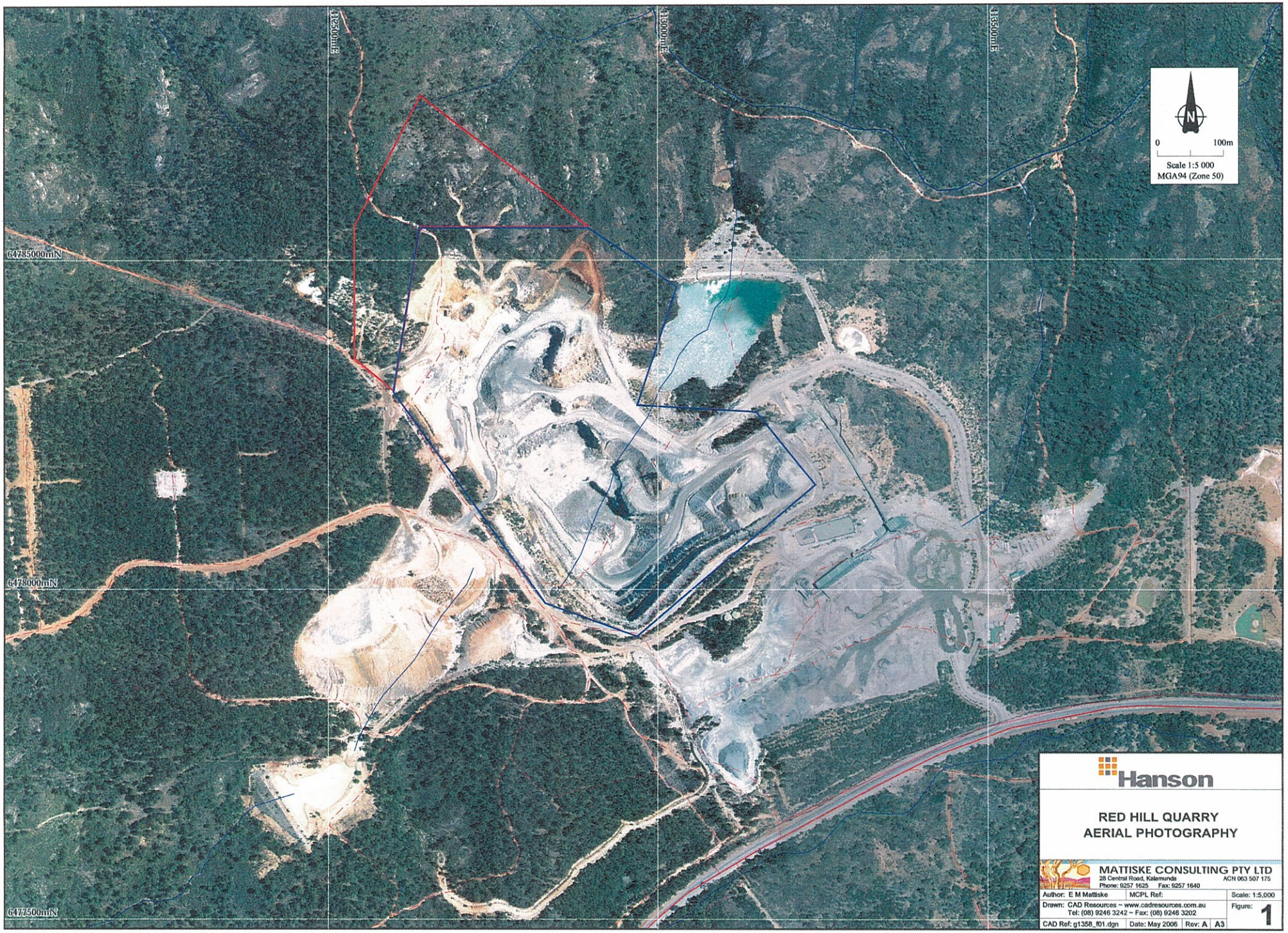
The Commonwealth of Australia and the State of Western Australia (1999)
Regional Forest Agreement for the South-west Forest Region of Western Australia. May 1999.

The Government of Western Australia (2000)
Bush Forever. Published by the Westralian Planning Commission, Perth Western Australia. Volumes 1 and 2.

Wildlife Conservation Act (1950-1980)
Wildlife Conservation Act and Regulations. Western Australian Government Publication.

Williams, R.F. (1932)
An ecological analysis of the plant communities of the jarrah region on a small area near Darlington. J. Roy. Soc. W. Aust. **18**: 105-124.

Williams, R.F. (1942)
An ecological study near Beraking forest station. J. Roy. Soc. W. Aust. **31**: 19-31.

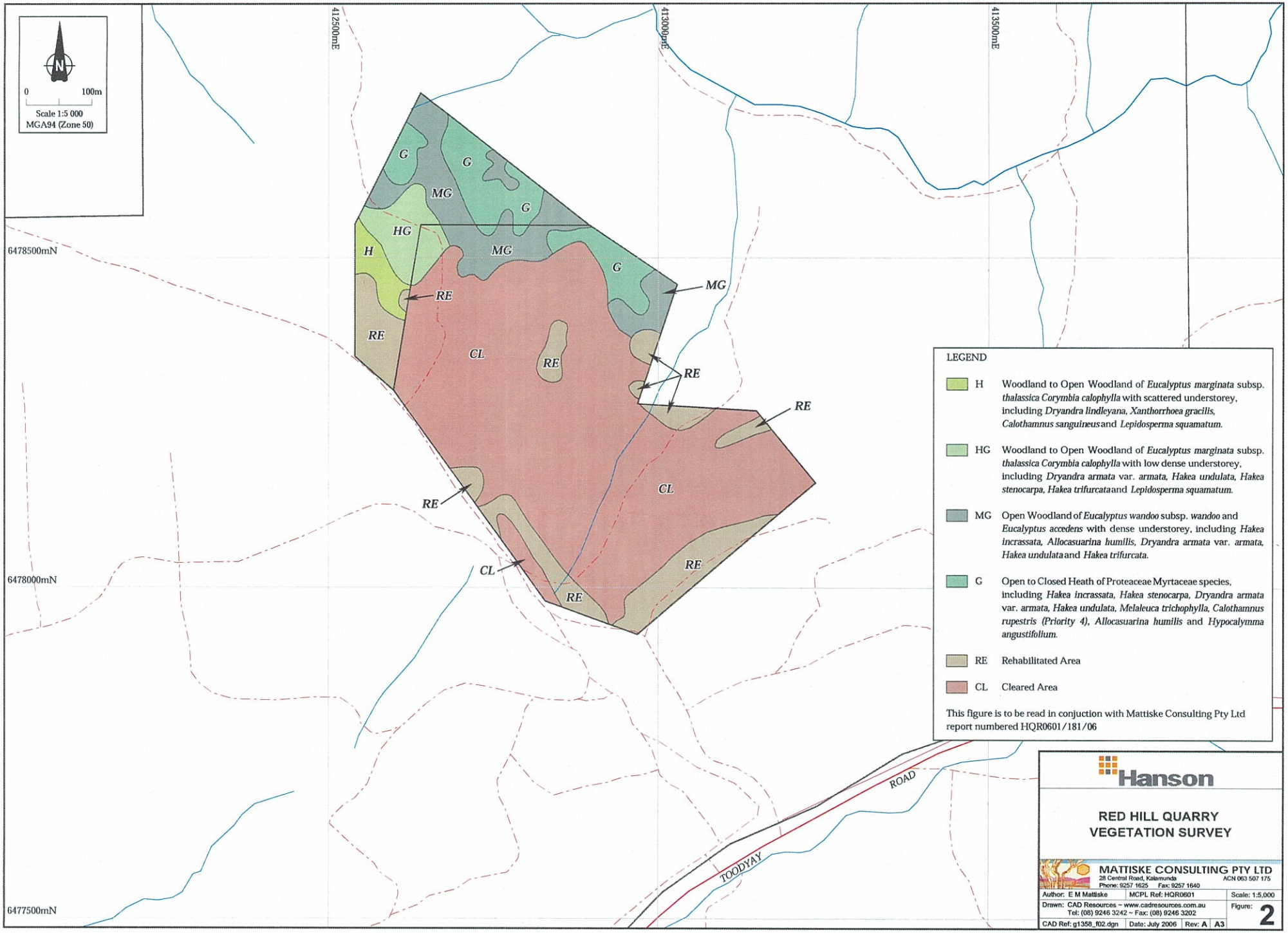


Hanson

RED HILL QUARRY
AERIAL PHOTOGRAPHY

MATTISKE CONSULTING PTY LTD
28 Central Road, Kalamunda ACN 063 507 175
Phone: 9257 1625 Fax: 9257 1640

Author: E M Mattiske	MCPL Ref:	Scale: 1:5,000
Drawn: CAD Resources ~ www.cadresources.com.au Tel: (08) 9246 3242 ~ Fax: (08) 9246 3202		Figure: 1
CAD Ref: g1358_f01.dgn	Date: May 2006 | Rev: A | A3	


N
0
100m
Scale 1:5 000
MGA94 (Zone 50)
412500mE
413000mE
413500mE
6478500mN
6478000mN
6477500mN
G
G
MG
G
HG
H
MG
G
MG
RE
RE
CL
RE
RE
RE
RE
CL
RE
CL
RE
RE
ROAD
TOODYAY
LEGEND
H Woodland to Open Woodland of *Eucalyptus marginata* subsp. *thalassica Corymbia calophylla* with scattered understorey, including *Dryandra lindleyana, Xanthorrhoea gracilis, Calothamnus sanguineus* and *Lepidosperma squamatum.*
HG Woodland to Open Woodland of *Eucalyptus marginata* subsp. *thalassica Corymbia calophylla* with low dense understorey, including *Dryandra armata* var. *armata, Hakea undulata, Hakea stenocarpa, Hakea trifurcata* and *Lepidosperma squamatum.*
MG Open Woodland of *Eucalyptus wandoo* subsp. *wandoo* and *Eucalyptus accedens* with dense understorey, including *Hakea incrassata, Allocasuarina humilis, Dryandra armata* var. *armata, Hakea undulata* and *Hakea trifurcata.*
G Open to Closed Heath of Proteaceae Myrtaceae species, including *Hakea incrassata, Hakea stenocarpa, Dryandra armata* var. *armata, Hakea undulata, Melaleuca trichophylla, Calothamnus rupestris (Priority 4), Allocasuarina humilis* and *Hypocalymma angustifolium.*
RE Rehabilitated Area
CL Cleared Area
This figure is to be read in conjuction with Mattiske Consulting Pty Ltd report numbered HQR0601/181/06
Hanson
RED HILL QUARRY
VEGETATION SURVEY
MATTISKE CONSULTING PTY LTD
28 Central Road, Kalamunda ACN 063 507 175
Phone: 9257 1625 Fax: 9257 1640
Author: E M Mattiske | MCPL Ref: HQR0601 | Scale: 1:5,000
Drawn: CAD Resources ~ www.cadresources.com.au Tel: (08) 9246 3242 ~ Fax: (08) 9246 3202 | Figure: 2
CAD Ref: g1358_f02.dgn | Date: July 2006 | Rev: A | A3

APPENDIX A: SUMMARY OF VASCULAR PLANT SPECIES RECORDED IN THE PROPOSED CLEARING SITE, RED HILL QUARRY, 2006

Note: *denotes introduced (weed) taxa

Family	Species
ZAMIACEAE	*Macrozamia riedlei*
POACEAE	* *Briza maxima*
CYPERACEAE	*Lepidosperma leptostachyum*
	Lepidosperma squamatum
	Tetraria capillaris
DASYPOGONACEAE	*Kingia australis*
	Lomandra sericea
XANTHORRHOEACEAE	*Xanthorrhoea gracilis*
	Xanthorrhoea preissii
ANTHERICACEAE	*Borya sphaerocephala*
COLCHICACEAE	*Burchardia congesta*
IRIDACEAE	* *Gladiolus caryophyllaceus*
CASUARINACEAE	*Allocasuarina fraseriana*
	Allocasuarina huegeliana
	Allocasuarina humilis
PROTEACEAE	*Banksia grandis*
	Dryandra armata var. *armata*
	Dryandra lindleyana
	Dryandra sessilis
	Grevillea manglesii subsp. *manglesii*
	Grevillea synapheae
	Hakea cristata
	Hakea erinacea
	Hakea stenocarpa
	Hakea trifurcata
	Hakea undulata
	Isopogon asper
	Petrophile biloba
LORANTHACEAE	*Nuytsia floribunda*
MIMOSACEAE	*Acacia barbinervis* subsp. *barbinervis*
	Acacia extensa
	Acacia pulchella
	Acacia saligna
PAPILIONACEAE	*Bossiaea eriocarpa*
	Bossiaea ornata

APPENDIX A: SUMMARY OF VASCULAR PLANT SPECIES RECORDED IN THE PROPOSED CLEARING SITE, RED HILL QUARRY, 2006

Note: *denotes introduced (weed) taxa

Family	Species
PAPILIONACEAE cont	*Daviesia polyphylla*
	Daviesia preissii
	Gastrolobium spathulatum
	Gompholobium marginata
RUTACEAE	*Boronia ovata*
EUPHORBIACEAE	*Phyllanthus calycinus*
STERCULIACEAE	*Lasiopetalum floribundum*
DILLENIACEAE	*Hibbertia commutata*
	Hibbertia hypericoides
	Hibbertia subvaginata
THYMELAEACEAE	*Pimelea suaveolens*
MYRTACEAE	*Baeckea camphorosmae*
	Beaufortia purpurea
	Calothamnus rupestris (P4)
	Calothamnus sanguineus
	Corymbia calophylla
	Darwinia citriodora
	Eucalyptus accedens
	Eucalyptus marginata subsp. *marginata*
	Eucalyptus marginata subsp. *thalassica*
	Eucalyptus microcorys (planted)
	Eucalyptus rudis subsp. *rudis*
	Eucalyptus wandoo subsp. *wandoo*
	Hypocalymma angustifolium
	Melaleuca incana subsp. *incana*
	Melaleuca nesophila (planted)
	Melaleuca radula
	Melaleuca trichophylla
APIACEAE	*Trachymene caerulea* subsp. *caerulea*
EPACRIDACEAE	*Leucopogon pulchellus*
	Styphelia tenuifolia
ASTERACEAE	* *Dittrichia graveolens*
	Pterochaeta paniculata